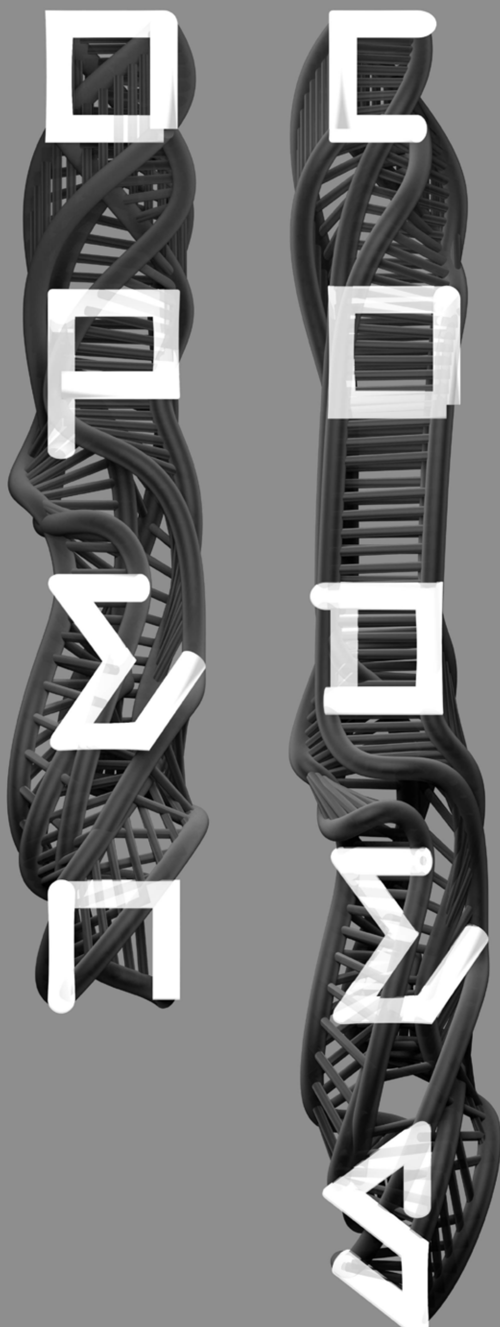

ZKM Zentrum für Kunst und Medientechnologie Karlsruhe

Open Codes

ZKM Zentrum für Kunst und Medientechnologie Karlsruhe

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Werkteil Signal- und Morsecodes

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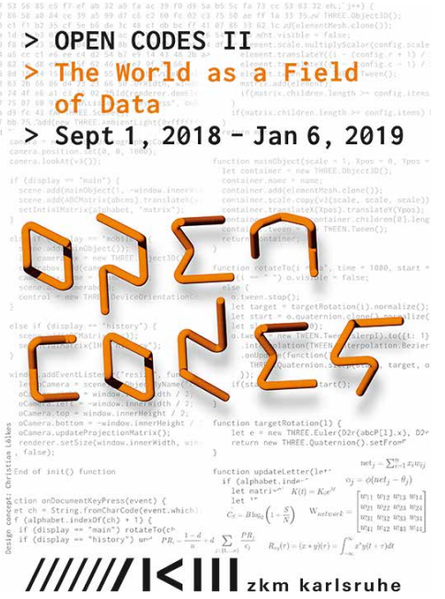
Open Codes. Living in Digital Worlds



We live in an age where knowledge production, dissemination, and acquisition are changing on a global scale due to the ongoing evolution of technologies based on codes. Codes determine how we perceive our world; they are the essence of a new cultural technique. Knowledge of programming and a profound understanding of coding is increasingly becoming a fundamental skill for individual agency and self-determination.

With the exhibition *Open Codes. Living in Digital Worlds* we are proposing a new definition of the exhibition for the twenty-first century, which addresses present-day challenges and integrates them into the museum. It is an attempt to engage with today's realities and point out perspectives and lines of development for the future in order to better understand the world we live in. To this end, we have developed a deinstitutionalized exhibition format, a platform of knowledge to which access is always free, and which resembles closely the actual worlds in which we live and work. *Open Codes* is designed as a communal space, as an environment in which people come together and exchange ideas, views, information, and experiences. Working and learning are understood here as collaborative processes to create synergies between different professions and various forms of knowledge and expertise; thus *Open Codes* is intended to be an educational experiment. The visitors of the exhibition are invited to work, produce, and learn together with others. *Open Codes* is a platform that facilitates collaboration and co-creation; that invites visitors to participate in open exchanges within an environment that undergoes constant change. In the exhibition various approaches are tried out to test new forms of encounter and critical debate. The visitors get to know a very new kind of environment where knowledge can be accessed; it is a place that continually changes, reconfigures, develops, and evolves.

Open Codes therefore constitutes a proposition for how to re-think exhibition making. This approach is not bound locally to the ZKM | Karlsruhe, but can be transferred to different contexts and spaces. In fact, a first adaptation has been realized in cooperation with the Goethe-Institut in Mumbai between April 6 and June 2, 2018. While the selected artworks were adapted to the local context, the exhibition's format, the exhibition model and its ideology, stayed the same.

Objectives and (Historical) Contextualization

Open Codes is conceived as a pilot project, an experimental space for creative encounters that promotes a genuinely inclusive approach to exhibition-making. *Open Codes* allows artworks, historical artifacts, presentations of scientific projects, and didactic exhibits illustrating certain aspects of computing and code, to coexist in an almost undivided postindustrial space. Their placement and position is the result of an aleatory process, producing an arrangement where objects of various origins and with manifold intentions find themselves interconnected. The only thematic feature uniting them is the immanence of code, echoing a worldview which assumes that computability is the premise of provability.

Open Codes disrupts predispositions and calls for different forms of knowledge creation and circulation in the sense of a free, open, and unrestricted sharing of ideas. A mix of hackerspace, makerspace, exhibition, and lab, the project is shaped as an open knowledge platform. As a communal space for exchange, the setting invites visitors to engage in a cross-disciplinary dialogue that fosters collaboration and triggers interactions related to the wide scope of topics touched upon by the exhibition.

In this context it is important to acknowledge that *Open Codes* is not the first attempt at the ZKM to engage with the genealogy, influence, and aftermath of code, algorithms, software, and programming languages. Since the foundation of the ZKM, the relationships between technology and the arts as well as their social implications have indeed played a crucial role.

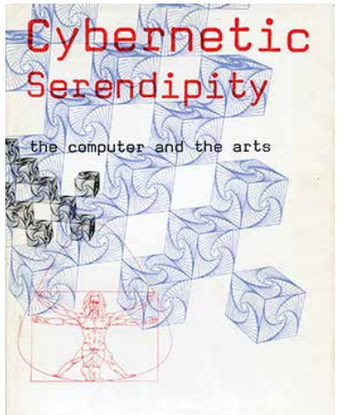
Posing the question "Can Net art really be exhibited?" the exhibition net_condition (1999) brought together a large number of artists working on or with the Internet in the late 1990s. At the same time the show was one of the first ZKM attempts to approach media art in relation to the analysis of social phenomena and processes.

This underlying idea has been a determining factor in many subsequent ZKM exhibitions such as *The Algorithmic Revolution* (2004), which analyzed the role of algorithmic decision-making processes in the arts, *YOU_ser: The Century of the Consumer* (2007), and *YOU_ser 2.0. Celebration of the Consumer* (2009), where the focus shifted from the artist to the visitor and sought to reflect on the first contours of user-based technological art.

With the GLOBALE, a new art format was launched by the ZKM: a polyphonic, multipolar event, both laboratory and academy, which aimed to analyze the cultural effects of globalization and digitization. As a "project in progress," exhibitions, lectures, concerts, performances, and much more besides ran for over 300 days at the ZKM, adding new works and contents on a regular basis from the opening of the project. The exhibitions *Infosphere, Exo-Evolution*, and *Global Control and Censorship*, the thematic shows curated at ZKM which took place within the framework of the *GLOBALE* between 2015 and 2016, were clearly precedents of the current exhibition: *Open Codes*.

So, if many of the crucial aspects of *Open Codes* were already addressed by previous ZKM exhibitions, if there are also similarities to other curatorial and museological approaches in past years, as we shall see below, what is it that makes *Open Codes* so innovative and different? Why do we call it an educational experiment? In order to answer these questions, let us take a brief look at the attempts, thought experiments, and exhibition concepts which were initiated in recent decades which share one or more key ideas with *Open Codes*.

Structures of Knowledge



Open Codes is definitely not the only exhibition dedicated to computing and its social implications. The fascination of artists and curators for technology has resulted in projects, some of which challenged the boundaries of the concept of contemporary arts.

When discussing past exhibitions that dealt with the relationships between technology and arts, it is impossible to ignore *Cybernetic Serendipity*. Curated by Jasia Reichardt, the show took place at the Institute of Contemporary Arts, London in 1968 and presented, in an extraordinarily and multidisciplinary way, multiple results and experimental approaches of computer-aided creative activity: from music to dance, from sculpture to painting, from film to architecture. The purpose of the exhibition was to show how computers and other electronic devices could be used creatively, within and beyond the arts.

In terms of content, the works and topics addressed by *Cybernetic Serendipity* have much in common with those covered by *Open Codes*. In both cases the visitor is confronted with the latest cutting-edge technological advances. Both shows introduce the highlights of the history and technology of computers from the past up to the moment they opened. And they certainly explore the way these developments have influenced the arts, the sciences, and/or society – this alone suggests similarities between *Cybernetic Serendipity* and *Open Codes* in terms of the curatorial concepts of the two projects.

At the very beginning of the *Cybernetic Serendipity* catalogue, in the Table of Contents, two rectangular boxes lie above the exhibition's title, which contain definitions of the words in the title. In general definitions appear to be very important, as they are plentiful throughout the entire catalogue, which also includes an extensive glossary with computer-related terms.

Fifty years have passed after *Cybernetic Serendipity* but computer-related exhibitions still rely heavily on detailed explanations and in the case of *Open Codes* on a classification system of contents. *Open Codes* provides visitors with an exhibition manual and a thematic categorization of the contents as an aid to navigate the show physically and digitally. The eight introductory texts to the main topics of the exhibition contain several definitions to clarify the concepts addressed. The topics dealt with in the exhibition are grouped in eight key areas: #GenealogyOfCode; #Encoding; #ArtificialIntelligence & #MachineLearning; #AlgorithmicGovernance; #Labor&Production; #AlgorithmicEconomy; #VirtualReality, and #GeneticCode.

The # character was used, among other things, most commonly to denote an ordinal number (particularly in U.S. English) – for example, #2 instead of no. 2 – until 2007, when social media users began to use it as a metadata tag to sort content related to specific keywords. It is now a dynamic, association-based classification system, widely used in social media for arranging content, discussions, and themes in specific categories. A nonhierarchical system results from hashtags being attached to content, images, videos, etc., that resembles a cloud: all types of content can be associated with very different keywords, and do not fall under just one specific and exclusive category.

The # began its triumphant advance on Twitter ten years ago, when the platform began to hyperlink all hashtagged terms in tweets to Twitter search results for the hashtagged word. When Instagram launched in 2010, the hashtag became the lingua franca for labeling content on both platforms. Now it can be found on any online platform, and it influences the way we search and access information online.

The importance of definitions, whether it is in the form of a glossary or as part of an exhibition manual, is actually speaking about the didactic approach pursued in both projects. After all, *Open Codes* is conceived as a tool *to understand the world we inhabit, the world, we live in, the world that sustains us.*

Educational Experiment / Thought Exhibition

Open Codes presents a thesis: that the world we live in is a world based on digital codes, in which computability is an epistemological basis, and where entities must be countable to be comprehensible. It is from this standpoint that the exhibition showcases retrospectively the progress in "binarizing" metaphysics and physics, important steps towards all-encompassing computability. Historical writings, contemporary publications, and the artworks on display demonstrate this process.

Computing is pervasive and was inevitable for many segments of organizing a posthuman life in an algorithmic society; from the fiscal system to design, from pattern recognition to the organization of big data, this ubiquity makes its repeated analysis essential. Code (i.e., programming languages), being the elusive and, in a certain sense, immaterial element of computing implies ontological questions, which are posed by *Open Codes*, thus we can rightfully call the exhibition a "thought exhibition." It is a statement, a presentation of ideas; it represents the cultural, philosophical, or political standpoint of the curators and the institution, and most importantly it invites the visitors to take part in a thought process or embark on an intellectual journey while visiting the exhibition.

Although the term "thought exhibition" was coined by Peter Weibel and Bruno Latour [°] in 2005, discursive exhibitions had appeared sporadically long before, one of which was a landmark show of the 1980s, and still bears significance both for its content and approach. Les *Immatériaux* [•] was a thought experiment manifested in an exhibition; it was a showcase of scientific, technological, but also artistic practices, and moreover – and therefore it resonates with *Open Codes* on many levels – it was a reflection on the exhibition as a medium and an interface.

Exhibits selected to demonstrate the state-of-the-art technology of the time along with artworks incorporating technical devices, considered as new media art – an eclectic selection ranging from skin samples in petri dishes to Nam June Paik's *TV-Buddha* (1974). The installations and objects were classified and ordered according to five categories of a telecommunication model, like the sixty sites at which they were presented.

The curatorial concept did not remain on a descriptive level but scrutinized the relationships of humans to telecommunications technology in a critical way. "In Lyotard's words, technology places humanity once again in a condition of childhood, of immaturity. This reference to immaturity is in direct contrast to what Kant defined as the project of the Enlightenment, namely to overcome the condition of Unmündigkeit." [°•]

[°] First used by Peter Weibel and Bruno Latour in the context of the exhibition Making Things Public. Atmospheres of Democracy, ZKM | Karlsruhe, 2005.

[•] Les Immatériaux. Curators: Jean-François Lyotard and Thierry Chaput. Centre Pompidou Paris, 1985. Catalog available online at: https://monoskop.org/images/f/f9/Les_Immateriaux_Epreuves_d_ecriture.pdf.

[°•] Yuk Hui and Andreas Broeckmann (eds.), 30 Years after Les Immatériaux: Art, Science, and Theory. (Lüneburg: Meson Press, 2015), 12.

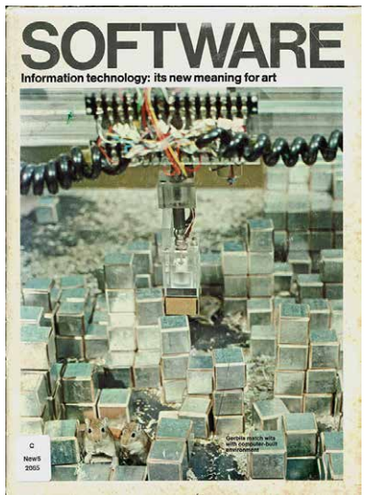
This may be the point where the concept of *Open Codes* differs from that of Les *Immatériaux*: although many artworks and exhibits in *Open Codes* are critical about the possibly subversive future impacts of computing, in general the exhibition and its accompanying program views code as a tool to attain digital maturity.

Open Codes attempts to grasp the societal significance of code, most importantly binary code and its abstractions (i.e. programming languages), and it also analyzes its origins and genealogy. Hence *Open Codes* could be read an as encyclopedia of code. The chronological development and recent influences of code are collected and sorted by a classification system, which not only categorizes and distinguishes between the sections, but enables synergies between them. These tools serve knowledge production within and through the exhibition, whether via artworks or historical artifacts, organized workshops or incidental encounters with interactive installations. All this is situated within an environment designed for different formats of learning (interactive, frontal, and autonomous), allowing the visitors to stay for a longer period of time, and to return; to inhabit the space.

The learning material is partly provided by the curators, and partly brought and generated by the visitors, thus the exhibition becomes a platform of an educational experiment.

In this context we recognize another interesting aspect about Jasia Reichardt's project. In *Cybernetic Serendipity* not only artists, but experts from different areas contributed to the exhibition: "no visitor to the exhibition, unless he reads all the notes relating to all the works, will know whether he is looking at something made by an artist, engineer, mathematician, or architect." [••]

Similarly, the participants' list of *Open Codes* reflects the multidisciplinary character of the project as it includes scientists, scholars, programmers, developers, and of course artists. In this sense, the collaboration with relevant institutions as well as local initiatives, which have not only contributed to the extensive art education program but also to the exhibition itself, is one of the principles underpinning the project. By approaching different areas of knowledge, and offering experts a platform to exchange ideas, we enable a greater exchange of information, in which the visitor is also involved.



This hybrid mixture is also one of the central aspects of another iconic exhibition: *Software. Information Technology: Its New Meaning for Art.* [•°°] The exhibition brought together artists and scientists in order to show "the effects of contemporary control and communication techniques." [•°•]

Contributors to this exhibition were interested in examining the link between computer systems and artistic representation, transferring the way information processing systems work to their artistic practice. In fact, the exhibition's title refers to the actual meaning of the term "software," understood as an instructional procedure, as a set of rules to be followed. The artists structured their pieces in this sense, as programmatic situations to which the audience could respond personally; they functioned as systems with which the visitor had to interact. Although not all of the exhibited projects relied on devices for transmitting information (such as fax or teletype machines), they were all reflections of the emergence of information technologies in the late 1960s and early 1970s, and highlighted the fact that the development of a media environment was of great importance in many areas of knowledge, including the arts.

Open Codes also aims to reflect on the way digital codes have been shaping every sector of our society, gradually turning it into a digitally operating society. Along with the thematic issues addressed in the exhibited projects, the exhibition itself is a reflection of our digital environments; it works as a system in which many different layers overlap, in exactly the same way that our digital lives are built nowadays.

° Jasia Reichardt, ed., Cybernetic Serendipity: The Computer and the Arts (London: Studio International, 1968), 5.

• The exhibition was curated by artist and critic Jack Burnham and held at the Jewish Museum in Brooklyn, New York, in 1970 as well as at the Smithsonian Institution, Washington, D.C., in 1971.

°• Jack Burnham and Robert Jakob, Software. Information Technology: Its New Meaning for Art (New York: The Jewish Museum, 1970), 10.

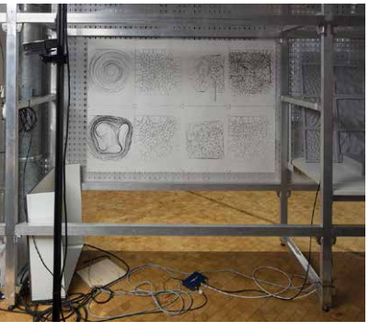
The Architecture of the Exhibition and its Design

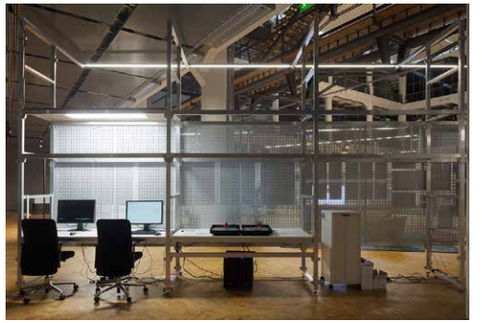
A key consideration of *Open Codes* is how to translate this heterogeneous topic of codes into a spatial language that would allow experimentation and an interdisciplinary dialogue to take place. How can an exhibition reflect the dynamics of the digital world? How to approach an exhibition space that has at its core such an immaterial phenomenon which resides in virtual space yet transgresses into material everyday life? How to create an exhibition design that highlights the networked character of the digital world, and reflects the character of the community? Therefore, the underlying consideration was how to bring the various thematic focuses of the exhibition into a dynamic relationship that would reflect the agility of developments of the field.

A central line of inquiry explored how spaces operate that have at their core digital labor. These can be found in the start-up scene, in coworking spaces, tech companies and research institutions, as well as, very importantly, in hackerspaces and makerspaces. Although ideologically very different from one another, they all exhibit similar characteristics in their infrastructural set up – starting from the power plugs everywhere, to the open communal working spaces, the solitary quiet zones, and the relaxed couch areas, all of which are there to enable possibility and to cater to the individual requirements of a person.

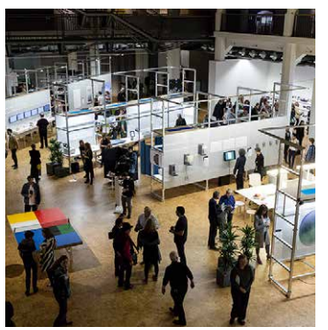
Especially the composite of hackerspaces influenced the outlines of *Open Codes*. Their nonhierarchical constitution, their open source attitude to the sharing and distribution of ideas, their communal peer-to-peer thinking based on accessibility, and their freedom of experimentation are all characteristics that strongly relate to what the exhibition is trying to achieve. This energy and vitality of the hackerspace is what we wanted to reflect in *Open Codes*.

Efficiency was an important feature while designing the display, as well as a certain openness, which makes the display look unfinished; cables of the technical devices are not hidden, the back sides of the images are visible through the peg boards, originally used in workshops to support peg hooks and tools. This









incompleteness and dynamics on purpose was inspired by parametricism, ° an architectural style rooted in digital animation techniques, which prefers open systems that always remain incomplete. Most importantly parametricism relies on algorithms to manipulate equations for design purposes to create autopoetic systems for a networked society, powered by and deeply relying on computation.

Not only the exhibits but the architecture and display themselves evoke the subject of *Open Codes*. The walls arranged in a radial form may remind the viewer, especially from above, of the Cray-2. The Cray-2 was a supercomputer released in the mid 1980s, with modules built together in a particular way, resembling the radial structure of the temporary walls in *Open Codes*, to increase the speed of computing.

It should be also mentioned at this point that *Open Codes* is meant to be an exhibition in flux; the list of works on the day of the opening does not equate to the list on the last day. Artworks and exhibits will be taken off display and exchanged for new works, either as determined before the opening or as decided by the curators afterwards; all are documented on the exhibition website. This particular feature emphasizes the ever-evolving nature of code. In case software bugs need to be fixed, update is needed, or bitrot has to be eliminated so that the algorithm can fulfill its function. The exhibition adapts to new developments as well as the altered needs of its visitors with a constantly changing set of exhibits.

The exhibition environment also needed to take into consideration the task and function of a museum as a place of learning and knowledge. It was our aim to create a space that stimulates, but at the same time allows the visitors to go after impulses and inspirations. A space that is flexible and adaptive to different desires and forms of engagement.

In connection with this endeavor it is interesting to mention that the exhibition *Laboratorium* • investigated experimental setups around which people would exchange ideas. *Laboratorium* incorporated an exhibition and a public program, which explored the heterogeneous being and content of laboratories. Similarly to *Open Codes*, this exhibition was conceived as a living or inhabited place, whereby visiting would entail a physical and a mental encounter. "We consider the museum as a place of action; producing an exhibition in it equals undergoing the active experience of the specifications in which each structural or symbolic element is taken into account, questioned, 'disturbed.' It is thus that we proposed to Roomade, the organizer of *Laboratorium*, to install its office in the middle of the exhibition rooms, and to run the project directly, and in public. We also took many decisions about the display device and the disorder of the works and documents which arrived daily, so that they could be spread out progressively in a space where all hierarchy had been abolished." °•

In *Open Codes* the considerations of a flexible space translated into different interiors, different scenographic components within the exhibition, starting from individual learning environments and secluded booths that foster concentrated learning, a cafe environment, an open table tennis field, to our very own hacker / makerspace adaptation that we called "OpenHub."

The OpenHub constitutes the heart of the exhibition. Equipped with a large projection space, sound system, tables and chairs that accomodates up to eighty people, this place is the performative center of *Open Codes*. The OpenHub provides the infrastructure that facilitates a variety of formats: screenings, performances, workshops, meetups, talks, lectures, and discussion groups. It is adaptable and can accommodate many different setups. This space also integrates museum education activities, in which the curators and the museum education departments invite designated people to share their knowledge and ideas about certain topics concerning coding.

Yet perhaps the most important feature of the OpenHub alongside the other spaces in the exhibition is that they are freely accessible to the public. Via an online system groups or individuals can book the spaces for their activities.

° Patrik Schumacher, "Parametricism: A New Global Style for Architecture and Urban Design," in AD Architectural Design – Digital Cities 79, no. 4 (July/August 2009), http://www.patrikschumacher.com/Texts/Parametricism%20-%20A%20New%20Global%20Style%20for%20Architecture%20and%20Urban%20Design.html.

• The exhibition was curated by Hans Ulrich Obrist and Barbara Vanderlinden and organized by Antwerpen Open and Roomade, in collaboration with the Provincial Museum of Photography, Antwerp, in 1999.

°• Michel François and Erwan Mahéo, "Bureau Roomade Déplacé," in Laboratorium, ed. Obrist and Vanderlinden, (Cologne: DuMont, 2001), 108.

The only stipulation is that the program must be free of charge, noncommercial, open to the general public, and thematically related to the exhibition. The aim was to provide the infrastructural basis that would bring people with different expertise, with different backgrounds into a conversation. The Internet and all its claims to make geography history and allow communities to be created across the world, still does not replace the invaluable exchange that happens when people meet face to face. The exhibition thus envisaged a cross-disciplinary platform for public discussion and knowledge exchange. It is used by university seminars, meetups, and schools, and at the same time for maker workshops, creative coding, creative tech workshops, performances, presentations, and many more stagings of public encounters for all ages and knowledge levels.

Creating this infrastructure for discussion and blurring the lines between art and our working life, allows a reframing of relations in the exhibition space in which traditional hierarchies are subverted and a more egalitarian, democratic approach to mediation can take place. The exhibition space can then be understood as a space of negotiation that tries to establish a common experience of shared interpersonal exchanges. The exhibition environment tries to create modes of constructing new possibilities of subjective enunciations: a proposal for reconfiguring forms of the circulation of thought, speech, and of exhibiting the visible, all of which try to open up possibilities for shared experiences.

It is by achieving this that the purpose of *Open Codes* can be realized. By revoking the separation between what is art and what is not, by uncovering and making available the tools of the digital realm in a participatory manner, and by granting insights into the workings of different fields of research, the exhibition unfolds its potential of lending agency to individuals and constructing modes of communality. In this open source ideology a shared understanding, a discussion is enabled through revealing the source, the essence, making it public, and debatable.

Furthermore, open accessibility of this infrastructure, with its perks, suggests that education, and self-education should be rewarded. Knowledge acquired in the exhibition space about code, in the widest sense of the word, empowers the visitor through acquiring digital competences, which are essential for the critical understanding of our algorithmic society; all the exhibits and artworks, debates, screenings, and talks point in this direction, and this is what makes the project unique and innovative.

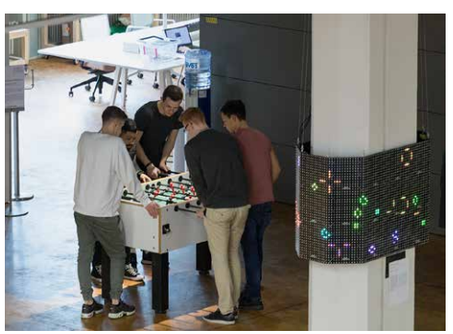
Open Codes is thus an educational experiment, as it reverses the method of knowledge production and dissemination: the student should not be charged, but recompensed for the time spent on the subject as an advanced guarantee for the innovation, which might evolve from the learning process and which might serve the community from which it originated.

We argue via *Open Codes* that empowerment of each and every citizen through digital competence is essential for successful future societies, and every tool should be used to catalyze this process.







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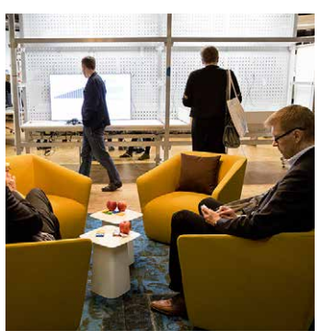

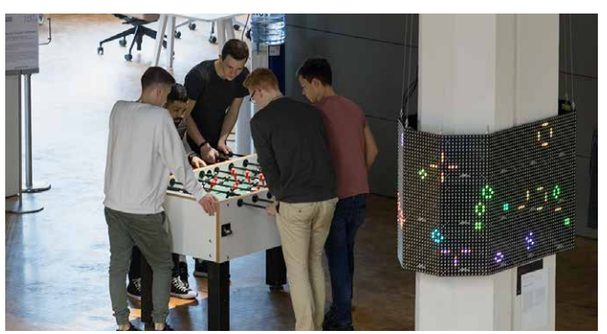



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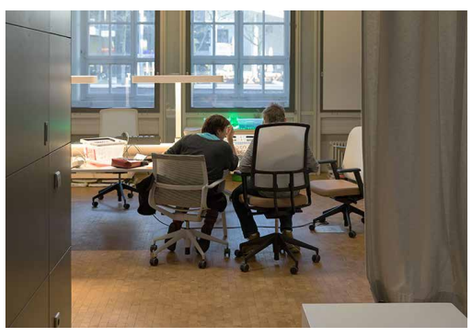
Creating this infrastructure for discussion and blurring the lines between art and our working life, allows a reframing of relations in the exhibition space in which traditional hierarchies are subverted and a more egalitarian, democratic approach to mediation can take place. The exhibition space can then be understood as a space of negotiation that tries to establish a common experience of shared interpersonal exchanges. The exhibition environment tries to create modes of constructing new possibilities of subjective enunciations: a proposal for reconfiguring forms of the circulation of thought, speech, and of exhibiting the visible, all of which try to open up possibilities for shared experiences.

It is by achieving this that the purpose of *Open Codes* can be realized. By revoking the separation between what is art and what is not, by uncovering and making available the tools of the digital realm in a participatory manner, and by granting insights into the workings of different fields of research, the exhibition unfolds its potential of lending agency to individuals and constructing modes of communality. In this open source ideology a shared understanding, a discussion is enabled through revealing the source, the essence, making it public, and debatable.

Furthermore, open accessibility of this infrastructure, with its perks, suggests that education, and self-education should be rewarded. Knowledge acquired in the exhibition space about code, in the widest sense of the word, empowers the visitor through acquiring digital competences, which are essential for the critical understanding of our algorithmic society; all the exhibits and artworks, debates, screenings, and talks point in this direction, and this is what makes the project unique and innovative.

Open Codes is thus an educational experiment, as it reverses the method of knowledge production and dissemination: the student should not be charged, but recompensed for the time spent on the subject as an advanced guarantee for the innovation, which might evolve from the learning process and which might serve the community from which it originated.

We argue via *Open Codes* that empowerment of each and every citizen through digital competence is essential for successful future societies, and every tool should be used to catalyze this process.





Educational programs for Open Codes

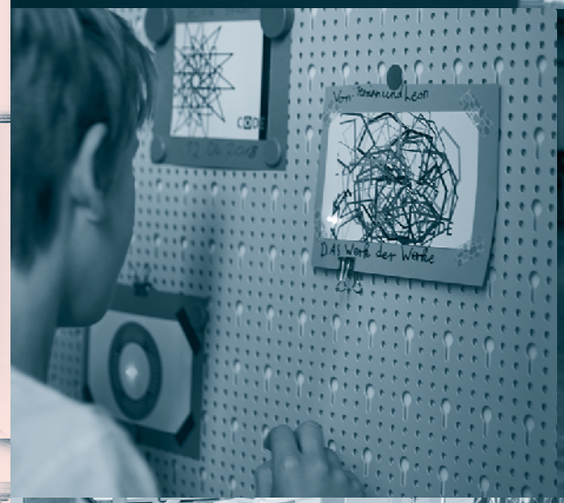
Computer code rules the world we live in, whether as the basis of global data flows or as what underlies the user-friendly interfaces of Google, Instagram, etc. The digital revolution has brought with it a shift in the power structures of society: those who understand code are clearly at an advantage. Knowledge of code is increasingly becoming key for operating and navigating our modern society in a way that is free, emancipated, and self-determined. This shift also brings with it new challenges for digital and cultural education – cultural institutions have to disseminate new knowledge and must develop innovative programs that will contribute to democratizing code.
Within the ZKM, the ZKM | Museum Communication stands for an innovative approach to learning about art, culture, and media. Museum education mediates art as a process: we create communicative environments that comprise the visitors themselves, the artworks, and everyone who is part of the ZKM. In the context of the exhibition Open Codes, with an interdisciplinary and very network-oriented approach, we have developed a varied program for learning with art, which explores an artistic understanding of code and questions age and gender stereotypes.

Code and Paint

In this workshop, which was offered on ZKM's Open Day, the main focus was on a playful approach to coding in combination with performative elements. Self-driving cars programmed by the visitors draw patterns and shapes on large sheets of paper while performing a poetic dance that was based on code written by the workshop participants themselves. At the beginning of the workshop, participants tried out the basics of programming analogically: instructed by clear commands, one person had to reach a certain point in the room, and for this task the person was "programmed" by the rest of the group. In the next step, the acquired basic knowledge was transferred to a graphics-based programming software, and expanded to include basic principles such as recursive loops or the "If … Then …" commands. The single-board mini computer of Calliope (Calliope Mini) functioned as the controller and receiver for the robot cars, which were fitted with a mount for pens or paintbrushes. Random, aesthetic, programmed drawings were created while experimenting with differently programmed driving directions and movements.

Code Camp

The Code Camp, which lasted for several days, also centered on the linking of analogue and digital artworks. It was organized in collaboration with the initiative Code Your Life (www.code-your-life.org) and was supported by the Innovation Fund of the State of Baden-Wurttemberg. Children and young people from various cultural backgrounds programmed digital art in heterogeneous learning groups. In a variety of workshop formats, children and young people learned – the language of the digital world: code. Children from different types of school were involved as well as from different cultural backgrounds, both German-speakers and others who were still learning German. Code was the main focus of these learning formats, and represented the common language above all spoken languages. The Code Camp pursued the aim of opening culture and society to children and young people, to make them to creators of new things, and at the same time to foster social cohesion irrespective of language restraints – in this process it became clear how creative experimentation opens new perspectives on programming, and how different participants complement each other with their knowledge.



Algorave

In April 2018, in collaboration with the Digitale Kunstfabrik, an Algorave was celebrated. An Algorave is a global party and concert format, which revolves around algorithmically generated music. Artists programmed sounds with their own custom software, and in this context unlocked new points of access to electronic music. During their live coding performances, the process could be viewed via projections, like how danceable sounds are formed from software algorithms – yet another way to experience the title and aspiration of the Open Codes exhibition. Pioneering performers of the international Algorave scene, such as Alex McLean (Yaxu), Alexandra Cardenas, and Renick Bell, complemented each other at the ZKM in a non-stop dance event, attended by many fans of experimental electronic music, enthusiasts of computer culture, as well as rank beginners in programming. The lineup kicked off in a very special way: three participants of the Sonic Pi Workshops (Joris, aged 11; Robert, aged 16; Sebastian, aged 30) had the courage to step up to the DJ turntable, and gave the audience a demonstration of their talent and acquired skills. The regular Sonic Pi Workshops facilitated artistic and creative access to programming through music, and to learning a programming language with fundamental programming techniques through the experimental creation of sounds and melodies.

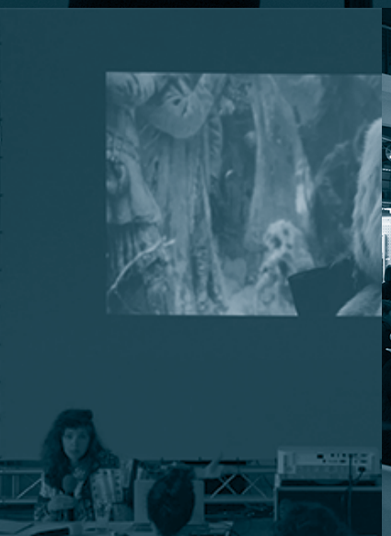
Cryptolab

The Cryptolab was a conceptual attempt to bring the topic of cryptographic currencies into the museum. A small mining-farm was shown as an installation piece as part of the exhibition. With the help of highly specialized computers (ASIC Miners) the cryptographic currency Bitcoin (BTC) was mined. Visitors could thus pier into what happens otherwise in large warehouses in China, Canada, or Island, in giant more or less secret mining farms: By solving cryptographic puzzles, financial assets were generated during the runtime of the exhibition and the generated values were then used to finance further projects connected to the exhibition. These were workshops, which provided interested visitors an insight to the handling of cryptographic currencies. Often, people hesitate to put their hands on this topic because they do not know how to exchange fiat money into crypto currency or just do not want to connect their bank account to a shady exchange company.

During the ZKM Cryptolab workshops participants were provided with small amounts of Bitcoin, which they could use to experiment without the risk of having to invest their own money. This learning by doing approach enabled people to make their own experiences.

Another part of the generated value was invested in token-based digital assets in the context of art. So called non-fungible tokens, based on smart contracts in the blockchain are currently an emerging trend, that got fueled by platforms like thecryptopunks.com and cryptokitties.co that bring back the concept of collectible trading cards into the digital world. This concept might influence the future of how digital art is handled and how artists can manage and control the trading of their work. ZKM is the first museum that included such tokenized artworks in their collection and displayed them in an exhibition. The topic was also discussed in a series of panels and talks.

Therefore, the Cryptolab can be seen as a self-evolving installation, which changed its appearance over time, by adding more and more parts over the runtime of the exhibition.



Artistic Positions

There are as many ways to creatively approach coding and everything that surrounds it as there are artists dealing with these ideas. Once a month artists taking part in Open Codes were invited to hold a workshop in the exhibition space, followed by an artist talk. This way, topics addressed at the show such as computation governance, neural networks, image processing standards, or algorithmic trading were not only theoretically analyzed but even more important approached by the workshop participants in a practical way. In the first months of the exhibition, the visitors had the chance to discuss and participate in different projects with Dutch artist and theorist Rosa Menkman, the artist platform RYBN.ORG, New Zealand artist Simon Ingram, artist and curator Helen Knowles, and voice expert Damien Mahoney as well as conceptual artist Constant Dullaart. The various and extra-disciplinary proposals included a paper-and-pen programming atelier that introduced the question of core basics in the computational logic, a practical “dissection” of image data files in order to generate new or alternative uses of these files and the composition of a voice work on digital sovereignty amongst others.

In addition to the workshops and talks, visual and sound artists have also presented different performances at the main area in the middle of the exhibition space, the OpenHUB. French pioneer of digital poetry Jacques Donguy performed with typography, images, sound, loops, and an old Atari 520ST to create digital poetry and expand our understanding of language, writing, visual and auditory perception. In a different session, author Stefan Römer presented an experimental film performance dealing with our post-panoptical and networked society.

Public Events

The idiosyncratic approach to mediation in Open Codes didn't disappear, it was rather emphasized by public events, whether they were related thematically to the exhibition or not.

ZKM yearly holds an Open House Day (Tag der offenen Tür) when mediation of the exhibitions is in focus. This day has been busy for years, which implies the usage of frontal formats in mediation, mostly guided tours. Open Codes, and the specific, non-exhibition-like environment it offers could make a difference in this regard: beside guided tours, workshops and discussions could take place within the designated areas of the exhibition.

Throughout the Goulash Programmers Night (GPN) ZKM is crowded by a specific kind of audience. In 2018 the 18th GPN took place not only at the premise of the Hochschule für Medien but in the exhibition space of Open Codes as well. The Entropia Association, a collective associated with the Chaos Computer Club, organized the event, which attracted approx. 1500 visitors for whom approx. 3 tons of goulash was cooked throughout the four days of GPN. During these intense days the participants exchanged ideas about technology and society. The motto of the 2018 GPN sets a counterpoint to the concept of hope of the digital natives. The extensive workshop and lecture program on topics such as artificial intelligence, digital medicine, and a changing society resonated well with the general topics brought up by Open Codes.

Networks

Like no other exhibition Open Codes demanded – and fostered – working with external groups and local actors. Linking up with existing networks, as well as building new ones, contributed to breaking open the (spatial) confines of the museum and to taking the ZKM out into the city and environs. At a very early stage of the planning of this exhibition, colleagues from the ZKM | Museum Communication and the Curatorial Department met with dedicated members of various Karlsruhe associations, organizations, and groups and invited them to understand the exhibition Open Codes as a platform for their projects. They were asked what groups active in various digital fields would like to see in the design of the exhibition space, what ideas of possibilities for collaboration and synergies they envisioned, and there was collective brainstorming to develop innovative formats for learning: this all resulted in setting in motion a lively exchange that enriched the work of the museum tremendously.

Collaboration was particularly close with the association Entropia, the Karlsruhe division of the Chaos Computer Club. Besides their annual Goulash Programmers Night, Entropia used the exhibition Open Codes, for example, as a meeting place for the Freifunk project, a noncommercial open grassroots initiative for free WLAN, as well as for larger maker-workshops of the FabLab. The workshop format “Write Cryptocards,” designed for schoolchildren, was developed together with Entropia. A similarly close collaboration existed with OK Lab Karlsruhe, one of the 25 labs of the Open Knowledge Foundation (https://codefor.de/ueber/) in Germany. In addition to the workshop format “How do numbers become codes, and how do codes become numbers?”, the workshop series Citizen’s Knowledge Lab in which open source projects were developed took place monthly.
And last but not least, Open Codes had become a platform for important representatives of the Karlsruhe digital creatives scene: Open Codes included in its program events of the DMW (Digital Media Women), the CoachingLab, and the Netstrategists. Thanks to these networks and the collaboration with these platforms the goal of reaching new target groups and engaging an audience as heterogeneous as possible could be achieved far more effectively. In this way Open Codes was able to combine the concept of co-working spaces with the idea of a participatory museum.

#GenealogyOfCode
#Binary
#Computing
#NumeralSystem
#Babel

Computation clearly does not begin with personal computers and their direct ancestors from the twentieth century. To find the roots of the principles upon which computation of today is based on one has to go back at least to the Middle Ages.

Ramon Llull (1232–1316), a Majorcan thinker, sought to develop a system for solving basic theological and philosophical questions, a method by means of which he tried to find and explore all possible combinations of concepts with the help of dynamic charts. This procedure, his so-called *Ars magna*, is explained most extensively in his notable work Ars magna [Great Art] (1274–1308).[°] Gottfried Wilhelm Leibniz (1646–1716) conceived his Dissertatio de arte combinatoria [Dissertation on the Art of Combinatorics] (1666), in which he proposes a parallelism between logic and metaphysics inspired by Llull.[•]

In 1679 Leibniz wrote about a #Binary system ("dyadic" or "binaria arithmetica") in one of his unpublished letters, which uses only 0 and 1 as numbers. He was not sure about the practical use of his invention, but frequently wrote about its possibilities in various letters to his colleagues. In 1701 he claimed to a French mathematician that he imagined to foresee, that by this means and the endlessgh rows there is something to achieve, which wouldn't be easy in another way.

Leibniz described the first computing device (#Computing) that works with the binary system as early as 1679. The description remained unpublished and the machine was not built in his lifetime.[•°]

Two centuries later Charles Babbage was working on his Difference Engine, followed by the Analytical Engine, neither of which were constructed entirely under his guidance due to insufficient funding. The Analytical Engine would

[°] Raimundus Llullus, Opera, 2 vols. (Stuttgart-Bad Cannstatt: Frommann-Holzboog, 1996), 228–663. See also Anthony Bonner, The Art and Logic of Ramon Llull: A User's Guide (Boston: Brill, Leiden).

[•] See Ana H. Maróstica, "Ars Combinatoria and Time: Llull, Leibniz and Peirce," Studia Lulliana, vol. 32 (1992): 105–34, here 111.

[•°] See Hermann J. Greve, "Entdeckung der binären Welt," in: Herrn von Leibniz' Rechnung mit Null und Eins (Berlin: Siemens Aktiengesellschaft, 1966), 21–31.

have been the first general purpose computer, but still a mechanical one. "The bounds of arithmetic were, however, outstepped the moment the idea of applying the cards had occurred; and the Analytical Engine does not occupy common ground with mere 'calculating machines'"[••], wrote Ada Lovelace (1815–1852), acknowledged today as the first programmer, in her notes on Babbage's computing automaton. This early device operated with a decimal #NumeralSystem. Computers nowadays are based only on a binary numeral system, first used by Leibniz, then reintroduced by George Boole (1815–1864).

Boole first cast logic into algebraic form in his book The Mathematical Analysis of Logic (1847), introducing the Boolean algebra.[•°°] Boole's binary system is based on the three most basic operations used as logical operations: AND, OR, and NOT.[•°•]

This system was not put into operation until "Claude Shannon, in 1937, proved in what is probably the most consequential M.A. thesis ever written, that simple telegraph switching relays can implement, by means of their different interconnections, the whole Boolean algebra."[••°]

Also in 1937, Alan Turing (1912–1954) built a Boolean logic multiplier and proposed a theory of computability in his essay on the "Entscheidungsproblem" [decision problem].[•••] The paper had already been written the previous year while he was working on his well-known Turing machine, which was not a physically existing computer, but a mathematical model of computation. With his multiplier based on Boolean logic, Turing tried "to embody the logical design of a Turing machine in a network of relay-operated switches",[•°°°] which served as a basis for creating the multiplier.

Soon after, from the 1940s with the appearance of electronically powered computers, different programming languages were designed and assembler (asm) was one of the first. This low-level programming language can be converted into executable machine code in one step, as there is a very strong correspondence between the language and the machine code. From the 1950s onward high-level programming languages started to replace their "low" antecedents. Dozens of programming languages have been written and developed, starting with ALGOL (ALGOrithmic Language), then Fortran, Pascal, C++, Java, and Python, to name just a few. "This postmodern Tower of Babel reaches from simple operation codes whose linguistic extension is still hardware configuration, passing through an assembler whose extension is this very opcode, up to high-level programming

[••] L. F. Menabrea, Sketch of the Analytical Engine Invented by Charles Babbage, trans. Ada Lovelace (London: printed by Richard and John E. Taylor, 1843), 696–97.

[••°] See George Boole, The Mathematical Analysis of Logic: Being an Essay Towards a Calculus of Deductive Reasoning (Cambridge: Macmillan, 1847).

[•°•] See Paul J. Nahin, The Logician and the Engineer: How George Boole and Claude Shannon Created the Information Age (Princeton, NJ: Princeton University Press, 2013).

[•°°] Friedrich Kittler, "There Is No Software," Stanford Literature Review 9, no. 1 (Spring 1992): 81–90, here 88.

[•••] See Alan Turing, "On Computable Numbers, with an Application to the Entscheidungsproblem," Proceedings of the London Mathematical Society 42, ser.: 2, no. 1 (January 1937): 230–65.

[•°°°] Andrew Hodges, Alan Turing: The Enigma (Princeton, NJ: Princeton University Press, 2014), 177.

[••°•] Kittler, There Is No Software, 82.

languages whose extension is that very assembler." •°°• (#Babel)

All these languages are based on a binary number system, a sequence of "ons" and "offs" allowing electricity in the circuit to flow or stop. Despite the simplicity of their basic components, programming languages can describe exceedingly complex operations. The computing devices mentioned above all run with binary code, except Babbage's machines, which used the decimal system. Due to Shannon's work and the implementation

•°•° See Tim Cross, Vanishing point: "The rise of the invisible computer," The Guardian, January 26, 2017), https://www.theguardian.com/technology/2017/jan/26/vanishing-point-rise-invisible-computer.

•°•• Seth Lloyd, Programming the Universe: A Quantum Computer Scientist Takes on the Cosmos (New York: Vintage Books, 2007), 136–39.

•••° Ibid., 206.

#Encoding #MorseCode #ProgrammingSound #Algorithm #Software #Hardware #Interface #Decoding

From #GeneticCode (see correlating key area) to music notation, from communication systems for sensory impairments, such as sign language, to #MorseCode, from safety codes and standards to social rules of conduct, the term "code" may outwardly designate recognizable elements and familiar processes, but what does it mean in terms of #Programming (see key area #Labor&Production) and computing?

The *Dictionary of Computing* defines code as "a rule for transforming a message from one symbolic form (the source alphabet) into another (the target alphabet)." [°] Therefore, code could be seen as a set of instructions "that changes the input from one state to another, and as a consequence the code performs work." [•] This way of performing designates precisely one of its main characteristics: code is at the same time legible and executable; it is simultaneously a medium and an instruction. This essential virtue makes code different from common languages, which can be read or written but do not cause any changes by doing this per se. In that sense, computer code "is the first language that actually does what it says – it is a machine for converting meaning into action." [•°]

Another crucial aspect of computer code is its deceptive invisibility. Code is generally hidden; it lacks materiality in itself and remains mostly unseen inside the machine, but it generates visible, concrete, and tangible effects in the world. Taking a programmed sound work as an example, the different sounds or compositions would be the output, in other words, the result of one or many lines of code (#ProgrammingSound).

Similarly to code, the word #Algorithm is often associated with computing and programming, although the definition of algorithm, being a sequence of actions to be performed, could be applied for various procedures. An algorithm is a set of rules that specify how to solve a problem or perform a task. In that sense, a recipe or a manual of production could be understood as an algorithm, too. In computing, these sets of rules or steps are established in order to process data and, as we have already seen, produce an output.

Algorithms and code are also the invisible part, commonly summarized under the term #Software, which is "a generic term for those components of a computer system that are intangible rather than physical." [••] By contrast, #Hardware is the compilation of physical components that form a computer system like, for example, the mainboard. In order that software and hardware can exchange information, a third element is needed, the #Interface, which also can be the link between software, hardware, and humans. To understand how this exchange works, we only have to think about a "power" button: the button is, namely, the interface between you and the electrical wiring behind the machine. You press it and the machine turns on and off.

Even in common, ordinary applications such as sending an SMS, code executes an extremely high number of algorithmic operations. In computers, #Encoding is the process in which a sequence of characters is transformed into a specific format for efficient transmission or storage. In order to convert an encoded format back into the original sequence of characters, the opposite process, called #Decoding, would be necessary. Both processes are commonly used in data communications, networking, and storage, and especially with regard to wireless communications systems. By running these and other processes, code nowadays has the capacity to process and control many different operations within seconds, shaping and creating new horizons for social, economic, or cultural activity.

[°] Andrew Butterfield and Gerard Ekembe Ngondi, A Dictionary of Computer Science, 7 ed. (Oxford: Oxford University Press, 2016), 93.

[•] Rob Kitchin and Martin Dodge, Code/Space: Software and Everyday Life (Cambridge, MA: The MIT Press, 2011), 25.

[•°] Alexander R. Galloway, Protocol: How Control Exists after Decentralization (Cambridge, MA: The MIT Press, 2004), 166.

[••] Susan M. Hockey, A Dictionary of Computing, 2 ed. (Oxford: Oxford University Press, 1986), 352.

#MachineLearning #ArtificialIntelligence #Cybernetics #PatternRecognition #AutonomousSystems #SelfDrivingCars #Drones #Robots

In computer science #ArtificialIntelligence (AI) determines the study of intelligent agents investigating forms of mechanical or "formal" reasoning. AI was founded on the idea that a machine can precisely simulate human intelligence. Alan Turing's theory of computation suggested that it was possible to represent logical operations by modifying simple symbols such as 0 and 1. Turing assumed that reasoning was to be seen as distinctive sequences of mechanical operations based on cause and effect – in other words, discrete sequences of logical steps based on a set of rules (#Algorithms, see key area #Encoding). [°] What came to be known as the classical symbolic approach to AI considers machine cognition as rule-governed manipulation of formal symbols with a centralized control mechanism. It was the attempt to hand code knowledge about the world in formal mathematical language. This approach was successful for so-called expert systems, which were able to carry out complex tasks, such as medical diagnosis, or planning and configuration at the level of human experts. However, they proved difficult to program since one simple error sometimes caused the whole system to fail. But most importantly the systems were not able to inherently learn. [•] By 1980 the approach was no longer pursued as it became clear that a mere simulation of thought does not amount to real understanding; therefore, that syntactic manipulation of symbols does not suffice for cognition. [•°]

A more flexible and adaptive approach to machine cognition came from the field of neuroscience and #Cybernetics, where artificial intelligence was not treated in terms of rules and representations but as dynamic systems. Warren S. McCulloch and Walter Pitts' ground-breaking research was the first work that treated the brain as a computational apparatus. [••] Together with Donald O. Hebb's work on associative learning deriving from the firing of nodes that produce synaptic interrelations, [•°°] Frank Rosenblatt developed the foundation for machine learning. [•°•] #MachineLearning is a field of AI that explores forms of computation which allow programs to change and adjust its internal parameters automatically, that is, without hand engineering the algorithms, in order to process data. The algorithmic structure is constituted as an artificial neural network, whose reasoning is executed by thousands of neurons, arranged into hundreds of intricately interconnected layers breaking up causal relations. Neural computation is based on modelling an adaptive system that evolves through the capturing of environmental data, which is fed back into the system. [••°] Crucially, the networks' output constitutes an approximation, a statistical likelihood for the most probable outcome.

Since 2006, machine learning has made huge leaps forward as a consequence of a steady increase in computational power coupled with the vast expansion of data capturing mechanisms and the enlargement of the physical IT infrastructure. [•••] In its practical application machine learning algorithms are heavily employed for #PatternRecognition; visual object recognition and object detection particularly relevant for #AutonomousSystems such as #SelfDrivingCars, #Drones, and #Robots. In essence, machine learning reconstitutes what thinking means and raises many ethical and legal questions with regard to automated decision-making, machine bias, liability, and accountability.

[°] See Alan Turing, "On Computable Numbers, with an Application to the Entscheidungsproblem," Proceedings of the London Mathematical Society 42, ser. 2 (January 1937): 230–65

[•] See David Davenport, "The Two (Computational) Faces of AI," in Philosophy and Theory of Artificial Intelligence: Studies in Applied Philosophy, Epistemology and Rational Ethics, vol. 5, ed. Vincent C. Müller (Heidelberg: Springer, 2013), 43–58, here 44.

[•°] See John R. Searle, "Minds, Brains, and Programs," Behavioral and Brain Sciences 3, no. 3 (September 1980): 417–24.

[••] Warren S. McCulloch and Walter Pitts, "A Logical Calculus of the Ideas Immanent in Nervous Activity," Bulletin of Mathematical Biophysics 5, no. 4 (December 1943): 115–33.

[•°°] See Donald O. Hebb, The Organization of Behavior: A Neuropsychological Theory (New York: Wiley, Chapman and Hall, 1949).

[•°•] Frank Rosenblatt, "The Perceptron: A Probabilistic Model for Information Storage and Organization in the Brain," Psychological Review 65, no. 6 (1958): 386–408.

[••°] See Yann LeCun, Yoshua Bengio, and Geoffrey Hinton, "Deep Learning," in Nature 521, (May 2015): 436–44.

[•••] See Geoffrey E. Hinton, Simon Osindero, and Yee-Whye Teh, "A Fast Learning Algorithm for Deep Belief Nets," Neural Computation 18, no. 7 (July 2006): 1527–54.

#AlgorithmicGovernance #BigData #QuantifiedSelf

Governance refers to a process of governing – the way in which norms, laws, and actions are structured, sustained, and held accountable, whether undertaken by the government, society, or the market economy. Essentially, governance involves the practice in which societies are organized, the logic or language of regulation. Hence governance also implies a way of exercising power over someone or something. ° #AlgorithmicGovernance explores the formal and informal rules of organizing the living through #Algorithms (see key area #Encoding). Algorithmic Governance refers to a form of *soft power* that interrupts habits and reorients action potentials. It is a producing force that generates the particular behavior that comes to the surface next; a force that acts before the behavior takes shape. • As such algorithmic governance offers a radically different form of managing all aspects of human life, be it socially, politically, economically, or environmentally. It raises immanent questions of how algorithmic processing should be regulated and legislated.

Underlying new forms of governance is the way in which data is gathered and analyzed in order to ascribe value. The last decade has seen an explosion in the amount of data that is being captured and processed in real time. Our environment is increasingly encoded (see key area #Encoding), rendered machine-readable, uniquely indexical, and identifiable by the vast assemblage of connected devices and sensors. Daily life is becoming more and more mediated by digital devices and facilitated by computational infrastructure. The #BigData undertaking strives at capturing society as a whole, the entirety of the population and its activities •° The endeavor of data collection and the quantification of the self (#QuantifiedSelf) is underpinned by the intention to produce sophisticated statistical models that characterize, simulate, and predict human life. The key to assembling all this data is the way in which information is correlated – the processing of data through various kinds of statistical analysis and #MachineLearning algorithms (see key area #ArtificialIntelligence & #MachineLearning) – which detect patterns and connections between pieces of data.

In consequence, governance seems to have turned into a struggle of *how* data is evaluated and *by whom*. Essentially, what the correlation of data allows for is the assemblage of profiles for individuals and groups of people to determine so-called normal behavior and distinguish the abnormal. Individuals are thereby turned into "dividuals," numerical bodies of code comprised of data assemblages. •• On the basis of these profiles governments and businesses implement their agendas. Whereas the latter adopt strategies to realize capital accumulation that will produce significant profits, the concern of the former is state security. With increasingly invasive means of profiling, companies seek on the one hand to personalize customer experiences through micromarketing of products. The state on the other hand gathers intelligence in line with new technologies connected with the preemption of crime. In both cases powerful algorithms in combination with predictive analytics are employed to conditions of life's nextness. Control is exercised subtly, making it seem as if the dividual is acting autonomously, yet it lacks the ability to make decisions of its own volition.

° See Isabell Lorey, States of Insecurity: Government of the Precarious (London: Verso, 2015), 23ff.

• See Luciana Parisi, Contagious Architecture: Computation, Aesthetics, and Space (Cambridge, MA: The MIT Press, 2013), 169ff.

•° See Rob Kitchin, The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences (Los Angeles: Sage Publications, 2014), 67ff.

•• Gilles Deleuze, "Postscript on the Societies of Control," October 59 (Winter 1992): 3–7.

#Labor&Production #Industry4.0 #InternetOfThings #Programming #SmartFactories #Automation #Work4.0

The desire for on demand goods and services, customized to one's personal tastes and available 24–7, is steadily increasing. It is a phenomenon of the digital economy, a business model that cuts across sectors – including manufacturing, services, transportation, and telecommunications – which is heavily reliant on information technology. ° This model is reshaping the organization and management of the entire value chain of consumer goods and putting in place a new infrastructure. What makes this business model possible is the real-time networking of products, processes, and infrastructure, as well as related customer services via the Internet. This enables rigid value chains to be transformed into highly flexible value networks.

The approach has been termed #Industry4.0 and is deemed to constitute a fourth industrial revolution. It is characterized by its interoperable design where machines, devices, sensors, and people are connected and can exchange relevant information in real time over the #InternetOfThings (IOT). This transparency enables dynamic, efficient production processes that can be optimized on the basis of different criteria such as cost, availability, and resource consumption. Software and machines operate autonomously and do not require complicated #Programming to meet new requirements, which makes it possible to react fast to individual customer requests. Individual parts of the chain "know" what they are, where they belong, how they need to proceed, and can interact with the production plant. The plant then decides by itself what should be done in accordance with priority and time frame. In these modular structured #SmartFactories the implemented software recognizes defects or mistakes at an early stage and is able to counteract them. •

° See Nick Srnicek, Platform Capitalism (Cambridge, UK: Polity Press, 2017), 4–5.

• See Bundesministerium für Wirtschaft und Energie, Industrie 4.0 und Digitale Wirtschaft: Impulse für Wachstum, Beschäftigung und Innovation (Berlin: Bundesministerium für Wirtschaft und Energie, 2015).

Industry 4.0 is as yet a developing process. To work successfully, it will require a great deal of standardization and uniformity on an international scale. New forms of cooperation between companies across sectors both nationally and globally need to be created. The smart factory's highly flexible value networks call for the harmonization of #Interfaces (see key area #Encoding); that is, a reference architecture, a set of uniform definitions and methods. It necessitates a common structure and language for standardized description and specification of systems. Industry 4.0 brings many challenges to IT and data security, which can compromise the integrity of production processes. Similarly, it raises legal issues that need regulation, concerning data protection (corporate, employee, and consumer) and liability for automated systems. •°

However, the greatest transformation that the new business models bring with them is the way in which labor is organized. Routine and low-skill jobs are increasingly threatened by #Automation, for they are being taken on by intelligent machines and #Robots (see key area #MachineLearning). Employees are obliged to acquire a much broader range of skills which allow them to take action and make decisions that #Algorithms (see key area #Encoding) cannot. Considering these changing dynamics of labor, employees will need to be trained and qualified for new roles, be more flexible and mobile. This transformation has been termed #Work4.0. •• In this economy knowledge is the key resource in which everything is geared towards innovation. The changeover from a labor-based society to a knowledge society is imminent. Fewer people will be top wage earners, fewer people will have less (routine) work to do, and fewer people will do more (highly technical and highly qualified) work. Knowledge and know-how will be the new gold, the new oil. At one end of the spectrum, the workplace increasingly adapts to more flexible and dynamic structures that cater to individual needs in order to harness creativity. Yet only the top-end workers receive these benefits as well as profit from healthy and family-friendly working arrangements. The other end of the spectrum may resemble the manual labor factories for software engineering similar to the Silicon Valley accelerators.

•° See Bundesministerium für Bildung und Forschung, Zukunftsbild Industrie 4.0 (Berlin: Bundesministerium für Bildung und Forschung, 2015).

•• See Ned Rossiter, Software, Infrastructure, Labor: A Media Theory of Logistical Nightmares (New York: Routledge, 2016), 109.

#AlgorithmicEconomy #HighFrequencyTrading #Bitcoin #Cryptocurrencies #Decrypt #Blockchain

In a world where everything is becoming digital (our way of communication, our advertising, our leisure and workplaces), it was only a matter of time before money could be generated in a digital way. Banks and markets have been operating for decades using computerized algorithms and many customers have had digital access to their money for some time now. However, the matter at hand – #AlgorithmicEconomy – is more extensive and complex. Which impacts has the implementation of code had in our globalized economy? Which systems have appeared – or will appear in the future?

One of the first concepts that emerges when talking about the combination of economics, mathematics, and computer science is algorithmic trading, a practice widely used by investment banks and pension funds that utilize automated preprogrammed instructions to make decisions and execute transactions in the financial markets. This means that nowadays #Algorithms (see key area #Encoding) drive a great number of stock trades. Many systems of these automated activities fall into the category of #HighFrequencyTrading (HFT), which is characterized by such high speeds that a human could never carry them out in the same time nor even close to it.

As an alternative to this hegemonic system and its financialization, a new digital currency called #Bitcoin was released online in 2009, followed by many other digital cash currencies, such as Ethereum or Litecoin. But what makes #Cryptocurrencies different from traditional currencies? As its name implies, they are based on a cryptographic system, ° which means that the code behind them is elaborated on a system that keeps information secret. Only the people – or more precisely, the programs – that know how to solve it, how to #Decrypt it, will have access to this information. Cryptocurrencies are also immaterial and decentralized. Unlike centralized banking, where governments control the currency values through the process of printing money, governments have no control over cryptocurrencies: their value circulates on the Internet without the regulating involvement of any intermediaries.

To understand the correlations, one has to look at the #Blockchain, the system behind cryptocurrencies. Blockchain is an open database that, in this case, stores a history of financial transactions. Single blocks contain various transactions, each of which is linked to a previous record in the chain. When someone purchases something with Bitcoins, a request in the form of a cryptographic puzzle is sent to and received by all the computers – known as miners – on the Bitcoin peer-to-peer network. When a miner solves a puzzle, a new block is added to the chain and it is rewarded with some Bitcoins. But earning Bitcoins is not the only point of mining: the puzzles are so complex that every new block makes the previous ones and the whole chain a safer environment. Hacking the block-chain would require immense speed to alter just one transaction. With many miners adding blocks continuously, a vast amount of computing power would be needed.

Like other disruptive technologies born in the digital age, cryptocurrencies are challenging the way things have been done in economics so far, foreseeing a future in which middlemen would become obsolete. In a world run by blockchain technologies, new tools for business strategies and managing transfers would be developed, shifting "the control of money and information away from the powerful elites [...] to the people to whom it belongs." • While many people argue that these models will disrupt the centralized economic and political establishments, others say that they will severely impact our job market and only benefit those in the upper echelons of the workforce. It is not possible to predict the future, but to understand the world we live in and the economy we are building, we necessarily need to recognize and analyze the power of algorithms and computation.

° The term cryptography derives from Greek κρυπτός, kryptós, which means "hidden" or "secret," and γράφειν, graphein, Greek for "writing." See Henry George Liddell and Robert Scott, A Greek-English Lexicon (Oxford University Press, 1984).

• Paul Vigna and Michael J. Casey, The Age of Cryptocurrency: How Bitcoin and Blockchain are Challenging the Global Economic Order (New York: St. Martin's Press, 2015), 6.

#VirtualReality #HMD #ComputerSimulatedEnvironments #AugmentedReality #ComputerGeneratedDesign #Escapism

To understand the significance of *virtual* and *virtual reality* (#VirtualReality) in the present context let us take a closer look at the rise of current usages of the term. Virtual Reality (VR) is understood here as a technical term, a medium which reproduces the experience of a space for viewers, including the impression of *being there*, especially when other visual stimuli are blocked out (for example, by head-mounted displays, #HMDs). To understand the impact of what is virtual on our vision let us first look at the etymology and definitions of the term. The adjective virtual derives from strength, virtue. A virtual entity possesses a power of acting without the agency of matter. Since the term has been used in the context of computer technology the meaning relating to #ComputerSimulatedEnvironments has been added to most dictionary definitions as follows: simulated on a computer or computer network, or existing within a virtual reality. °

Thus we can conclude that "the virtual is a substitute – 'acting without agency of matter' – an immaterial proxy for the material. The term becomes a key marker of a secondary order in the relationship between the real and its copy, the original and its reproduction, the image and its likeness." •

In philosophy Henri Bergson, Gilles Deleuze, Félix Guattari, and Pierre Lévy all developed various concepts of the virtual. Bergson describes the immateriality of memory as *virtual*. •° For Deleuze *virtual* is not opposed to real, but to actual – in this understanding *virtual* is a mode of reality. •• Guattari describes virtual as one of "four ontological functors" •°° – the virtual, the actual, the real, and the possible.

The term virtual reality is relatively recent and was probably coined by Antonin Artaud in his book *The Theatre and Its Double*, first published in French in 1938. •°• Our current understanding of VR does not coincide with Artaud's usage of the term; the meaning has shifted over the last decades, and now the term is predominantly used for computer-aided interactive and immersive environments, together with #AugmentedReality, that are accessed via screened images and in many cases additional devices (such as HMDs).

Artists and engineers began to experiment with the medium and contributed to its development of #ComputerGeneratedDesign. Especially in the 1990s applications and artistic experiments using VR proliferated and resulted in artworks. Although at that time the technology was not sufficiently developed for wider usage, with the wider availability of the hardware and various software for it, in the last few years more and more artists have started to work with VR as a medium.

The medium offers complete visual immersion; it not only opens a window, as framed images do, as Leon Battista Alberti claims in his treatise *On Painting* (1435), it drags the viewer in, literally opening up a reality to reflections on spatial affairs.

Besides art, VR is widely used by the gaming industry and other forms of entertainment, such as virtual cinema. In medicine the technology is already widespread. Virtual models help surgeons, for example, to identify the safest and most efficient way to locate tumors and place surgical incisions. Psychologists and other medical professionals are using VR to enhance traditional therapy methods and find effective solutions for treatment of posttraumatic stress disorder (PTSD), anxiety, and social disorders. Real estate businesses and architects accompany their possible tenants or building contractors on walk-throughs of as yet nonexistent buildings.

VR technologies are becoming ubiquitous, not only because of the supreme #Escapism the medium offers, but also because of its practical and commercial potentials.

° See Merriam Webster, Webster's Third New International Dictionary, Unabridged (Cologne: Könemann, 1993).

• Anne Friedberg, The Virtual Window: From Alberti to Microsoft (Cambridge, MA: The MIT Press, 2006). 8.

•° See Henri Bergson, Materie und Gedächtnis: Eine Abhandlung über die Beziehung zwischen Körper und Geist, introduction by Erik Oger, trans. Julius Frankenberger (Hamburg: Verlag Felix Meiner, 1991), 127.

•• Manuel DeLanda provides a comprehensive explanation of the process that Deleuze calls counter-actualization (moving from the actual to the virtual); see Manuel DeLanda, Intensive Science and Virtual Philosophy (London: Continuum, 2002).

•°° Felix Guattari, Chaosmosis: An Ethico-aesthetic Paradigm, trans. Paul Bains and Julian Pefanis (Bloomington: Indiana University Press, 1995).

•°• See Antonin Artaud, The Theater and Its Double, trans. Mary C. Richards (New York: Grove Press, 1958), 49.

#GeneticCode
#DNA #SourceCode #Bioengineering
#Phenotype #DNADataStorage #Genotype

#DNA (deoxyribonucleic acid) is known to contain the #SourceCode. #GeneticCode is the set of rules by which information encoded within genetic material (DNA or mRNA sequences) is translated into proteins by living cells.

The description of genetic code began in the 1950s. By the end of the 1960s it was clear that the genetic information in DNA, a macromolecule forming a double helix, is made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). At this time the central dogma of molecular biology became that DNA contains the code for the construction of proteins that catalytically and structurally "execute" life. °

The metaphors and phrasing used in molecular biology were strongly influenced by #Cybernetics (see key area #ArtificialIntelligence & #MachineLearning) and information theory that became influential in the late 1940s and 1950s, exactly when genetics started to spread its wings. •

DNA and RNA were called "informational molecules" or "tapes" governed by the rules of information processing. •° Genetic code was also compared to a computer program, for example, "organs, cells and molecules are united by a communication network." ••

To decipher the code of the biological "Book of Life," was a central issue in molecular biology, and researchers were racing to crack it. The Human Genome Project (HGP, 1990–2003) was an international scientific endeavor with the goal of determining human #Genotype •°°, the sequence of nucleotide base pairs that make up human DNA.

The developments in molecular biology facilitated new fields of engineering. #Bioengineering "is the manipulation of an organism to produce non-native molecules (such as drugs or proteins)." •°• Recombinant DNA technology, a method originally invented by Stanley N. Cohen and Herbert Boyer in the 1970s to insert human DNA into bacteria to produce a recombinant version of insulin for the treatment of diabetes, is the key for this discipline. The latest developments in the field are genome editing methods; CRISPR/Cas9 recently got the most publicity. Genome editing allows researchers to modify any genomes, including human, with wide application possibilities. ••° The method, just like genetic engineering in general, raises ethical questions.

It has been recently discovered that DNA molecules can store any data (#DNADataStorage). Textual and visual information, even moving images, can be converted to binary then to genetic code •••, which has allowed researchers to encode in a decodable way, for example, a series of frames from Eadweard Muybridge's Human and Animal Locomotion in bacterial DNA.

° Adrian Mackenzie and Theo Vurdubakis, "Codes and Codings in Crisis: Signification, Performativity and Excess," Theory, Culture & Society 28, no. 6 (2011): 3-23, here 7.

• See Lily E. Kay, Who Wrote the Book of Life: A History of Genetic Code (Stanford: Stanford University Press, 2000), esp. 73-127 (Chapter Three: Production of Discourse: Cybernetics, Information, Life).

•° See Carl R. Woese, The Genetic Code: The Molecular Basis for Genetic Expression (New York: Harper & Row, 1967), 253-54.

•• François Jacob, The Logic of Life: A History of Heredity [1970], trans. Betty E. Spillmann (New York: Pantheon Books, 1973).

•°° #Genotype defines the genes within the organism, while #Phenotype describes its physical appearance.

••° Brandon Adkins, A Future Guide to Bioengineering, (Leipzig: Amazon Distribution, 2016), Kindle e-book, 5.

••• See Alex Reis, "CRISPR/Cas9 and Targeted Genome Editing: A New Era in Molecular Biology," NEB expressions, no. I (2014), https://www.neb.com/tools-and-resources/feature-articles/crispr-cas9-and-targeted-genome-editing-a-new-era-in-molecular-biology.

••• See Andy Extance, "How DNA Could Store All the World's Data?," Nature 537, no. 7618 (September 1, 2016): 22-24.

Genealogy

1614 — Wilhelm Schickard, a professor at the university of Tübingen, mentions the first mechanical four-species calculating machine.

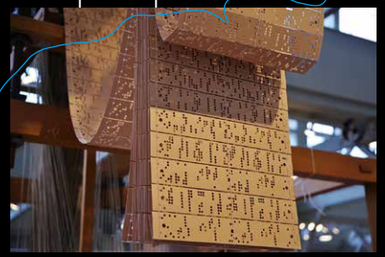
1623 — Gottfried Leibniz designs a calculating machine.

1642 — Blaise Pascal constructs a calculating machine.

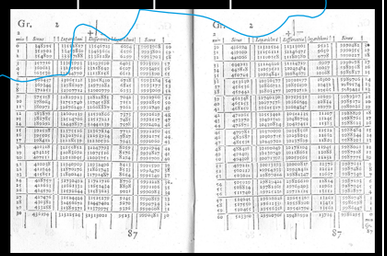
c. 1666 — Samuel Morland develops a calculating machine based not on decimals but rather the British currency system.

1673 — Charles Xavier Thomas de Colmar constructs the arithmometer, the first industrial calculator for the four elementary arithmetic operations to go into mass production.

1805 — Charles Babbage develops the difference engine, followed in 1833 by the analytical engine, but is unable to complete its construction because of a lack of funds.



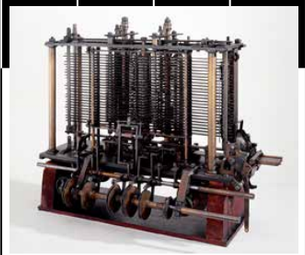
1820 — Joseph-Marie Jacquard develops punch cards to control the operation of looms.



1822 — John Napier publishes his table of logarithms.

1614 1623 1642 c. 1666 1673 1805 1820 1822

1614 1623 1623 1642 c. 1666 1673 1805 1901

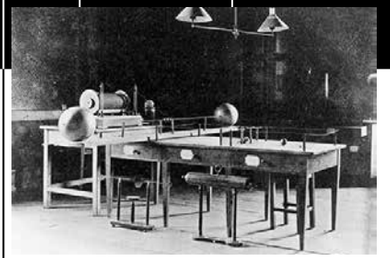


1623 — The first description of the analytical engine by Charles Babbage is published in On the Mathematical Powers of the Calculating Engine.

1642 — The first computer program, an algorithm to compute Bernoulli numbers for Babbage's analytical engine, is written by Ada Lovelace.

1805 — Boolean algebra is introduced by George Boole inThe Mathematical Analysis of Logic (1847), followed by An Investigation of the Laws of Thought (1854).

1820 — In Stockholm, Edvard and George Scheutz construct the first mechanical computer based upon Babbage's concept.



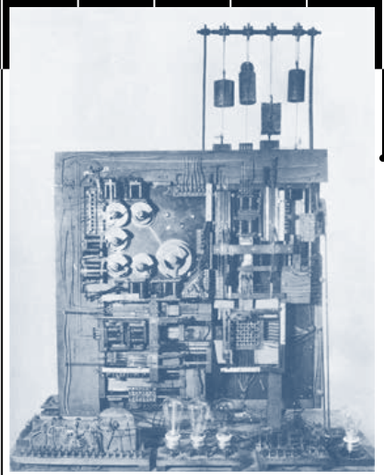
1673 — Heinrich Hertz provides the first proof of electromagnetic waves.

c. 1666 — The volume Begriffsschrift. Eine der arithmetischen nachgebildete Formelsprache des reinen Denkens [Begriffsschrift, a Formula Language, Modeled Upon That of Arithmetic, for Pure Thought] is published by Gottlob Frege.

1901 — Guglielmo Marconi makes the first transatlantic radio transmission of the letter "S" in Morse code.

1673 — The Hollerith tabulating machine consisting of a tabulating machine, a sorter, a card punch, and a punch card reader, is used by the US Census Bureau.

1910 1910–1913 1935 1936 1936 1937 1938 1941 1942 1614 1943 1943 1944 1944 1945 1945 1946 1944 1944–1948



El Ajedrecista [The Chess Player], one of the first autonomous machines capable of playing chess, is constructed by Leonardo Torres y Quevedo. The machine was designed for the end game of rook and king against the lone king.

Principia Mathematica by Bertrand Russell and Alfred North Whitehead is published in three volumes.

IBM (International Business Machines) launches the IBM 601, a punch card machine which can perform one multiplication per second. Approximately 1,500 machines are build.

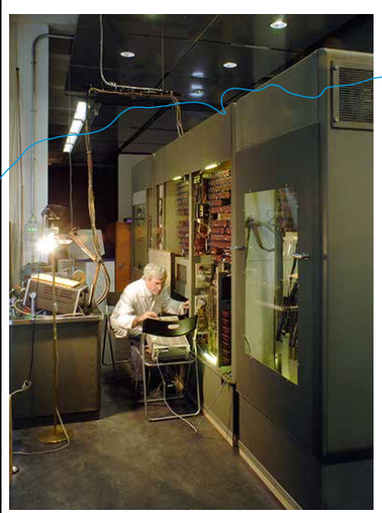
Claude Shannon introduces two-element Boolean algebra in his A Symbolic Analysis of Relay and Switching Circuits.

The Turing Machine, a mathematical model of computation described 1937 in On Computable Numbers, with an Application to the Entscheidungsproblem, is developed by Alan Turing.

Konrad Zuse registers two patents that already describe all the elements of so-called Von Neumann architecture.

John Vincent Atanasoff constructs the ABC computer, a non-programmable specialized computer, which could be regarded as the prototype for parallel processing.

Konrad Zuse completes work on the Zuse Z1, a freely programmable mechanical calculator that never became fully functional due to issues of precision in its engineering.



Konrad Zuse completes work on the Z3, the first functional, program controlled, binary computer comprising a large number of relays, which today is considered to be the first functional computer.

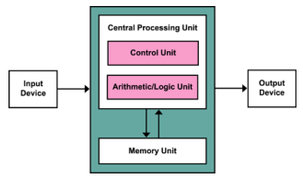
During the Second World War, Alan Turing provides the crucial clues to deciphering the ENIGMA codes, resulting in his construction of a specialized mechanical computer, which makes a significant contribution to the destruction of the German submarine fleet.

Tommy Flowers and his team at Bletchley Park complete work on the first Colossus.

A Logical Calculus of the Ideas Immanent in Nervous Activity concerning early mathematical neural networks by Warren S. McCulloch and Walter Pitts is published.

Reinhold Weber and his team complete work on a decryption engine for the US Army's M-209 encryption device.

The ASCC (Automatic Sequence Controlled Computer), called Mark I is constructed by Howard Hathaway Aiken.



The so-called von Neumann architecture (VNA), a reference model for an electronic digital computer, is described by John von Neumann.

Konrad Zuse completes work on the Z4.

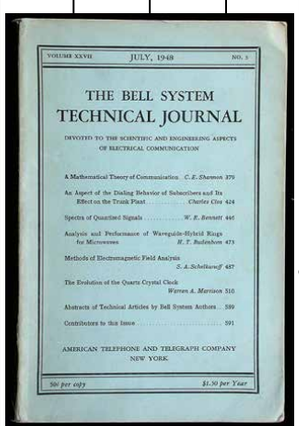
Plankalkül [Plan Calculus], the first real computer programming language designed for a computer is developed by Konrad Zuse.

Electronic Numerical Integrator and Computer (ENIAC) is developed under the supervision of John Presper Eckert and John Mauchly.

IBM constructs the Selective Sequence Electronic Calculator (SSEC).

1947 1948 1948 1949 1948–1950 1950 1951 1953 1955 1955 1956 1957 1958 1958 1958 1959 1959 1962 1963

Cybernetics: Or Control and Communication in the Animal and the Machine by Norbert Wiener is published.



Claude Shannon's A Mathematical Theory of Communication, a fundamental work on information theory, is published.

The transistor is invented by Herbert F. Mataré and Heinrich Welker and, at the same time, by William Bradford Shockley, Walter Houser Brattain and John Bardeen.

The Z4 goes into service at the university ETH Zurich.

The first Assembly languages are developed. Assembly code is converted into executable machine code by a utility program referred to as an assembler. Kathleen Booth and Nathaniel Rochester were the first computer programmers to develop an assembly language.

Maurice V. Wilkes and his team in Cambridge (UK) produce the EDSAC (Electronic Delay Storage Automatic Computer); based on von Neumann's architecture, it is the first computer with a fully programmable logic controller.

UNIVAC I, the first commercial vacuum tube computer is launched by the business machines manufacture Remington Rand.

The first version of the Mathematical FORmula TRANslating Systems (FORTRAN I), the first high-level programming language, is written. FORTRAN is especially suitable for application in science and engineering.

TRADIC, the first computer that is completely equipped with transistors instead of vacuum tubes is constructed by Bell Laboratories for the U.S. Air Force.

OPREMA, the German Democratic Republic's first computer appears.

IBM launches IBM 305 RAMAC, the first system using magnetic disk storage.

Bell 101 dataset, the first commercial modem for computers capable of transmitting digital data over regular unconditioned telephone lines, is released.

Frank Rosenblatt introduces Perceptron, a simplified artificial neural network.

Lisp is a family of programming languages developed by John McCarthy at the Massachusetts Institute of Technology (MIT). Historically, it is one of the most important programming languages for artificial intelligence research.

John W. Tuckey introduces the term software.

The IBM 1401 is introduced, a transistor-based computer including a punch card system.

DEC's (Digital Equipment Corporation) first minicomputer, the PDP-1 (Programmed Data Processor-1), appears.

J. C. R. Licklider is appointed head of ARPA (Advanced Research Projects Agency).

Ivan Sutherland develops the computer program Sketchpad, a precursor to computer-aided design (CAD) and a breakthrough in the field of graphic data processing.

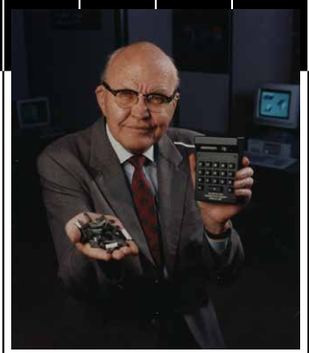
1965

DEC constructs the minicomputer PDP-8 for under $ 20,000.

1964

IBM develops the IBM System/360 (S/360) computer architecture, the first to enable computers of differing performance classes to execute the same code.

1964



Texas Instruments develops the first integrated circuit (IC).

1964

The programming language BASIC is developed at Dartmouth College by John G. Kemeny, Thomas E. Kurtz, and Mary Kenneth Keller.

1965

Ted Nelson coins the terms “hypertext” und “hypermedia.”

1966

Joseph Weizenbaum develops the computer program ELIZA, which demonstrates the processing of natural language by computer. It is regarded as a prototype for modern chatbots.

1961–1968

Ole-Johan Dahl and Kristen Nygaard from the Norwegian Computing Centre develop the computer language Simula (Simula I and Simula 67), the first object-orientated computer language.

1968

The exhibition Cybernetic Serendipity goes on display at the Institute of Contemporary Arts in London.

1968

Douglas Engelbart (Stanford Research Institute) presents the oN-Line System (NLS), instigating the use of a mouse to navigate data space.

1968

A conference sponsored by the NATO Science Committee addresses a software crisis and introduces the term “Software Engineering”.

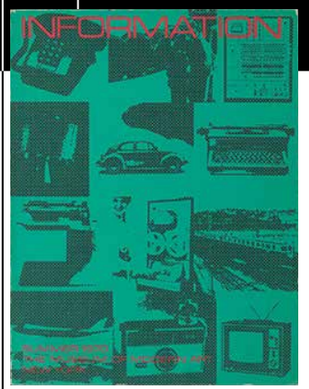
1969

ARPANET (Advanced Research Projects Agency Network) goes into service.

1970s

During the 1970s, Alan Kay and a team of scientists from Xerox PARC in Palo Alto, California, develop the GUI (graphical user interface), which simplifies working on computers, but also deepens disparities between application and programming, and between users and programmers.

1970

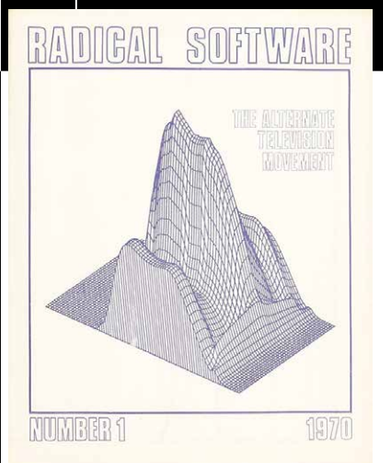


The exhibition Information goes on display at the Museum of Modern Art, Manhattan, New York City.

1970

The exhibition Software, Information Technology: Its New Meaning for Art goes on display at the Jewish Museum, Brooklyn, New York City.

1970

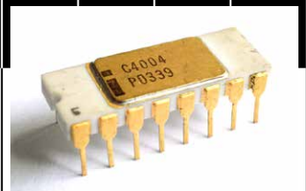


Under the editorial supervision of Ira Schneider, Phyllis Gershuny, and Beryl Korot the art magazine Radical Software starts publishing and continues until 1974.

1970

Winston W. Royce publishes Managing the Development of Large Software Systems.

1971 1972 1972 1972 1972 1973 1973 1973 1974 1974 1975 1977 1977 1970 1979 1980 1981 1981 1981 1982



The INTEL 4004, a 4-bit central processing unit co-invented by Ted Hoff, is the first Intel Corporation microprocessor to be launched.

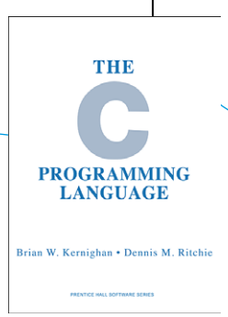
The ILLIAC IV, a supercomputer featuring array processors, goes into service.

The programming language Smalltalk is developed at the Learning Research Group (LRG) of Xerox PARC.

Xerox Alto, the first computer with a graphical user interface (GUI) is developed at the Xerox PARC (Palo Alto Research Center).

The Xerox Alto appears, the first computer with a mouse, GUI, and built-in Ethernet card.

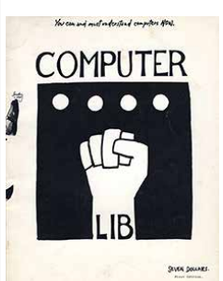
Motorola constructs the 6800 (MC6800) processor and Intel the Intel 8080 processor.



Dennis Ritchie (Bell Laboratories) develops the programming language C.

Alain Colmerauer (Aix-Marseille University) develops Prolog.

The first International Computer Art Festival takes place at The Kitchen, New York City.



Ted Nelson publishes the book Computer Lib / Dream Machines.

Microsoft is founded. The name is derived from the words microcomputer and software.

The Apple Computer Company launches the Apple I and Zilog develops the Z80 processor.

The Apple II, Commodore PET 2001, and Tandy TRS-80 Color Computer are launched.

Digital Equipment Corporation (DEC) launches the VAX-11/780, a computer specifically for virtual address processes.

The first Ars Electronica festival takes place in Linz, Austria.

IBM introduces the IBM-PC (personal computer) and in doing so crucially defines further developments.

The company Microsoft introduces the operating system MS-DOS, which they had developed on behalf of IBM.

John Warnock, Charles Geschke, Doug Brotz, Ed Taft and Bill Paxton develop the page description language PostScript (PS).

Barry W. Boehm proposes/ published Constructive Cost Model (COCOMO) as a software cost estimation model.

The IBM Personal Computer (IBM PC), model number 5150, with the MS-DOS (Microsoft Disk Operating System) operating system, from Microsoft, is launched on the US market.

1982

Intel launches the Intel 80286 processor.

1982

Sun Microsystems develops the UNIX computer workstation Sun-1.

1983

C++, an object-oriented extension of the C programming language, is developed by Bjarne Stroustrup.

1984

The first Apple Macintosh, Macintosh 128K, personal computer is launched, setting new standards for user friendliness.

1984

William Gibson coins the term “cyberspace” in his science fiction novel Neuromancer.

1985

The Free Software Foundation is founded in the USA by Richard M. Stallman (www.fsf.org).

This organization has been dedicated to promoting and distributing free software since 1984, particularly the GNU Project, a UNIX-based, non-proprietary operating system composed wholly of free software, the best-known variant of which, GNU anfd Linux (developed by Linus Torvald), has been running on a large number of computers since around 1993 with increasing success.

1985

Commodore International produces the personal computer Amiga.

1986

An article in the Wall Street Journal contributes to spreading both the concept and the term CASE (computer-aided software engineering).

1987

Intel introduced the processor Intel 80386 and 1987 Motorola released the processor Motorola 68030.

1989

Intel launches the processor Intel 80486.

1989

Tim Berners-Lee develops a global hypertext project: the World Wide Web, which is introduced worldwide on August 6, 1991.

1991

The first European Software Festival takes place in Munich.

1991

The first version of the Unicode Standard is published. Unicode is an international standard for consistent encoding representation and the handling of text for most of the world’s writing systems.

1991

The AIM alliance (Apple, IBM, Motorola) establishes specifications for the PowerPC architecture.

1992

DEC introduces the first system using a 64-bit Alpha processor.

1993

The first Next Five Minutes conference takes place in Amsterdam.

1993

NCSA Mosaic, developed by Marc Andreessen, the first graphical user interface for the World Wide Web is introduced.

1993

Intel launches the Intel Pentium processor.

1994

Leonard Adleman introduces the TT-100, the first prototype for a DNA computer.

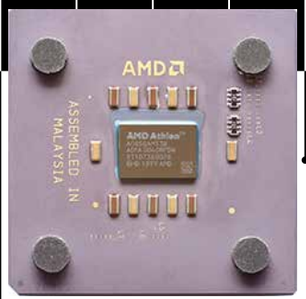
1995

The Java programming language for Internet applications, created by James Gosling is released. It enables the development of applications that can run on multiple platforms.

1997

The chess computer Deep Blue defeats Garry Kasparov, the reigning world chess champion.

1999 1999 1999 2000 2001 2001 2002 2003 1987 1989 1989 2003 1991 2004 2006 1993 1993

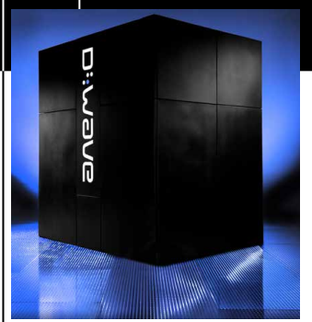


AMD introduces the successor to the K6 processor family, the Athlon.

IBM constructs the supercomputer ASCI White.

The Earth Simulator by NEC Corporation goes into operation.

Publication Software Art. Eine Reportage über den Code appears, published by Künstlerhaus Bethanien and Media Arts Lab, Berlin.



D-Wave One, the first commercially available quantum computer is announced.

More than 30 million websites are registered globally, compared to just 5 million in 1998.

The exhibition net_condition. Kunst / Politik im Online-Universum goes on display at ZKM | Karlsruhe.

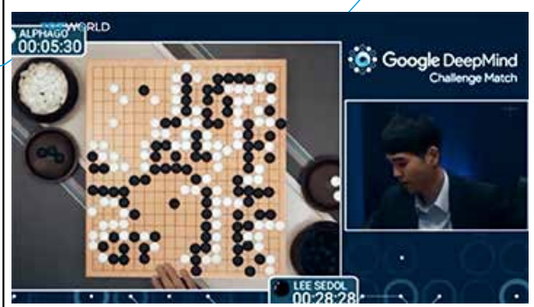
The transmediale festival in Berlin awards a prize for software art for the first time.

Apple launches the Power Mac G5, the first computer aimed at the general public to include 64-bit processors.

AMD introduces the Opteron and the Athlon 64, their first 64-bit processors.

The conference Programmation orientée art is organized in Paris at the Université Paris 1 Panthéon-Sorbonne.

A Fast Learning Algorithm for Deep Belief Nets by Geoffrey E. Hinton, Simon Osindero, and Yee-Whye Teh is published in the journal Neural Computation.



A computer defeats a professional Go player for the first time.

Intel constructs the supercomputer ASCI Red comprising 9,472 processors.

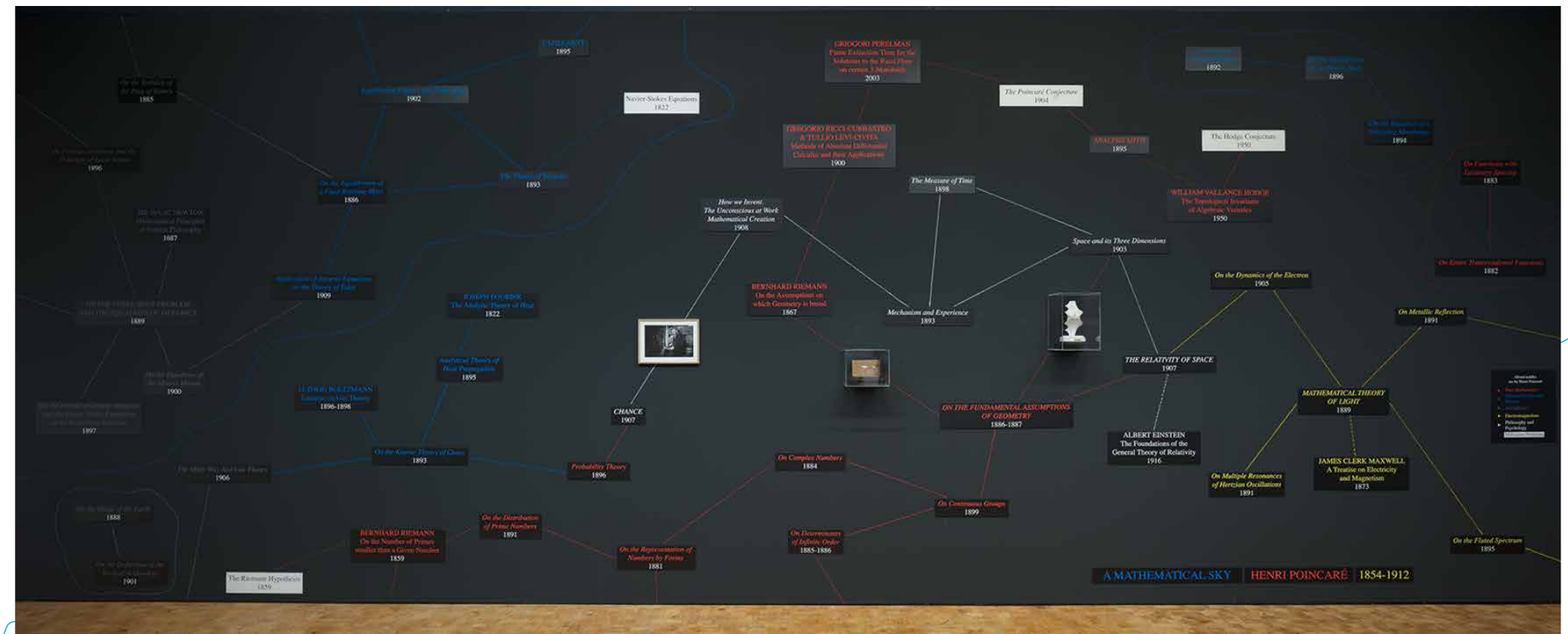
OPEN CODES. LIVING IN DIGITAL WORLDS

Works in the exhibition

A Mathematical Sky – Henri Poincaré

Installation on the wall
and 2 mathematical models
2011

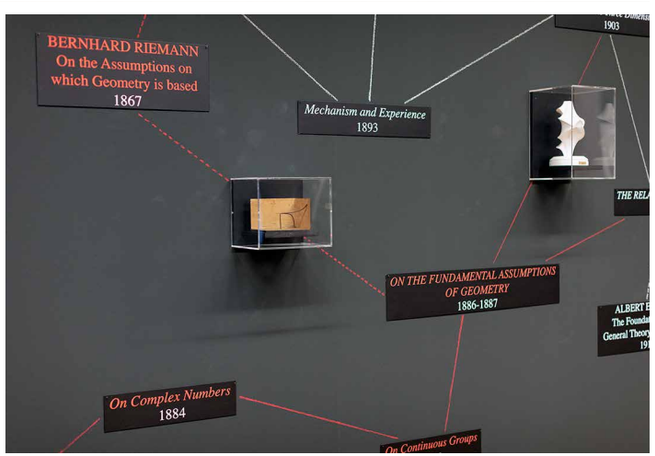
Jean-Michel Alberola



Henri Poincaré's main scientific works, and also important scientific findings, theories from the field of mathematics and physics, which influenced Poincaré and shaped Western mathematics and physics in the late nineteenth and early twentieth centuries, are represented on this "celestial map." The "stars" are linked to each other by lines, representing the relations between these theories.

Henri Poincaré (1854–1912) made numerous contributions to the field of mathematics, physics, and philosophy. He is often described as the last universalist in mathematics. Much of his research involved interactions between different mathematical topics, and his broad understanding of the whole spectrum of knowledge allowed him to attack problems from many different angles. He also wrote many popular scientific publications including *The Value of Science* (1905) in which he deals particularly with the relationship between intuition and logic.

Clearly it is not only the scientific achievements that make Poincaré's work important, but also his approach to science, which has widely influenced the way that logic and intuition are perceived. Two terms, which are crucially important, and are still in conflict in today's computing.



Material Speculations

2

3-D printed plastic resin and electronic components, 22.2 × 20.3 × 6.4 cm, edition of 3 Courtesy of Upfor Gallery, Portland
2015 / 2017

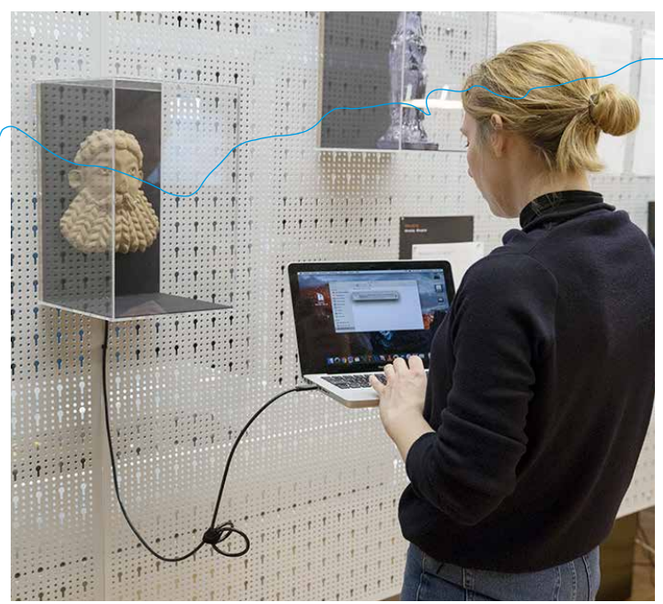
Morehshin Allahyari

#Encoding
#AlgorithmicGovernance
#Decoding

ISIS is a 3-D modeling and 3-D printing project focused on the reconstruction of twelve selected original artifacts (statues from the ancient city of Hatra and Assyrian artifacts from Nineveh) that were destroyed by ISIS (now referred to as ISIL) in 2015. The project creates a practical and political possibility for artifact archival, while also proposing 3-D printing technology as a tool both for resistance and documentation. It intends to use 3-D printing as a process for repairing history and memory.

The project goes beyond metaphoric gestures and digital and material forms of the artifacts by including a flash drive and a memory card inside the body of each 3-D printed object. Like time capsules, each object is sealed and kept for future civilizations. The information in these flash drives, encrypted in binary code, includes images, maps, PDFs, and videos on the artifacts and sites gathered in the last months before they were destroyed.

The reconstruction of Lamassu's and Ebu's sculpture is presented at ZKM together with a USB dead drop (entitled *South Ivan Human Heads: Bearded River God*), where visitors can download data related to the artifacts.



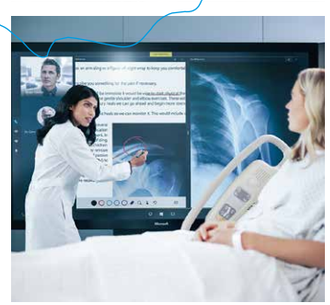
3

Presentation of ideas for modern and forward-looking IT workplace models Microsoft Surface Hub, Microsoft Studio, Microsoft Surface Book, Microsoft Hololens

#Labor&Production
#Programming
#Work4.0

AppSphere AG

Digitale Transformation. Die Kunst des modernen Arbeitslebens



AppSphere AG was far ahead of its time when it was founded in 2010. The company's stated goal was to establish modern styles of working at corporations and in medium-to-large companies. This is to enable companies to operate better on the market through increased efficiency, as well as to enable employees to perform their daily tasks with greater flexibility and less dependence on specific hours and locations. Achieving this requires modern technology so that the digital transformation away from the analogue and toward a modern office succeeds. Cloud computing, Internet access, and the adaptation of infrastructure and applications, as well as hardware such as the Microsoft Surface Hub for conferences that provide eye contact even across great distances and Microsoft Studio for digital design and sharing, are all components that help achieve this goal.

At the *OpenCodes* exhibition, AppSphere AG is presenting *Digitale Transformation. Die Kunst des modernen Arbeitslebens* [Digital transformation: The art of modern working life]. Visitors can get a sense of the new working environments that the digital transformation brings in its wake. These new workplaces also generate material for discussion: Does 24/7 availability bring people additional stress or does it make work easier? Do clear boundaries between work and the office make things easier or more difficult?

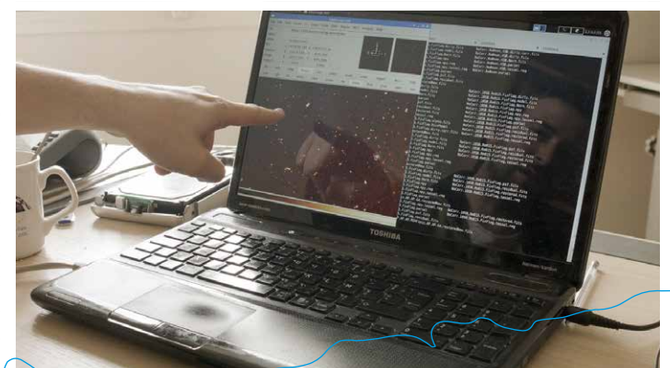
All We Know We Know from Light

HD video, color, sound, 45 min.
2017

4

Lisa Bergmann

#Encoding
#VirtualReality
#ComputerSimulatedEnvironments



All We Know We Know from Light is a documentary about scientific research and the beauty of abstract thought. The film engages with the subject of scientific knowledge gained by optical means; that is, through observations and through the analysis of images. Astrophysical research is based on the exploration of visual and acoustic phenomena. Electromagnetic radiation allows us to gather information on the composition of objects that are billions of light years away from the Earth. Astrophysicists work on the refinement of technical instruments to create precise images of as yet unknown objects, which turns the applied imaging techniques into constitutive tools that simultaneously explore and make their research object experienceable. In doing so, they are based on conventions of perception and practicability. The film offers insights into the way data is collected on the most abstract natural phenomena and how knowledge is thereby generated.

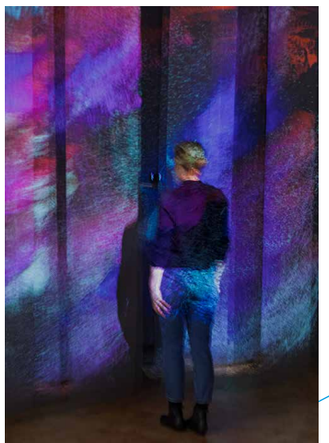
5

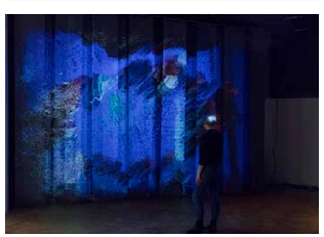
Interactive installation, camera, computer, software, mosquito nets
2017

Narzisstische Maschine

#Encoding
#QuantifiedSelf
#Algorithm
#PatternRecognition

Michael Bielicky
Kamila B. Richter





"Homo algorithmus" experiences today's reality like in a nineteenth-century fairground mirror maze. In the mirror maze visitors were confronted with multiple images of themselves seemingly reflecting into infinity; they had difficulties orientating in this imaginary space and finding the way out again. The digital space potentiates the mirror maze: perpetual searching and uploading of personalized content in social networks result in a far more complex multiple self-image in the digital space.

We follow our "image" and feel assured that we are indeed "we." We affirm ourselves in a modern mirror maze, lost in a selfie culture in which our self-image has entered a permanent relationship with algorithms.

Narzisstische Maschine [Narcissistic Machine] doubles the real reflected images of the visitors in a projection. It continues to multiply the real image algorithmically until visitors find themselves in front of an abstract, dynamic, exploding image: the true essence of narcissism is revealed as a desire that craves recognition and love in a cycle – love that will never be found in a disintegrated multiple mirror image of oneself.

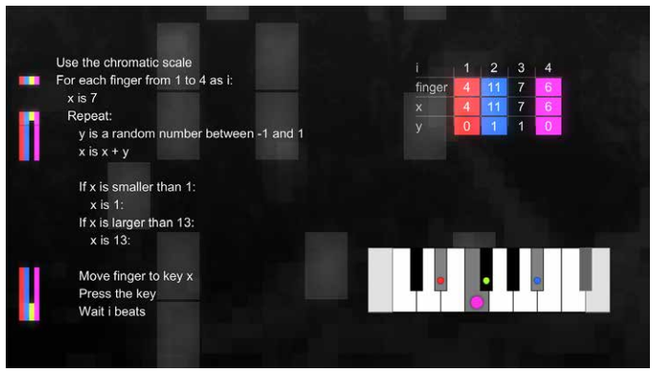
Notation. Prozess. Musik.

Video presentation
2017

6

Patrick Borgeat

#Encoding
#ProgrammingSound
#Interface



"Normally notes are points and lines on the two-dimensional surface of a piece of paper. The notation of the tone sequences is made up of signs on a surface. Nonetheless, these notes are interpreted as a temporal sequence, a chronological order. This is why music is considered the mother of all the time-based arts." °

In an algorithmic composition, the composers do not directly write a musical score, but rather describe a process with an outcome that can be heard directly. A musical notation can also emerge as an intermediary step, which is in turn interpreted by musicians. The tonal result of an algorithmic composition can be identical every time or can be completely different each time if it is influenced by the artists' chance decisions or interventions in the process it is running or by changing external factors. The music can also be stretched out temporally to become infinite through repetitions or jumps in the process description. The computer is the suitable instrument for implementing the algorithms. Understood as step-by-step instructions, however, the command sequences can also be handled by people much as cooking recipes are. Deft arrangement of the algorithms can enable highly complex tonal structures which in many cases were never anticipated when the algorithmic compositions were conceived – to emerge through just a few instructions

This idea is systematically taken further in live coding, with the composition process appearing onstage in this case. The algorithms are written and performed live and with frequent improvisation in the form of programming source texts. Those who are programming live enter into a dialogue with the audience and also with the process that is underway. Live coding should be understood not as a musical genre, but rather as a musical performance practice. The programmers determine the musical result, which can touch on every possible genre, from abstract noise music to jazz to electronic dance music, which is currently enjoying great popularity through the label Algorave. The idea that underlies live coding, however, is not limited to the purely auditory – visuals are also a popular medium for live coding.

Through a multi-channel video presentation of *Notation. Prozess. Musik.* [Notation. Process. Music.] on two walls facing each other at the *Open Codes* exhibition, an arc is traced from traditional notation to algorithmic composition to processual live coding by four renowned artists. Exhibition visitors can also make their own first attempts at live coding at an interactive station.

7

Performance documentation, Ditone archival pigment print, 150 × 200 cm Courtesy of NOME, Berlin
2017

Autonomous Trap 001

#MachineLearning
#Labour&Production
#SelfDrivingCars #Automation
#PatternRecognition

James Bridle

The photo shows a vehicle sitting in the middle of a parking lot surrounded by a salt circle, with Mount Parnassus in the background. The artist drew the circle as a trap for a self-driving car: the solid and dotted line form a "no entry" sign in 360 degrees. The vehicle, which relies on machine vision and processing to guide it, has been put under a spell by the materials of a magic ritual: it cannot leave the circle without breaking its own programming.

Self-driving cars are gradually becoming available to the public. Many vehicles have self-driving capabilities already; trucks on US highways and cabs in crowded cities such as Singapore will also have them soon. Bridle developed his own self-driving car, and in the process also created the satirical artwork *Autonomous Trap 001*. All the code developed for the DIY self-driving car is open source and available online.

Autonomous vehicles bring many developing technologies, such as machine vision and artificial intelligence, into contact with crucial social issues like the atomization and changing nature of labor. The salt trap is a sign of resistance, but also an attempt to define a shared space where both human and machine can converse.

CodeChain

Interactive sound installation, app, tablet PC
2017

8

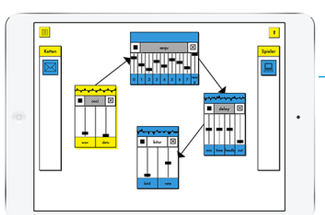
Ludger Brümmer
Elizabeth Pich

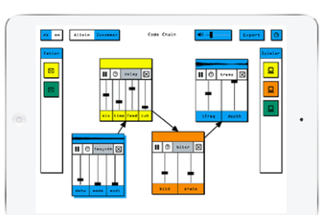
#Encoding
#ProgrammingSound
#Software
#Interface

Devices connected to each other enable chain processes involving several players. In CodeChain, sounds are generated according to the principle of the popular children's game "whisper down the lane" or "telephone," which are sent to other players and processed by them. Thus the players alter a sound step-by-step, and may change it until it bears no resemblance to the initial sound.

The chain begins with rushing sounds, various oscillators, frequency modulators, and own or prepared recordings, which users select via double click. The selected sound is sent to one of the devices in the pool, where a fellow player can add effects. Available effects are echoes and reverberations, delay, treble and bass filters, granular synthesis, and distortion. In addition the sounds can be formed into a melody with a sequencer. After the sound has had as many effects as desired added to it, it is sent to the next player. Each player changes the sound one more time. The sounds resulting from this process are therefore the result of a collective, partially random, partially deliberate process.

You can listen to all exported CodeChain sounds at codechain.zkm.de.





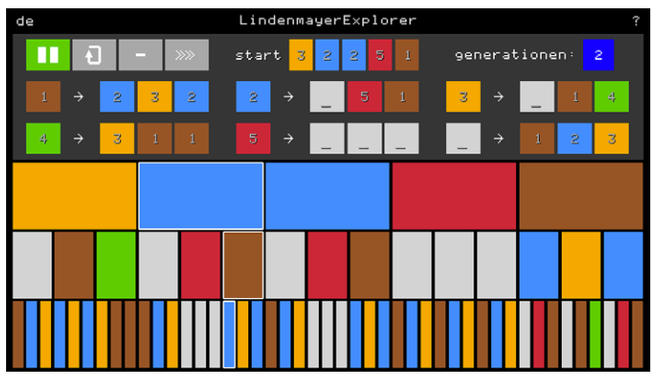
9

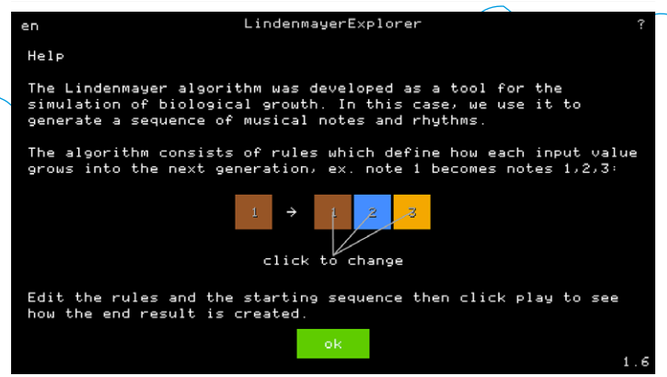
Interactive sound installation,
computer, monitor, mouse
2017

Lindenmayer Explorer

#Encoding
#ProgrammingSound
#Software
#Interface

Ludger Brümmer
Dan Wilcox





The *LindenmayerExplorer* is a program that generates sounds and rhythms by applying a Lindenmayer algorithm to sound notes. The Lindenmayer algorithm was developed as a tool to simulate biological growth. Through it, trees, bushes, and many plants can be artificially created and depicted: out of one tree trunk, for example, come three branches, and two or three new branches in turn grow out of these branches, etc. The algorithm is made up of the following rules: 1 → 1,2; 2 → 2,3; 3 → 3,1. These three rules can be applied to a number in that every time a 1 appears, it is replaced by a 1 and a 2. When a 2 appears, it is replaced by a 2 and a 3, and when a 3 appears it is replaced by a 3 and a 1.

1. Generation 1
2. Generation 1, 2
3. Generation 1, 2, 2, 3
4. Generation 1, 2, 2, 3, 2, 3, 3, 1 etc.

Interesting sound patterns can also be developed through Lindenmayer systems. Visitors can define the patterns themselves and experience what sequences of tones are created when they are applied.

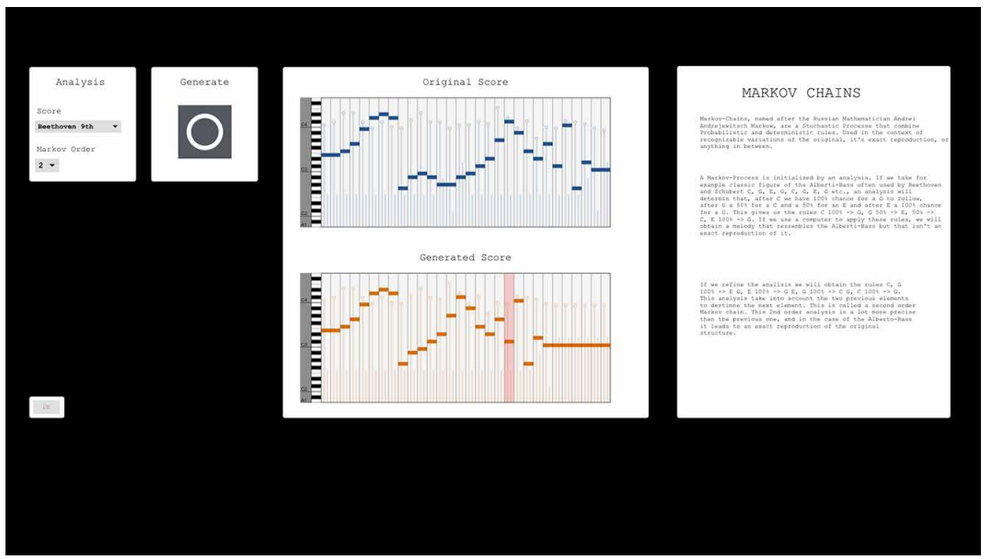
MarkowKetten Explorer

Interactive sound installation,
computer, mouse, monitor
2017

10

Ludger Brümmer
Benjamin Miller
Sami Chibane

#Encoding
#ProgrammingSound
#Software
#Interface



Markov chains, named after the Russian mathematician Andrey Markov, are stochastic processes that connect random and rule-based properties. Applied to music, this means that patterns or melodies that have been varied beyond recognition can be changed or even reproduced exactly.

A Markov process is initiated through an analysis. Take, for example the Alberti bass, an accompaniment figure in classical music that was used frequently by Beethoven and Schubert: following the pattern of C, G, E, G, C, G, E, G, etc., the analysis determines that there is a 100% chance that a C will be followed by a G, a 50% chance that a G will be followed by a C and a 50% chance that it will be followed by an E, and a 100% chance that an E will be followed by a G. This means that the rules are as follows:

C 100% → G
G 50% → C
G 50% → E
E 100% → G

If these rules are applied by a computer, a sound figure is created that is similar, but not identical, to the Alberti bass.

For a second-order Markov chain, the analysis is refined through a more precise description of the past.

C, G 100% → E
G, E 100% → G
E, G 100% → C
G, C 100% → G

This is significantly more precise than the simulation in the analysis above, and in the cases of the Alberti bass it leads to an exact reproduction of this structure.

In *MarkowKetten Explorer* [Markov Chain Explorer], visitors can input melodies and reproduce them roughly or identically by means of the rules analyzed. Through the juxtaposition of the original melody and the "reproduction" generated by applying the rules, it is possible to experience the operating principles of Markov chains acoustically.

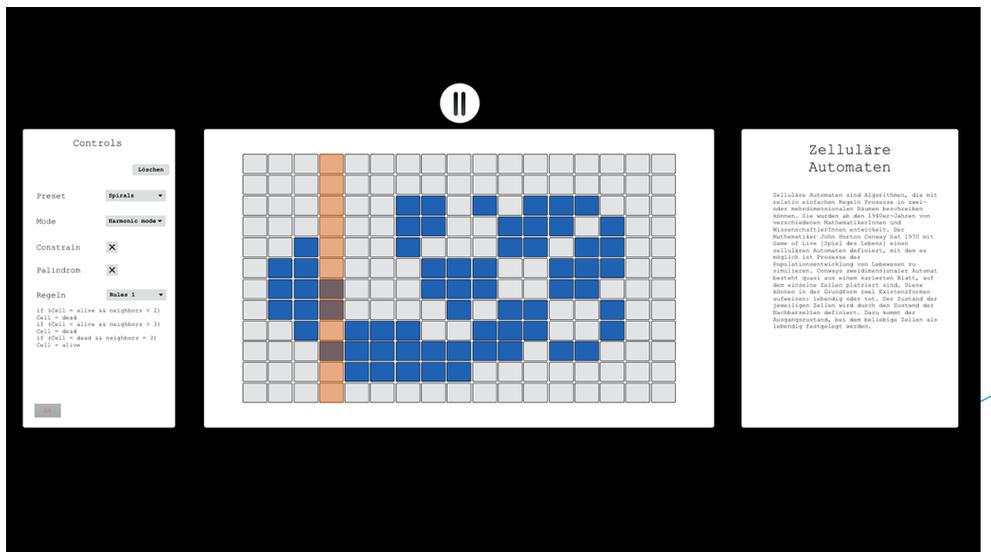
11

Interactive sound installation,
computer, monitor, mouse
2017

Cellular AutomataExplorer

#Encoding
#ProgrammingSound
#Software
#Interface

Ludger Brümmer
Benjamin Miller



Cellular automata are algorithms that can describe processes in the two- or three-dimensional space through relatively simple rules. They were developed by various mathematicians and scientists beginning in the 1940s. In his 1970 *Game of Life*, mathematician John Horton Conway defined a cellular automaton through which it is possible to simulate the processes of the development of populations of living beings. Conway's two-dimensional automaton is effectively comprised of graph paper on which individual cells are placed. In their basic form, these cells can exist in one of two forms: living or dead. The state of each cell is determined by the neighboring cells that surround it. There are also starting conditions, under which cells arbitrarily are defined as living or dead. Each of these cells then faces the following rules:

→ A dead cell with exactly three living neighboring cells will be reborn in the next generation.

→Living cells with fewer than two living neighbors die of loneliness in the next generation.

→ A living cell with two or three living neighbors remains alive in the next generation.

→ Living cells with more than three living neighbors die of overcrowding in the next generation.

Cellular automata can be used both for visual processes and for the development of sounds. With the *CellularAutomataExplorer*, visitors can alter the rules of cellular automata, triggering compositional processes.

MusiCode

Interactive sound installation,
computer, mouse, monitor
2017

12

Ludger Brümmer
Dan Wilcox

#Encoding
#ProgrammingSound
#Software
#Interface

Programming codes are made up of a series of instructions, which the computer processes in sequential order. These instructions can be used to generate tones, sound designs, and even entire works of music. This code also generates upward and downward movements or a random selection of tones.

A musical scale could be described as follows:

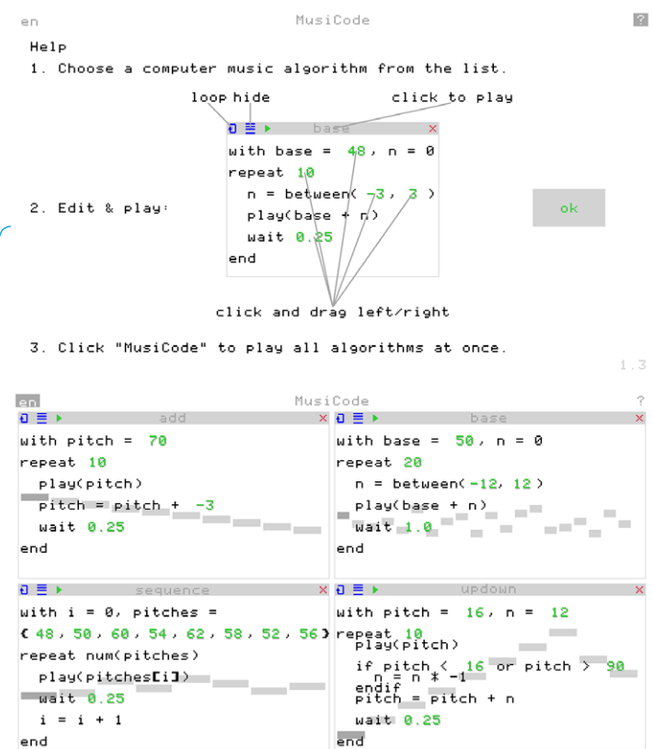
→ Start at 40 (that is, E2) with the time 0,

→ raise the tone by one step [y = x + 1], and jump 0.25 seconds forward,

→ carry out this procedure 20 times – finished.

Now the numbers can be changed or the + can be replaced by a –, changing the upward musical scale into a downward arpeggio.

Visitors to the *MusiCode* installation can play with different code fragments, changing them to create their own sound structures. Become a composer of computer music!



106

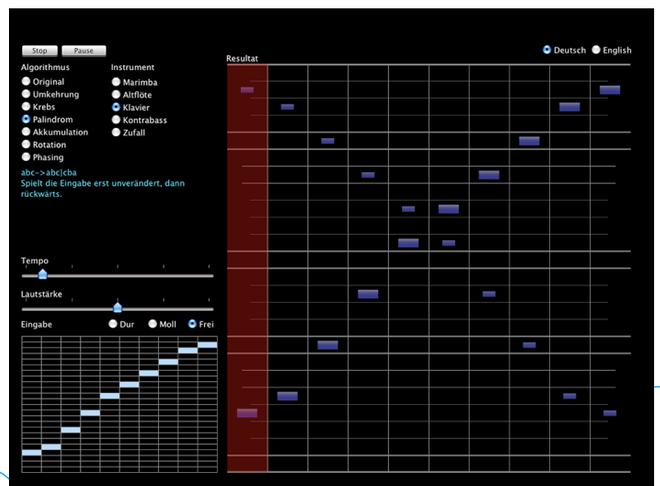
13

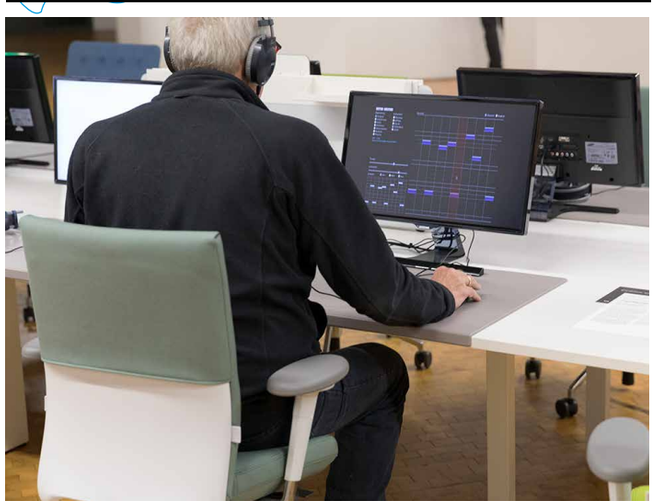
Interactive sound installation
2004

Pattern Machine

#Encoding
#ProgrammingSound
#Software
#Interface

Ludger Brümmer
Chandrasekhar Ramakrishnan
Götz Dipper





Patterns are units of information, which are repeated. Patterns can be used visually, as language or words, and as music. They are a principle that has been utilized in almost all style epochs. Many preludes by Johann Sebastian Bach, the accompaniment known as Alberti bass in classical music, or the arabesques in the music of Debussy or Ravel exhibit the rhythmic or melodic use of patterns. The pattern aesthetic became well known through the composers of minimal music, which is constructed exclusively of patterns, especially through Steve Reich. The installation *Pattern Machine*, which was developed in the ZKM | Institute for Music and Acoustics, is an interactive tool for designing musical patterns. *Pattern Machine* formalizes strategies of composition and perception as pattern formation, derivation, and progressive form, and renders them experienceable for visitors.

107

Random Machine

Interactive sound installation
2004

(14)

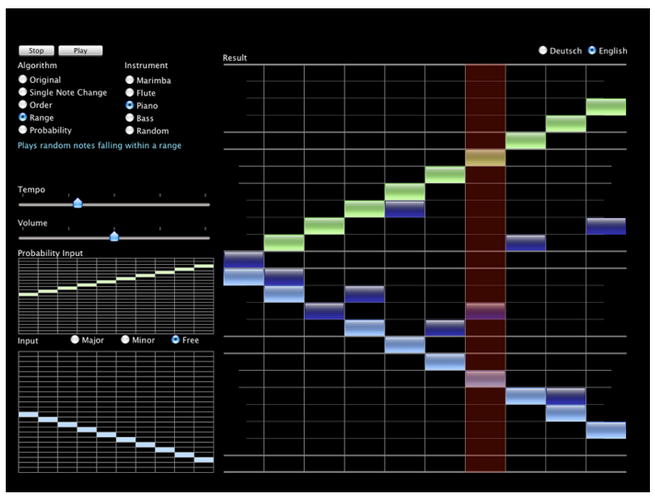
Ludger Brümmer
Chandrasekhar Ramakrishnan
Götz Dipper

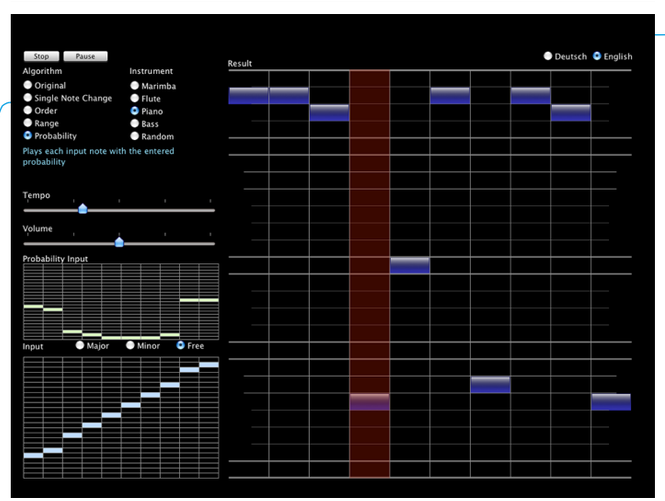
#Encoding
#ProgrammingSound
#Software
#Interface

Random processes have tremendously creative, easily controllable, and constantly changing results.

Wolfgang Amadeus Mozart already understood how to utilise such processes in his work, for example, “Musikalisches Würfelspiel” [musical dice game] (“KV 294d”), which was constantly recreated by using dice. The random method creates a constantly transforming, though always uniformly distributed series of values. The most consistent users of this method in music are the American composer John Cage and the Greek composer Iannis Xenakis.

All users of *Random Machine* have one thing in common: producing randomness is very simple; the artistic challenge, however, is to develop artistic usages, because for human perception, randomness is only interesting in connection with clear rules. In the installation created by the ZKM Institute for Music and Acoustics, different kinds of randomness and their application are presented. With the help of this instrument, even a musically inexperienced user can work with the phenomenon, and utilize randomness artistically.





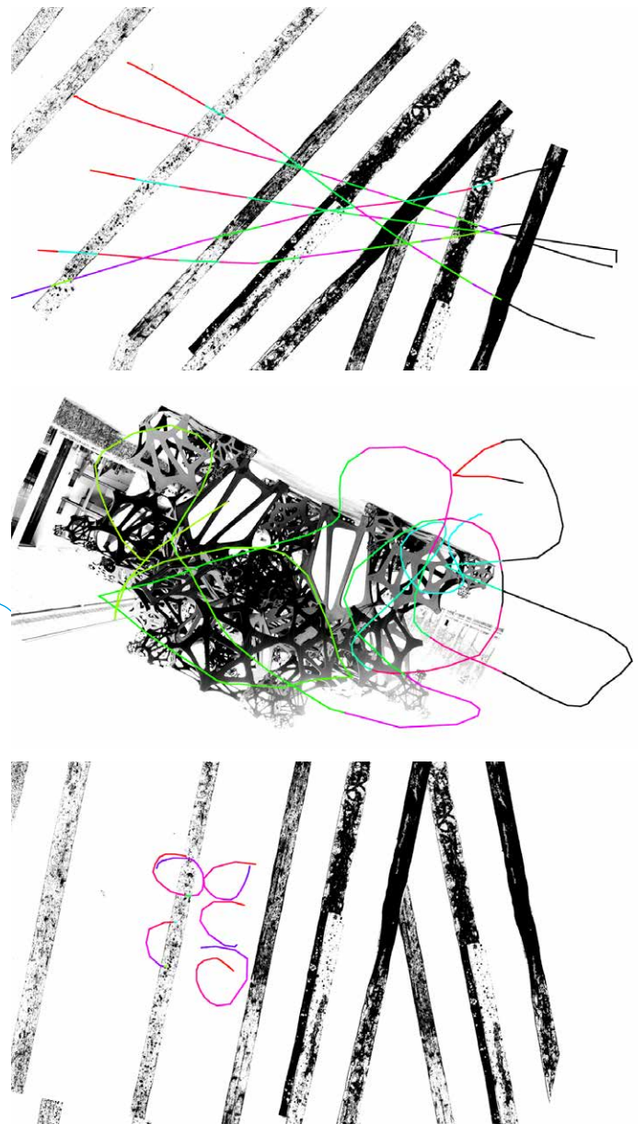
(15)

Interactive sound installation
2016

Rotating Scores

#Encoding
#ProgrammingSound
#Software
#Interface

Ludger Brümmer
Anton Himstedt
Chikashi Miyama
Alex Rodrigues



In the traditional musical notation system, the x-axis represents the time and the y-axis represents the pitch. In case the piece is composed for more than one musician, they should read the score synchronously. What if we loosen these strict rules of the musical notation and make it more flexible? For example, if we gradually rotate the score, the function of a musical note in regard with pitch and time is altered accordingly. This interactive sound installation explores this kind of more flexible and dynamic relationships between the musical symbols and the sounds.

PLAY

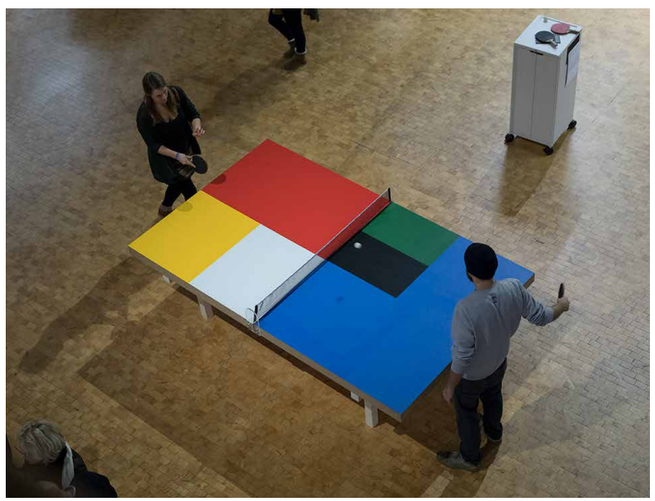
Lacquered MDF, wood beams, Plexiglas,
table tennis net, 274 × 152 × 76 cm
2016

16

Butternutten AG
Oliver-Selim Boualam
Lukas Marstaller

#Encoding
#ProgrammingSound
#Software
#Interface

PLAY is simply a table tennis table. Its colors and surfaces, however, personify the prototypes of table tennis as a sociocultural phenomenon: two sides competing against one another in a game. The abstraction of the traditional table markings through colored surfaces expands the game's realm of possibilities to include improvisation. The table demands that the familiar game be conceived differently, that players act creatively and react spontaneously. At the same time, *PLAY* complies with the requirements of DIN EN 14468, making it possible to play at a competitive level.



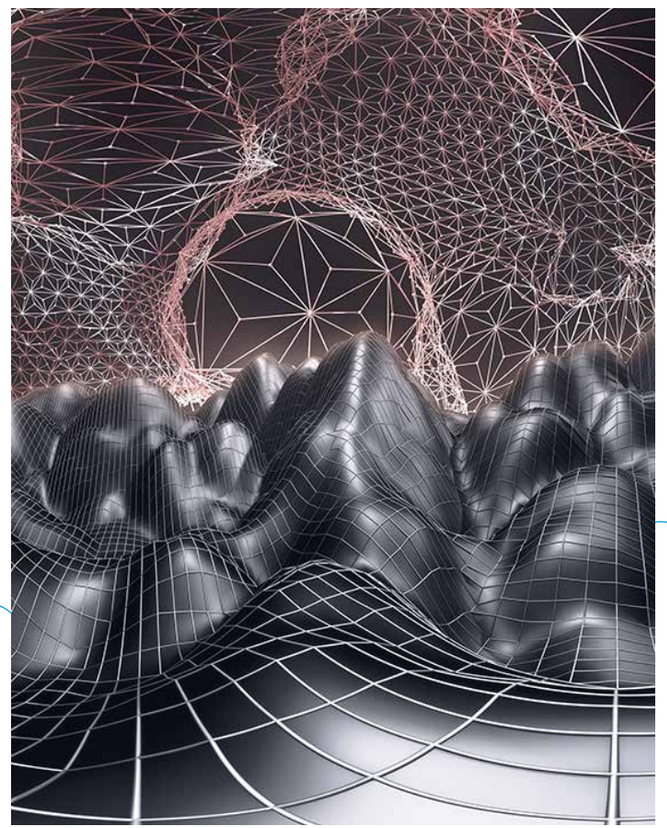
17

Virtual reality installation
3 prints, 42 × 59,4 cm each
2016

Morphogenesis

#VirtualReality
#Encoding
#Escapism #HMD
#ComputerSimulatedEnvironments

Can Büyükberber
Yagmur Uyanik



Morphogenesis (from the Greek *morphê* "shape" and genesis "creation"; literally "beginning of the shape") is the biological process that causes an organism to develop its shape. The virtual reality piece inspired by the phenomenon of emergence in self-organized systems consists of a continuous transformation of basic geometric patterns and uses them as the building blocks of immersive spaces. During the audiovisual journey through different planes of the digital and physical universe, *Morphogenesis* embodies the systems that produce the complexity we encounter in the living world. Like the common characteristics of emergence that can be perceived universally, the audiovisual experience seeks to emphasize the systemic interconnectedness over space and time of all natural dynamics and how these dynamics result in creating novelty at micro and macro scales.

Exploring the ideas of geomorphology and mathematics and understanding the world, *Morphogenesis* requires the audience to be actively aware, and not just passive onlookers. It invites the viewer into a poetic and sensational world, where space becomes infinity, a primal sense of the immaterial world is experienced, and the process of creation is reevaluated.

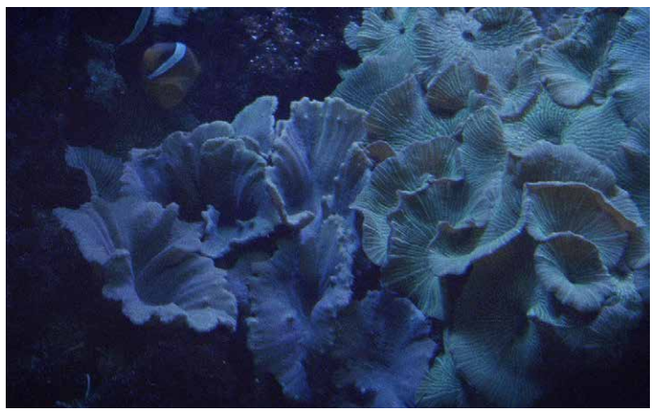
White Mountain

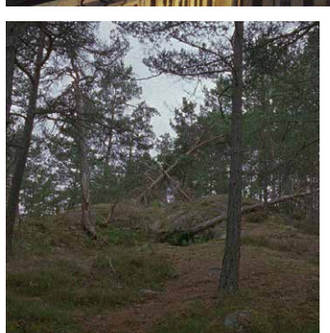
16 mm film transferred to
HD video, color, sound, 20 min.
2016

18

Emma Charles

#AlgorithmicGovernance
#BigData





A 16 mm docu-fiction film set in and around the Pionen data center, a former Cold War era civil defense bunker buried thirty meters underground in Stockholm and redesigned by architect Albert France-Lanord in 2008 to house large servers, notably having included those of WikiLeaks and The Pirate Bay. Part Bond villain lair, part retro-futuristic spaceship, fish and lush greenery coexist alongside the flashing lights of the data storage systems. With poetic narration written by Jussi Parikka, the film explores the temporal nature of data space and geology.

Gathering vibrational and electromagnetic sound from the rock face above the data center as well as deep inside the server room itself, a soundscape has been created that both reveals and processes the reverberations of the hidden environment.

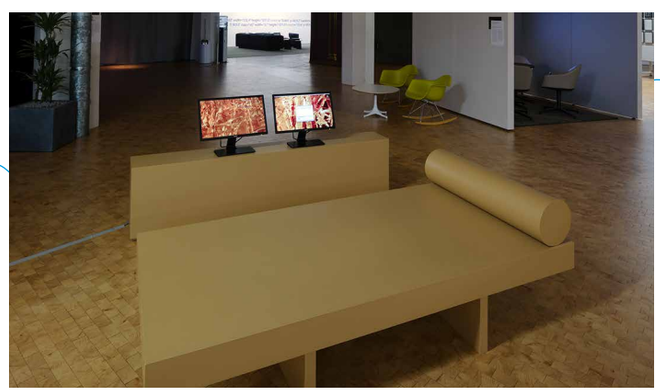
19

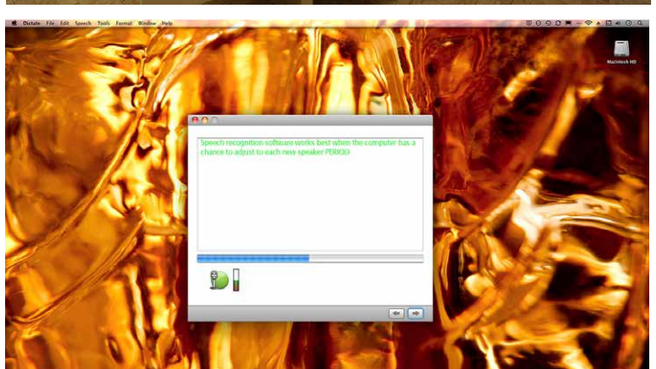
Mixed-media installation, text,
screensaver, monitors, furniture
2013 – 2014

#MachineLearning
#PatternRecognition
#Interfac

Tyler Coburn

Naturally Speaking





NaturallySpeaking takes form as an experimental essay, which advances a few propositions: First, that we are assuming increasingly oral relationships with our devices; that orality does not just denote vocal speech, but also various forms of writing facilitated by social media platforms; that our voice recognition devices often elicit flat, nonaffective registers of speech, thus transforming communication into a process by which one is rendered communicable to machines; and, finally, that affective, nonlinguistic, and vibratory sounds exceeding programmatic registers might contribute to the "unsovereign, unintelligible speech" that, Dina Al-Kassim writes, periodically gathers itself into a "counterdiscourse."

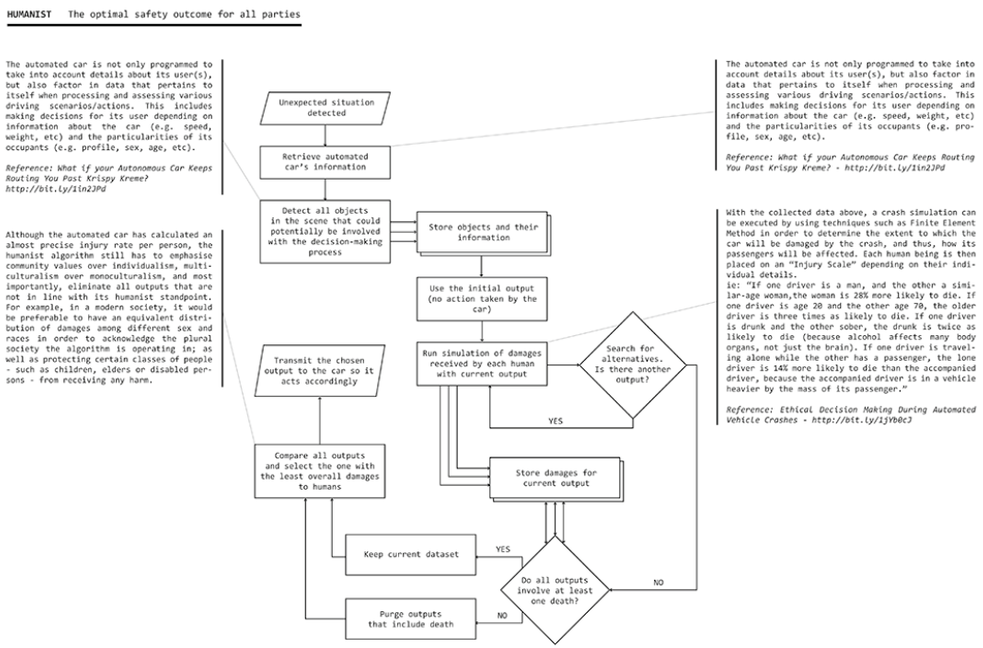
Practically, this essay intervenes in the standard training script of Macintosh speech recognition software, retelling famous stories of the births and afterlives of the voice. On an adjacent monitor, a screensaver tracks the melting of an ice sculpture of Pantagruel's ship.

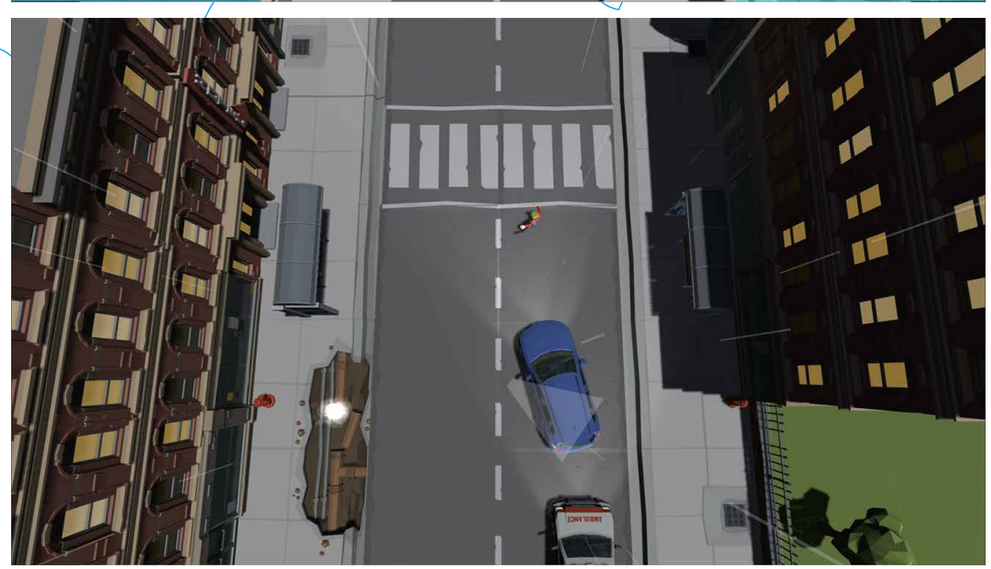
Ethical Autonomous Vehicles

Touchscreen, 3 prints, 42 × 59,4 cm each
2014

Matthieu Cherubini

#MachineLearning
#AlgorithmicGovernance
#ArtificialIntelligence
#AutonomousSystems
#SelfDrivingCars





Many car manufacturers are projecting that by 2025 most cars will operate on driverless systems. While it is plausible to think that our roads will be safer as autonomous vehicles replace traditional cars, the unpredictability of real-life situations that involve the complexities of moral and ethical reasoning are complications that detract from this assumption. How can such systems be designed to accommodate the complexity of moral and ethical thought processes, especially when human lives are involved? Just like choosing the color of a car, ethics may become a commodified feature in autonomous vehicles that one can buy and change, depending on personal taste.

Three distinct algorithms have been created, each adhering to a specific ethical principle: the humanist algorithm looks for the optimal safety outcome for all parties; the protector algorithm is focused on the safety of the driver and passenger(s); and the profit-based algorithm makes its decision based on budgetary reasons. The three algorithms have been embedded into driverless virtual cars which the viewer can drive in a simulated environment where the vehicles are confronted with various ethical dilemmas.

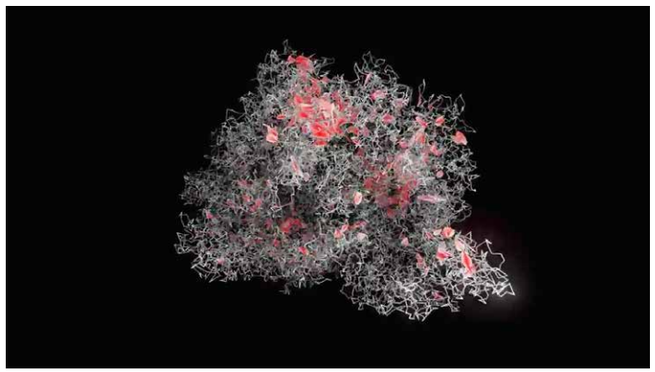
Chromos

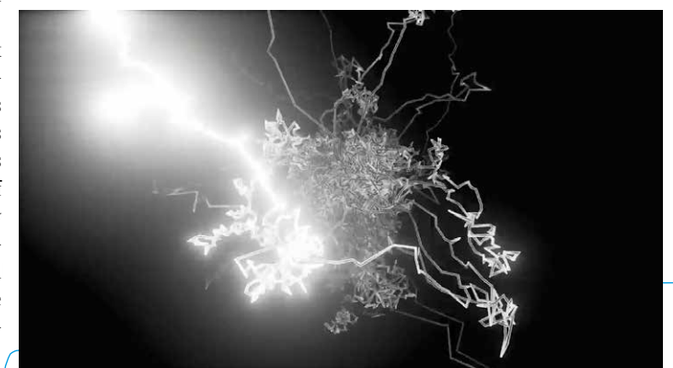
HTC Vive, Unreal Engine software
2017

21

Max Cooper
Andy Lomas

#VirtualReality
#GeneticCode #HMD
#ComputerSimulatedEnvironments
#DNA





This project was created by experimental electronic musician Max Cooper and visual artist Andy Lomas, using data provided by Csilla Varnai, Peter Fraser, Takashi Nagano, and Mikhail Spivakov, scientists at the Babraham Institute in Cambridge (GB), from their research on chromosomal conformation capture.

The work explores the complex dynamic beauty of three-dimensional chromosomal structures as they are transformed by a process called "simulated annealing." This starts by emulating the effect of heating the DNA strands to a very high temperature so that structure is violently moved by thermal noise. Over time the temperature is reduced, and the structure coalesces into a final coherent form.

Through the use of data acquired from real cells that indicate points of contact between strands of DNA, the aim is to use these simulations to create the best possible guess of the real structure of chromosomes in cells. How the chromosomes fold is believed to influence the activation of different sections of DNA, which in turn dictates the proteins expressed and the function of different cell types.

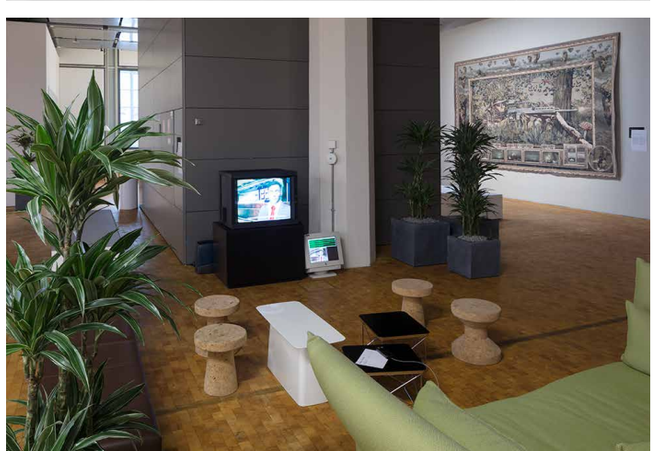
22

Interactive network installation
1999

Remote Control

#AlgorithmicGovernance
#Binary

Shane Cooper



Visitors enter the installation *Remote Control* to find a sofa with a television set playing in front of it. An everyday scene – you sit down and watch TV. An apparently current news program is playing: in a virtual studio, a computer-animated news anchor reads out news reports that have been generated by accessing online newswires. A remote control can be used to flip to a second news channel broadcasting a mirror image of the same visual appearance. The news reports are just as current, but with complementary content. The two available channels are called "Truth 1" and "Truth 2," but neither of them presents actual world events. Beyond this, the artist illuminates the believability of artificially constructed images; presciently, in the 1990s he raised the question of what significance newscasters hold in the evaluation of news.

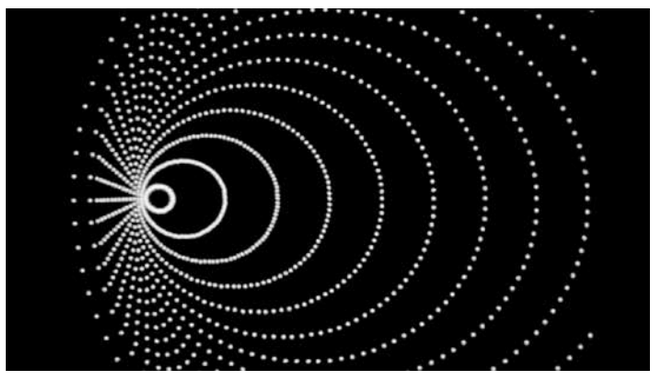
3/78 (Objects and Transformations); Two Space; Calculated Movements

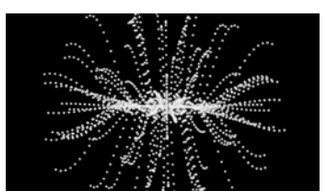
16 mm film transferred to HD video, b/w, 6 min., 1978
16 mm film transferred to HD video, b/w, 8 min., 1979
16 mm film transferred to HD video, b/w, 6 min., 1985

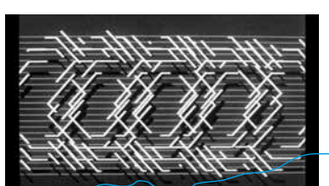
(23)

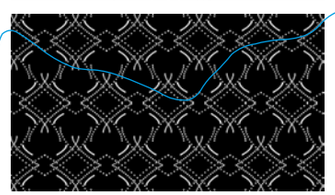
Larry Cuba

#Encoding
#Algorithm









Larry Cuba's original 16 mm films *3/78 (Objects and Transformations)* and *Calculated Movements* are two thrilling experiments in visual perception of motion and mathematical structure. In the videos, different points of light and volumes perform a hypnotic dance that explores the depths of our perception and leaves some beautiful afterimages. The rhythmic transformations of the forms go beyond the perspective and the pattern repetition, achieving an empyrean beauty of precise, mathematical structure. The immersive effect of this audiovisual experience is even more enhanced when viewed inside the panoramic 360° screen sphere in the ZKM_Foyer, where Cuba's film *Two Space* has been installed.

Produced between 1978 and 1985, these computer-animated films present us with the infinite potential for change and variation that is offered by a highly technical and mathematically precise medium.

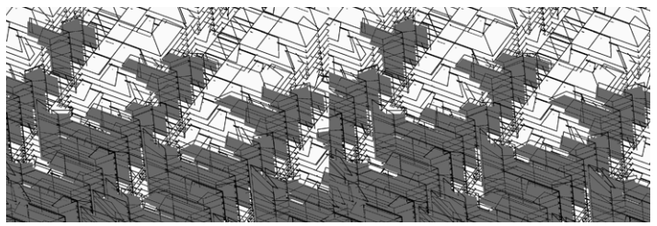
(24)

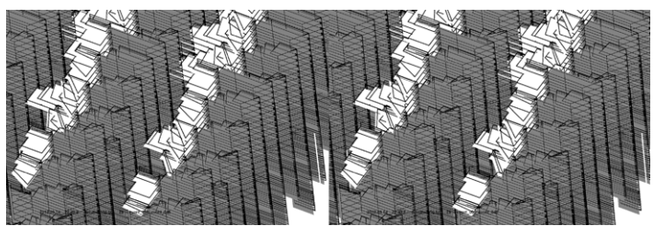
2010, generative animation, video, 70 min.
2012, generative animation, video, 13 min.

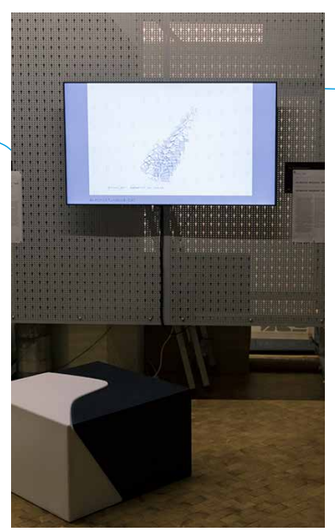
#Encoding
#Algorithm
#ComputerGeneratedDesign

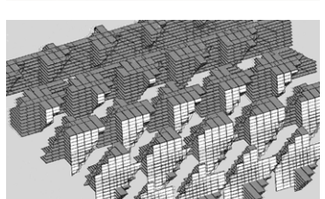
Larry Cuba

Animation Notebook 2010; Animation Notebook 2012









In the 1970s, back in the "mainframe era" before personal computers were developed, just getting access to a machine to work on was a major hurdle for artists. This changed in the late 1990s when PCs conquered the majority of households. Larry Cuba, who had been working on computer technology since 1974, was finally able to work in his studio at home. In 2013, a computer failure halted the project he was working on for several years, a project conceived during a residency at ZKM in 1995. Fortunately, we still have his notebooks full of experiments that now, twenty-two years later, return to their place of origin for their first public presentation, and offer the viewer some glimpses of the research process itself.

The principle behind the films is simple: algorithms are written to generate animation. The code is based on algebra and a hierarchical structure of picture definitions and functions. There is no predefined visual goal or target in mind; moreover the animation emerges from the execution of the algorithm with each successive experiment. In this sense, each parameter represents an axis in a multidimensional space of possible results.

In essence, Cuba's artistic practice explores the intriguing relationship between verbal representation of processes (code) and visual expression of form in motion (animation).

Rzl-Dzl-AI

HD video, color, sound, 7:46 min.
2016

25

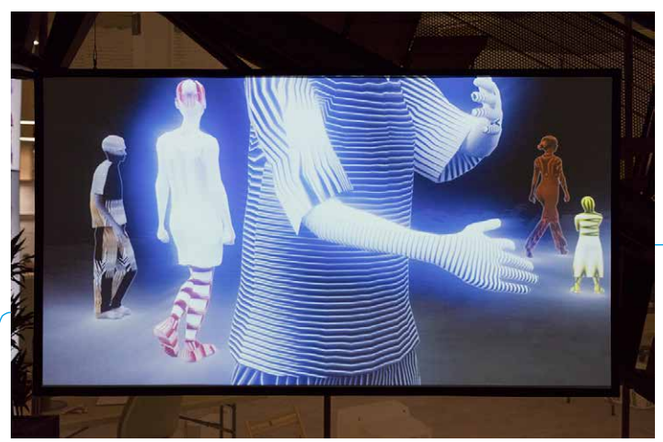
Frederik De Wilde

#MachineLearning
#AlgorithmicGovernance
#ArtificialIntelligence
#PatternRecognition
#Drones

Rzl-Dzl-AI demonstrates how deep neural networks are easily fooled, a dystopian reality when you realize that, for example, the military is already using them. The question is how much confidence do we have in ourselves and the technologies we develop?

Rzl-Dzl-AI consists of encoded neural network-generated images that mislead and hack other neural networks or AI-based image recognition systems. The encoded images and patterns were generated through evolutionary algorithms. The images are heavily abstracted and unrecognizable to humans, but state-of-the-art, cutting edge convolutional neural networks (deep neural networks trained on ImageNet) believe them to be a familiar object with ≥ 99.99 % certainty.

Rzl-Dzl-AI is the next level "razzle-dazzle," an old expression used to describe the effect of a new camouflage technique used extensively in World War I, and to a lesser extent in World War II; afterwards, it reduced collateral damage by more then 10 %. The camouflage consists of complex patterns of geometric shapes in contrasting colors, interrupting and intersecting each other. Unlike other forms of camouflage, the intention of razzle-dazzle is not to conceal, but to make it difficult to estimate a target's range, speed, and direction.



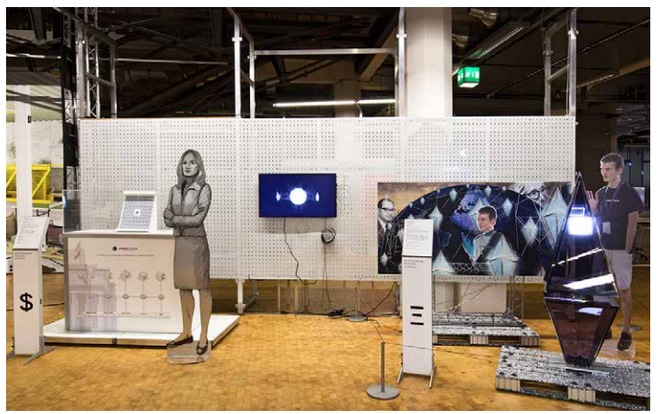
26

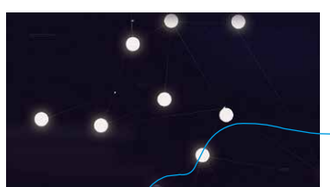
Mixed-media installation,
digital prints, HD video, 3 min.
2016

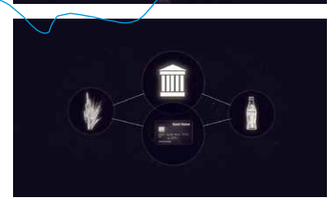
Blockchain Future States

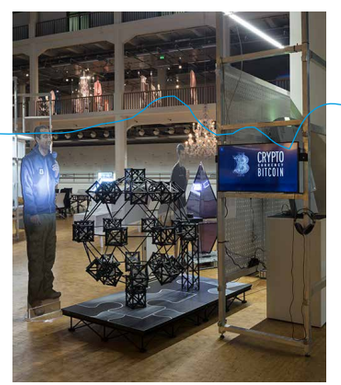
#AlgorithmicGovernance
#AlgorithmicEconomy
#Bitcoin #Cryptocurrencies
#Blockchain

Simon Denny









Blockchain Future States investigates *Ethereum, 21 Inc.*, and *Digital Asset*, three financial companies at the forefront of digital money and the application of the blockchain, a database technology that is the backbone of the denationalized cryptocurrency Bitcoin. The potential widespread usage of cryptocurrencies as supranational money and other applications of blockchain technology that involve propositions of a decentralized, financialized web enables these visionaries to propose radically different worlds where traditional political and geographical formations are obsolete. Financial-markets-as-logic here reaches an all time high as we say goodbye to state-regulated monetary policy and private market-based logic is embraced.

For *Open Codes* at ZKM | Karlsruhe Simon Denny presents a video introducing blockchain's core narrative, and three displays highlighting the nuances of each company's version of blockchain's potential and the political and ideological differences they are based on. Their radical propositions are concentrated into speculative postage stamps as infographics, calling into question whether any version of blockchain's radical future is desirable.

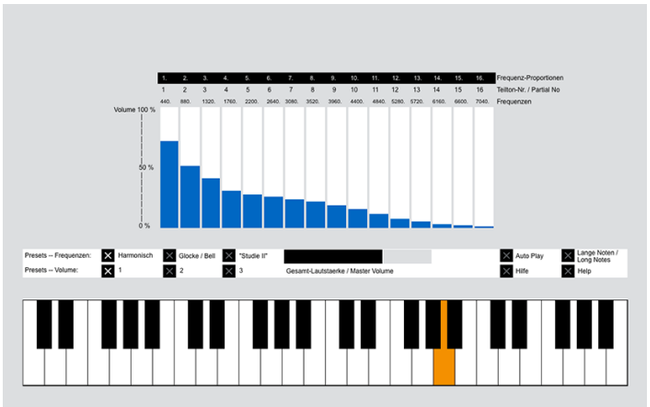
Add_Synth

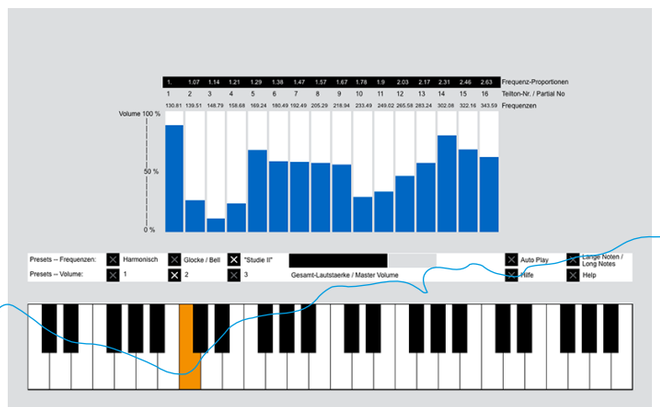
Interactive sound installation, computer, software, monitor, mouse, headphones
2017

27

Götz Dipper

#Encoding
#ProgrammingSound
#Software
#Interface





With the aid of the two interactive installations *Add_Synth* and *FM_Synth*, visitors are introduced to two classic sound synthesis systems.

In 1822, the French mathematician and physicist Joseph Fourier developed the method known as Fourier synthesis, which to this day is an indispensable tool for mathematicians and engineers. Fourier discovered that every periodic signal can be represented as a sum of simple sine waves. When applied to sounds, this is known as the harmonic series. In 1863, the German physicist and physiologist Hermann von Helmholtz advanced the theory that the composition of the harmonic series is responsible for the timbre of a sound. Building on this, the additive sound synthesis was developed in electronic music of the twentieth century, in which sounds from single pure tones (tones with sinusoidal waveforms) are assembled. Theoretically, a composer can produce all tone colors in the world using this method.

In the installation *Add_Synth*, the visitors can assemble a tone themselves from pure tones. They can regulate the strength of each and every harmonic individually, and via headphones they can observe the effect on the tone color.

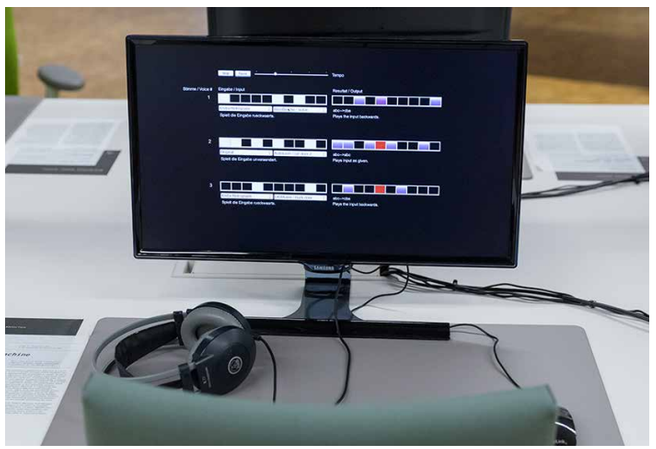
28

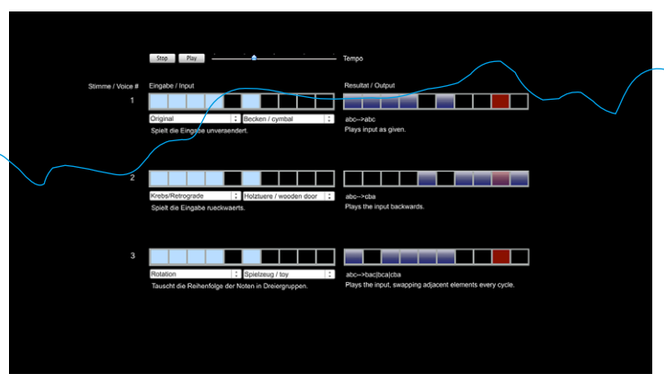
Interactive sound installation, computer, monitor, mouse, headphones
2017

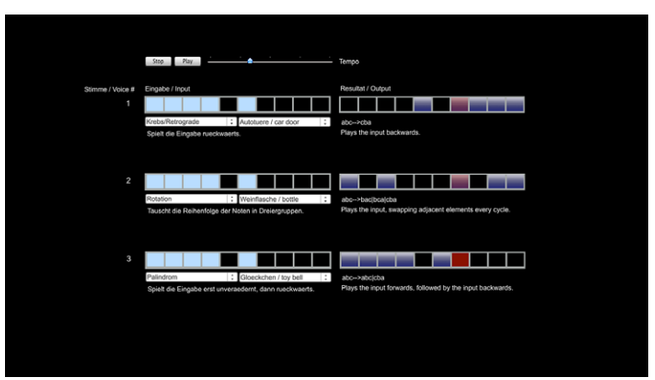
algoRhythm Machine

#Encoding
#ProgrammingSound
#Software
#Interface

Götz Dipper







The installation *algoRhythm Machine* is a sort of drum computer through which rhythms can be algorithmically generated or varied. Some of the algorithms that are utilized have been used in music for centuries, including the crab, for which one section is played backwards, creating a sort of crabwalk. Other algorithms, such as the various algorithms based on randomness, were first used broadly in the twentieth century.

algoRhythm Machine is inspired by the installations Pattern Machine and Random Machine from 2004, both are also being shown at the *Open Codes* exhibition. The same algorithms that generate melodies in those installations are used here to generate rhythms. Visitors can pursue the fascinating question of whether the algorithms are equally well suited for both uses.

Unlike with *Pattern Machine* and *Random Machine*, no variation in the pitch is possible with *algoRhythm Machine*. Instead, *algoRhythm Machine* is polyphonic, such that patterns can be layered in interesting ways. Visitors can explore what settings lead to interesting listening experiences.

FM_Synth

Computer, monitor, mouse, headphones
2017

29

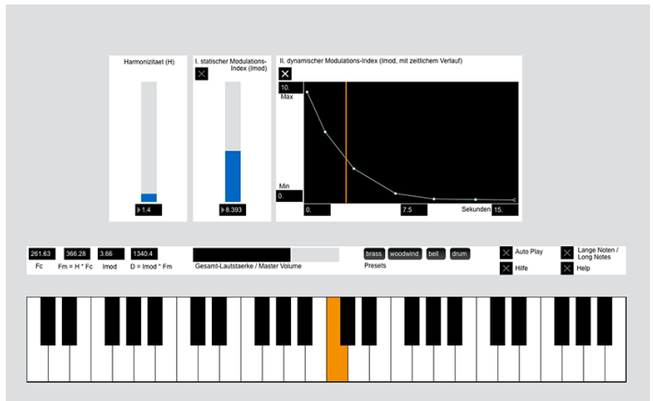
Götz Dipper

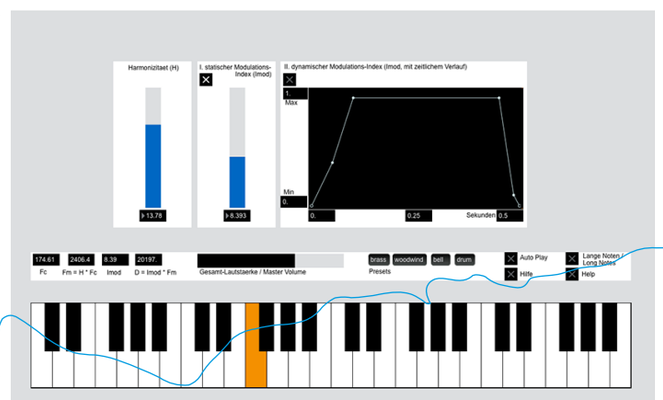
#Encoding
#ProgrammingSound
#Software
#Interface

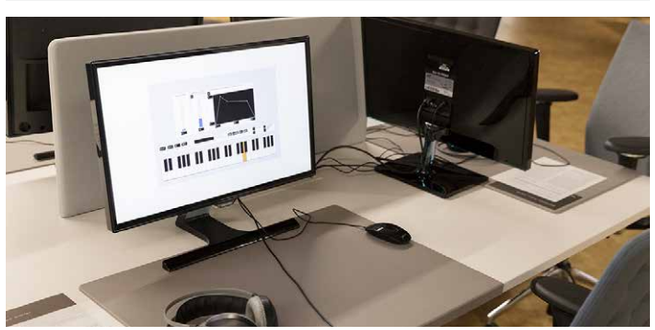
The two interactive installations *Add_Synth* and *FM_Synth* enable visitors to get to know two classic sound synthesis methods.

The frequency modulation (FM) method was developed for radio technology. Through it, audio signals such as language and music can be transmitted wirelessly via electromagnetic waves. In this process, the low-frequency audio signal (with frequencies up to a maximum of 20 KHz) is effectively imprinted onto a high-frequency electromagnetic wave (with a frequency of approx. 100,000 KHz). In Germany, FM is used for VHF radio.

In the 1970s, the American composer John Chowning discovered that FM could also be used for sound synthesis. He developed FM synthesis, which was used by the Yamaha company in commercial synthesizers. Unlike radio transmission, FM synthesis works without a high-frequency signal, instead using two low-frequency signals. The major advantage that FM synthesis holds over additive synthesis (see *Add_Synth*) is how economical it is: complex tones can be created with just two modulators. Visitors to the *FM_Synth* installation can try this out for themselves.







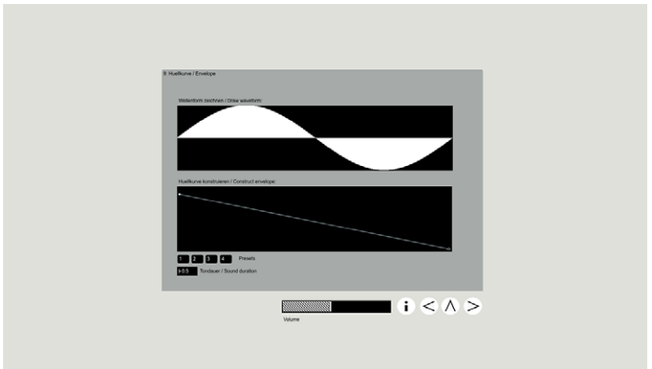
30

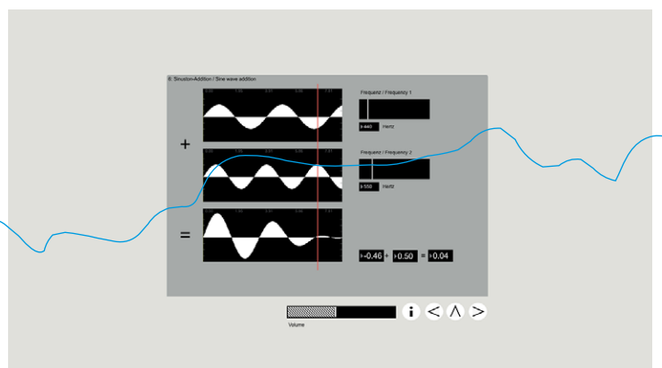
Interactive sound installation,
computer, monitor, mouse, headphones
2017

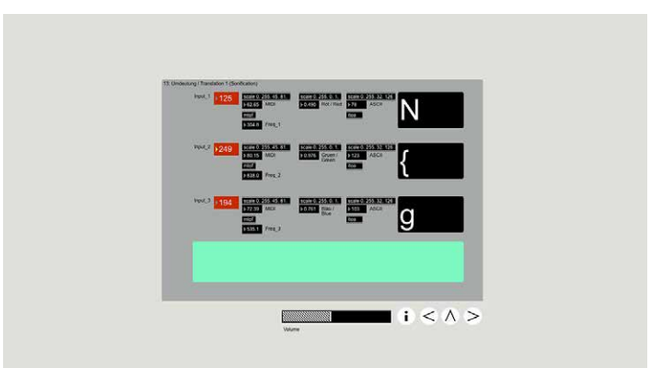
#Encoding
#ProgrammingSound
#Software
#Interface

Götz Dipper

...wie der Computer Musik macht







Sounds and sequences of tones generated by a computer are used today as a matter of course in many areas alongside the sounds of traditional instruments. They are widely used in contemporary music – in pop music, advertising, movies, experimental music, and experimental music.

With the sounds of traditional instruments we usually have an intuitive idea of how the sounds are generated, and how their characteristics can be influenced. For example, when I want to produce a piercing sound on a recorder, I have to blow hard into it. But when I want to produce a soft, warm sound, I have to blow more carefully.

When it comes to computer sounds, though, we lack this intuition. The computer is like a black box; we cannot see directly how its interior works.

The installation *...wie der Computer Musik macht* [...how the computer makes music] offers visitors the opportunity to cast a quasi-glance into the interior of a computer, and with the aid of a series of small, mostly interactive units, to understand how the sounds are produced there.

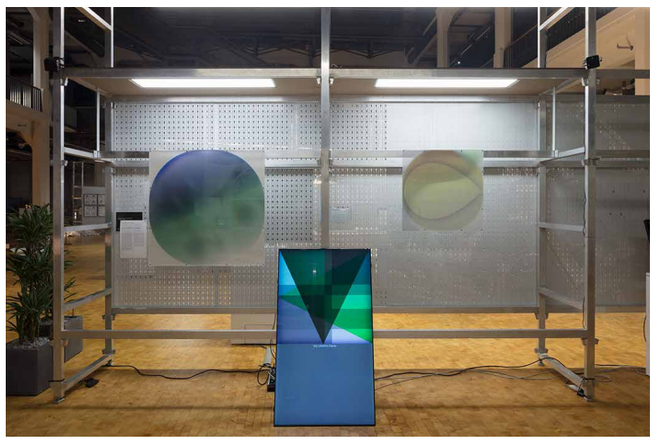
Death Imitates Language

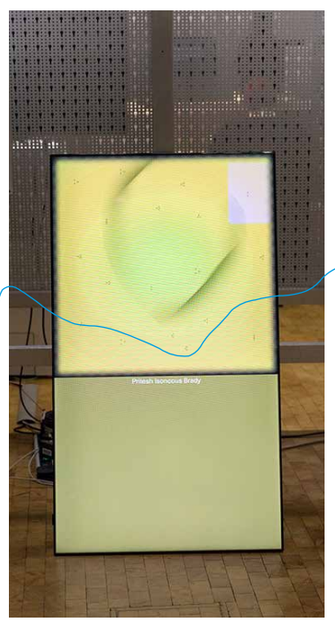
Website, two prints (unique edition),
100 × 100 cm, 70 × 70 cm
2016/2017

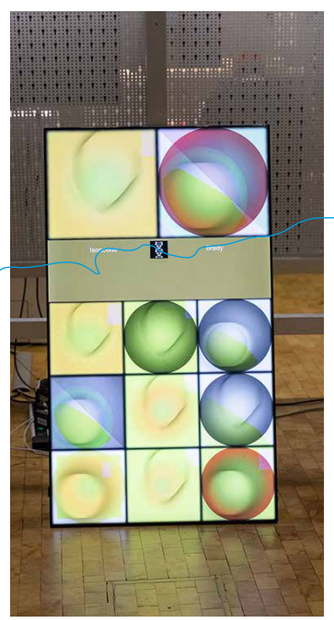
31

Harm van den Dorpel

#MachineLearning #GeneticCode
#Encoding #PatternRecognition
#AutonomousSystems #Algorithm
#Software







Death Imitates Language is a series of works exploring the development of meaning in generative aesthetics using micro feedback and a genetic algorithm. It consists of a website (http://death.imitates.org) and a series of printed and boxed collage works.

The public website contains an enormous collection, "population," of speculative works. Each of these works is generated by inheriting sequences of information – a sort of DNA – from its ancestors. These "genetic" codes determine which elements appear in the work and in what form or constellation. The population changes over time by means of subjective ("natural") selection by the artist: micro feedback or "likes." This feedback – combined with visitor statistics and simulated aging – causes the genetic program to mutate and (arguably) improve over time.

When creatures reach an optimal state they are "frozen" and translated into physical objects. These objects are layered in construction, partly transparent, and square.

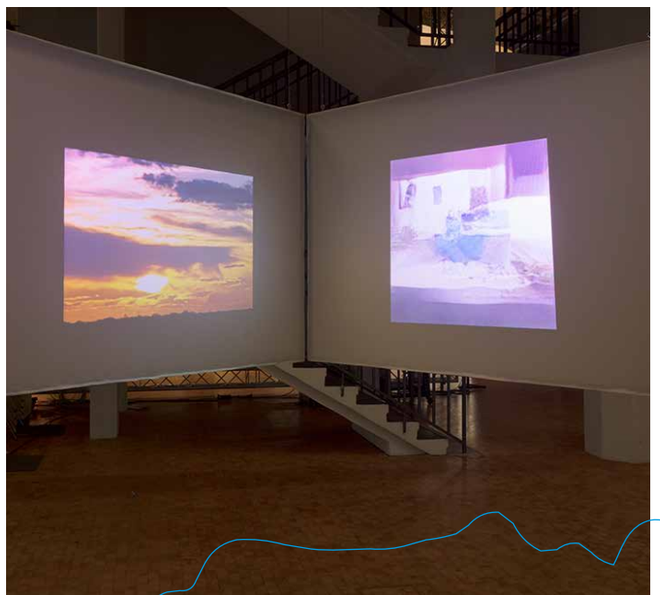
32

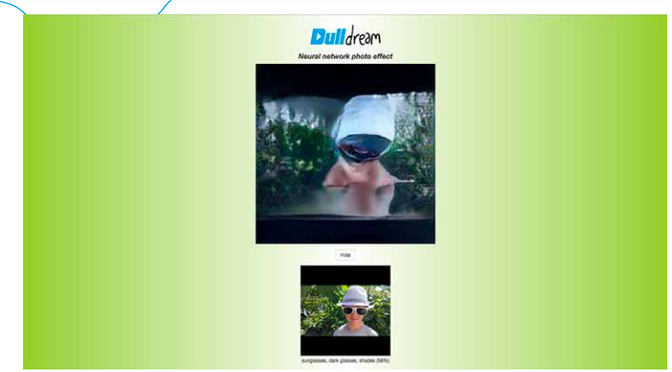
Neural network application
2015

DullDream

#MachineLearning
#AlgorithmicGovernance
#PatternRecognition
#Software #BigData

Constant Dullaart





In his work *DullDream* by DullTech™, Constant Dullaart reverses the traditional function expected of convolutional neural networks (CNN). CNNs are artificial neural networks that enable machine learning and pattern recognition through artificial intelligence. Facebook, Apple, and Google use them to analyze what is in an image. CNNs are often used for facial and speech recognition and they can also determine objects in images based on their shape, texture, gradients, colors, etc. To verify the functionality of a network's recognition capacity, the network can be requested to amplify the values that help it understand its categorization classes. Pattern recognition amplified, becomes pattern hallucination; the algorithm can make a tomato look even more like a tomato, a human more human. Constant Dullart's software does the opposite: while (for example) Google *DeepDream* highlights and intensifies patterns, *DullDream* reduces the specific characteristics of forms. "Deep dream" becomes a *DullDream*. The program enables users to upload images of themselves and have them returned devoid of individual characteristics – an impressive statement against increasing regulation through pattern recognition. Website: http://dulldream.xyz/.

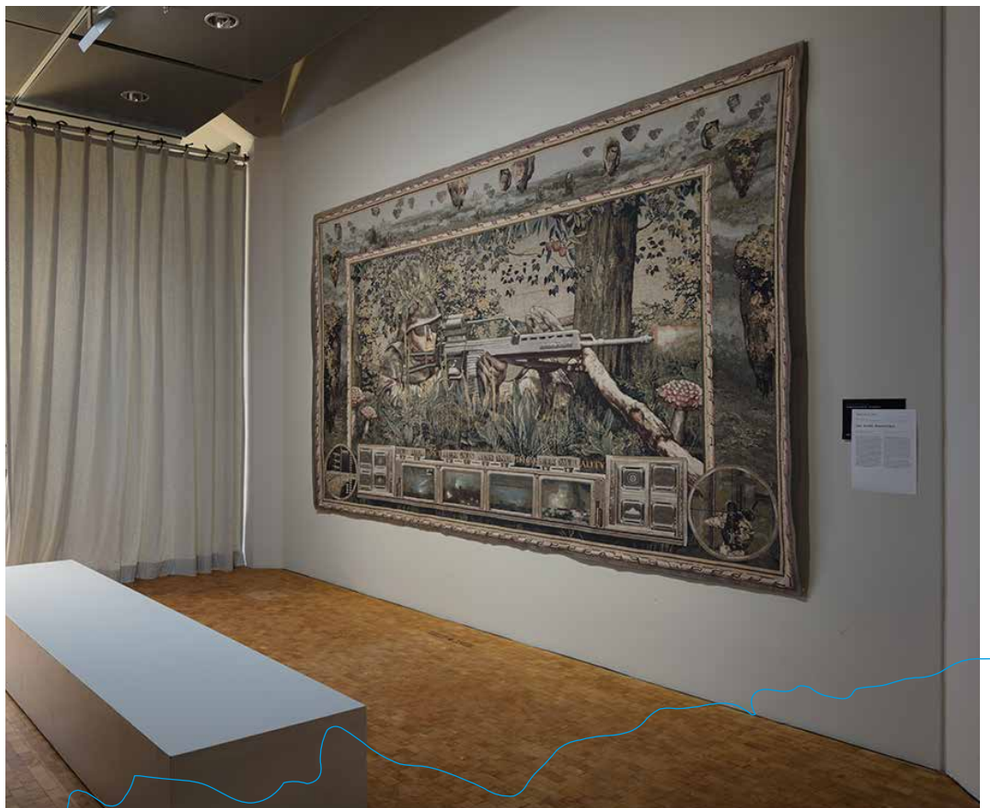
Das Große Rasenstück

Tapestry, digital collage, jacquard fabric, 275 × 425 cm
2013

33

Margret Eicher

#Labour&Production
#ComputerGeneratedDesign
#Programming



Das Große Rasenstück [The Large Piece of Turf] references Albrecht Dürer's eponymous watercolor of 1503. However, lying amidst the grasses and flowers here is a soldier firing an assault rifle. Here, the press photograph from a political magazine encounters one of the first nature studies of the Renaissance. Two levels of reality which are supplemented by a third: that of the computer game. The scene is framed by smaller images of war, reminiscent of the design of computer games. A quote from Jean Baudrillard draws attention to the game being played with the levels of reality: "In simulation the sign is indistinguishable from reality." In addition, floating islands from the movie *Avatar* can be seen in the border: reality as representation, not as reality per se.

The tapestry's motif was generated by computer, and here the medium has strong connections with the contents. Its production as a complex jacquard fabric refers back to an early precursor of computer technology: the weaving process on the Jacquard loom, like the binary code, is based on 1s and 0s.

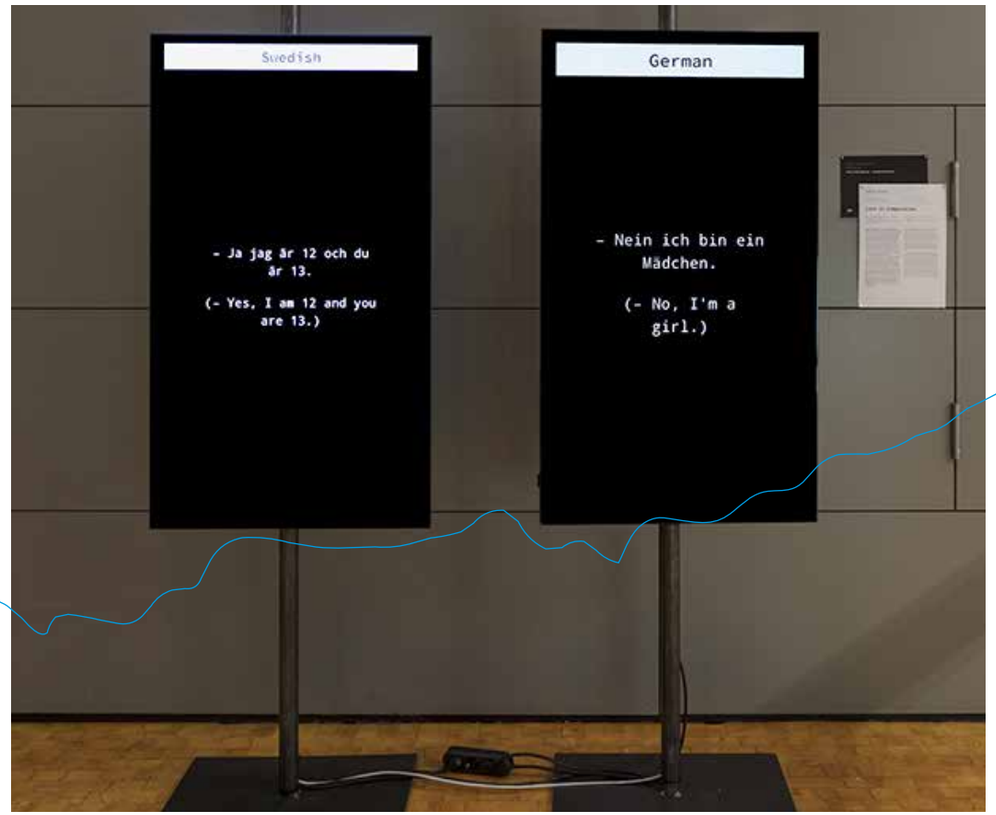
34

Mixed-media installation, 2 screens, 2 Raspberry Pis
2017

Lost in Computation

#MachineLearning
#Encoding
#PatternRecognition
#AutonomousSystems

Jonas Eltes/Fabrica



Lost in Computation is a multilingual conversation between two autonomous chatbots. Chatbots are computer programs, which can conduct humanlike dialogs via written text or audio processing. Their aim is to simulate humanlike conversations, and they are typically implemented in information exchange services, e-commerce platforms, and call centers. Chatbots used for these purposes are limited to conversations regarding a specialized purpose and not for the entire range of human communication.

In this work, two chatbots face each other. Trained in different languages, Swedish and German amongst them, the conversation simultaneously runs through *Google Translate*. The conversation runs on two small computers communicating with each other through a Node.js web server, using sockets for real-time communication between the two clients. The machine-learning algorithm of the chatbot highlights the level of sophistication bots have achieved, but also the absurdity of machine cognition, as the program is not able to appreciate the meaning of what is being talked about.

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2017

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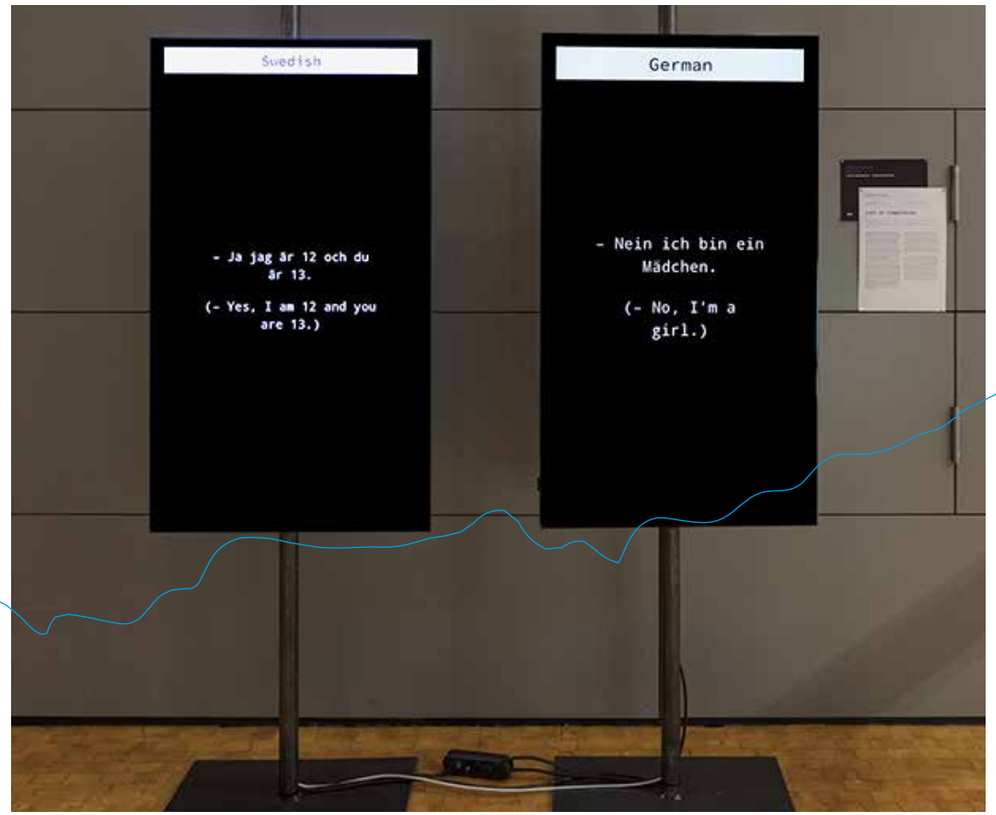

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BitterCoin

Installation, calculator
2016

35

César Escudero Andaluz
Martín Nadal

#AlgorithmicEconomy
#Bitcoin
#Cryptocurrencies
#Blockchain

Bitcoin was originally conceived as an electronic decentralized system for financial transactions. Each node (user) in the peer-to-peer network has the same opportunities to get a reward when validating a transaction.

In recent years this system has triggered a competitive struggle in which computing power is the most important variable for earning Bitcoins. This involves the use of powerful equipment, and server farms spending physical and environmental resources. A struggle that only benefits the owner of the most powerful and efficient technology.

BitterCoin, an old calculator machine hacked for use as a miner to validate the pending Bitcoin transactions in the blockchain, takes up this discourse in a rhetorical way: it works like the most basic computer, increasing the time needed to produce Bitcoins almost to infinity.

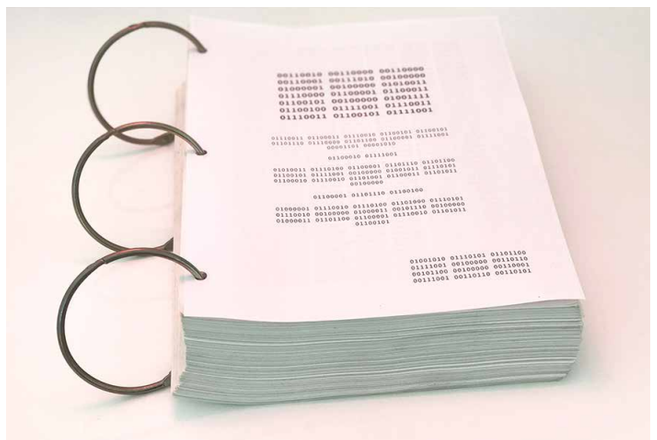
36

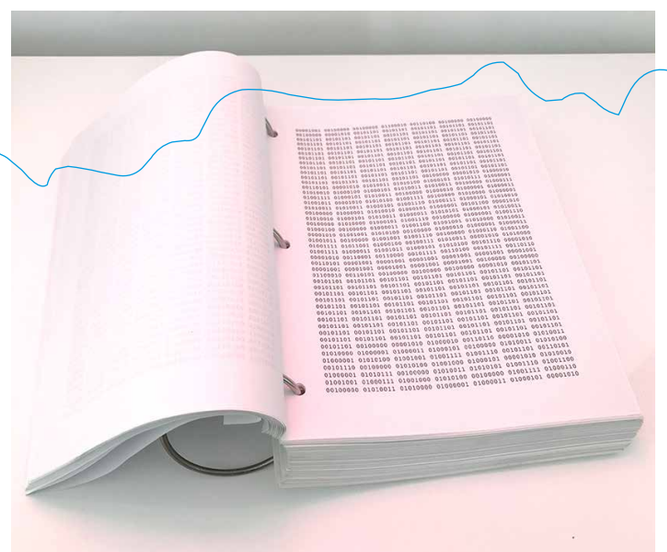
Screenplay, 21,6 × 27,9 cm
2011

2001 100011

#Encoding
#Binary

Claire L. Evans





2001 100011 is a faithful translation of the entire script of Stanley Kubrick's *2001: A Space Odyssey* (1968) into binary code. Presented in the standard screenplay format – 8.5 × 11 inches (216 × 279 mm), three-hole punched – its 419 pages are unintelligible to both human and machine readers. As such, *2001 100011* is an impossible object occupying the liminal zone between humans and computers. The book reflects the artist's opinion that Kubrick's film is a tragic allegory about the impossibility of true communication between two parties, when each holds what the other lacks.

Parallele

4 Videos
2012–2014

37

Harun Farocki

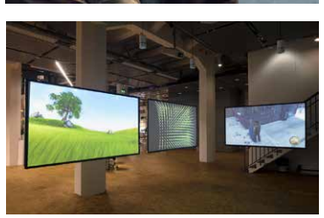
#VirtualReality
#ComputerSimulatedEnvironments
#Escapism

The four-part work *Parallele* is about the type of image brought forth by computer animation. Computer animation images are in the process of becoming a general model which is supplanting the filmic image. In films there is the wind that blows, and there is the wind that is generated by a wind machine. Computer images do not have two sorts of wind.

Parallele I presents a brief history of the style of computer images. The first computer games in the 1980s consisted solely of vertical or horizontal lines. This abstraction was viewed as a deficiency and today's representations are oriented on photorealism.

Parallele II and *III* interrogate the limits of game worlds and the character of the objects. It appears that many game worlds have the shape of a disk which floats in outer space. A reminiscence of pre-Hellenist conceptions of the universe.

Parallele IV explores the heroes of computer games. They have no parents or teachers so they have to discover which rules apply for themselves. The heroes nearly always have the same expression on their faces and very few character traits, which they declare in a number of different but virtually homogeneous short sentences. They are homunculi, humanlike creatures created by humans. Everyone who plays with them shares in the pride of creating them.



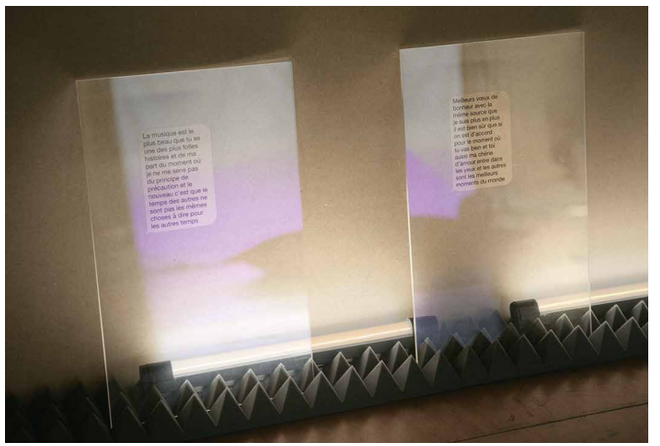
38

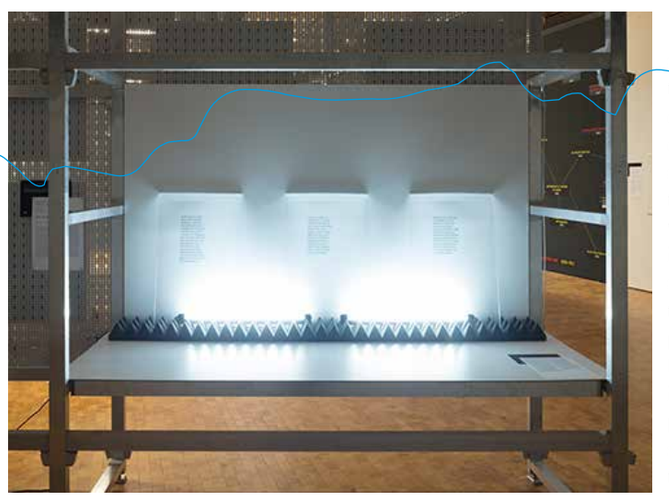
UV prints on Plexiglas, foam,
LED lights, 210 × 65 × 15 cm
2017

Oracles

#MachineLearning
#PatternRecognition

Thierry Fournier





The installation presents what appear to be excerpts of regular text message conversations. Yet on taking a closer look they are devoid of meaning. The messages are generated with a smartphone; the artist has chosen only the first word, followed by the automatic next-word suggestion – using always the same key between the three proposed by the smartphone, in order to eliminate any human decision. The resulting text is an incomprehensible mix of the program's words and rules, and some idiosyncratic expressions of the user: the writer becomes an undefined hybrid between a human and a program. The display, quotations printed on Plexiglas, freezes something that usually happens within a flow: it suggests that these texts could have an author, thus paradoxically highlighting its indetermination.

Parallele

4 Videos
2012–2014

37

Harun Farocki

#VirtualReality
#ComputerSimulatedEnvironments
#Escapism

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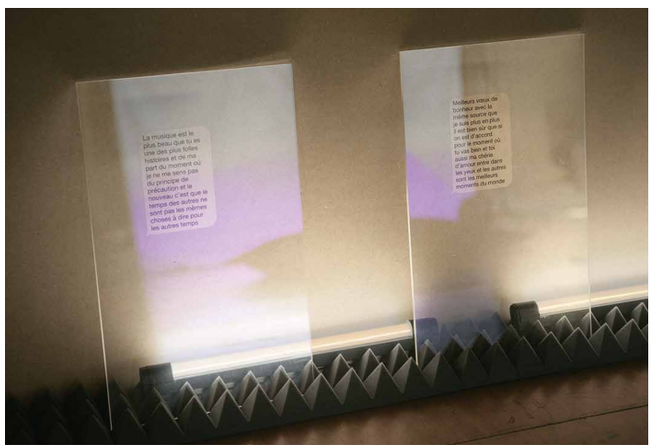
38

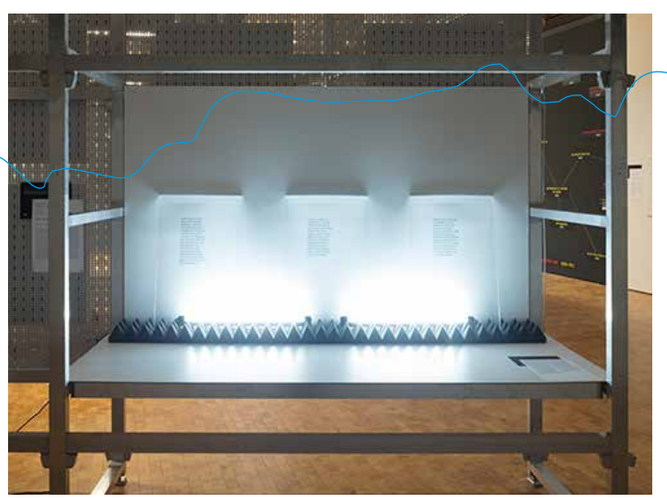
UV prints on Plexiglas, foam,
LED lights, 210 × 65 × 15 cm
2017

Oracles

#MachineLearning
#PatternRecognition

Thierry Fournier





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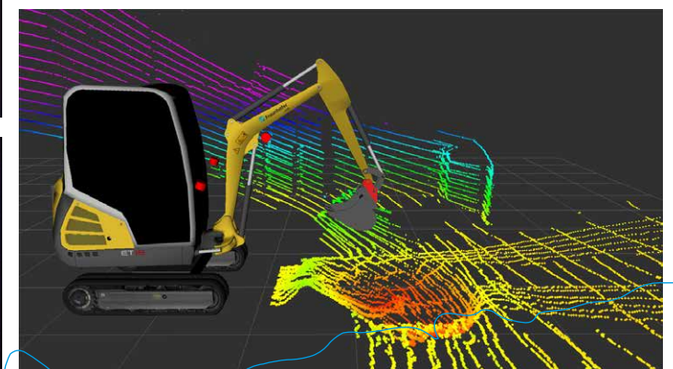
Autonome Fahrzeuge

HD video, color, sound, approx. 8 min.
2017

39

Fraunhofer IOSB
ZKM | Karlsruhe

#MachineLearning
#Labour&Production
#AutonomousSystems #Drones #Robots
#Industry4.0



Along with self-driving cars, the realm of autonomous driving encompasses a broad range of mobile robots that move independently across land, air, and water, and can make decisions. The film *Autonome Fahrzeuge* [Autonomous Vehicles], which was created in collaboration between the ZKM | Karlsruhe and Fraunhofer IOSB for the *Open Codes* exhibition, offers a glimpse of IOSB's latest developments and applications in this fascinating field.

Mobile robots can support people in a variety of ways. Their current applications range from robot assistants in industrial environments to reconnaissance robots in disaster areas to robotic systems for deep-sea exploration tasks. IOSB has developed a multitude of powerful algorithms for autonomous functionality, which also make it possible to navigate mobile platforms securely in challenging environments.

Thanks to cost-effective sensors and data processing components, autonomous vehicle applications are no longer just scientifically interesting: their implementation is also increasingly commercially viable. For years, Fraunhofer IOSB has been working on this implementation, and the film shows four examples of it: an autonomous backhoe, unmanned aircraft and deep-sea robots, as well as an autonomous land vehicle.

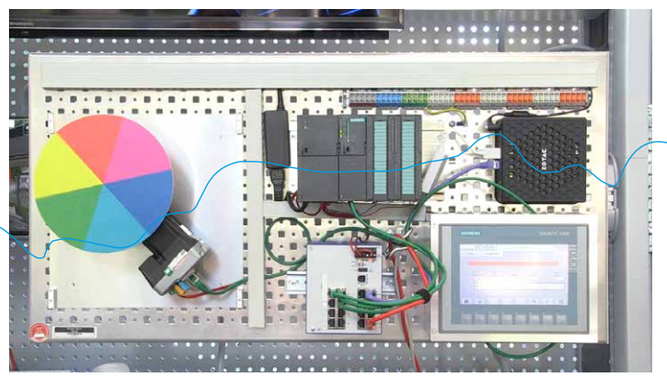
40

HD video, color, sound, approx. 8 min.
2017

Industrie 4.0

#Labour&Production
#MachineLearning
#AlgorithmicGovernance
#InternetOfThings #SmartFactories
#Automation #Industry4.0

Fraunhofer IOSB
ZKM | Karlsruhe



The film *Industrie 4.0* [Industry 4.0], which was created in collaboration between the ZKM | Karlsruhe and Fraunhofer IOSB, shows current research and development in Industry 4.0. The term Industry 4.0 designates the digital transformation of industry through the increasing use of automated processes that are guided by smart objects. Products and components are equipped with embedded systems that are capable of collecting data, joining networks, and communicating. Furthermore, ever more processes are standardized to ensure that both production and logistics processes run smoothly. Interoperable components are developed so that systems such as machinery can interact with one another even better and more efficiently. This leads to greater flexibility and more efficient processes. Beyond this, new strategies to maintain and service facilities with the support of machine learning are coming to the fore. Rather than simple corrective maintenance, there is a trend towards systems that make forward-looking suggestions about maintenance and other actions to take.

The film documents these processes and research areas, demonstrating how a smart factory could look in the near future.

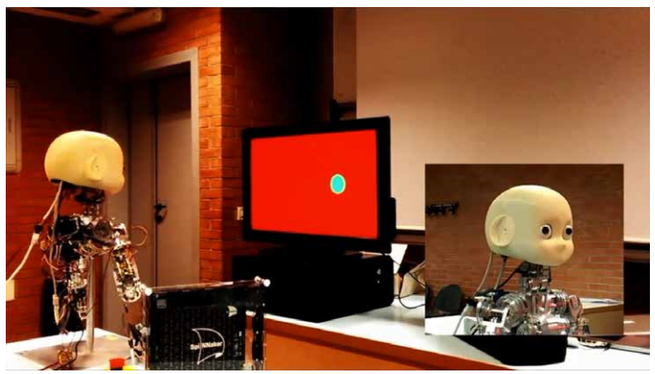
The Human Brain Project

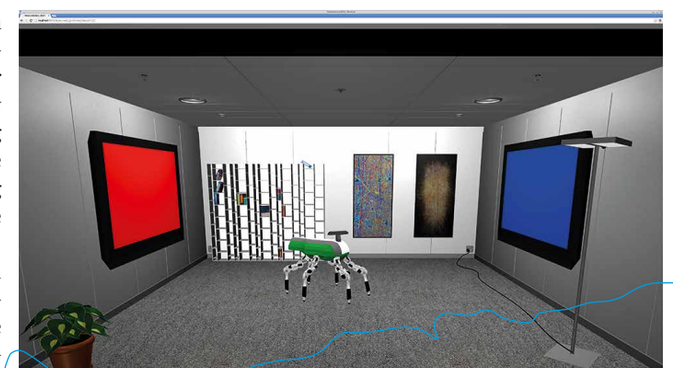
HD video, color, sound, approx. 8 min.
2017

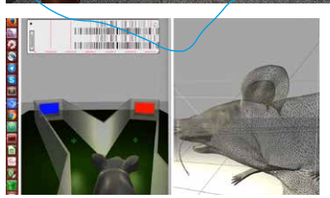
41

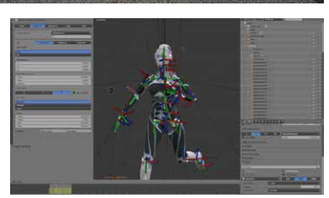
FZI Research Center for
Information Technology at the
Karlsruhe Institute
of Technology (KIT)

#GeneticCode
#Encoding
#Computing
#Robots









Attaining a fundamental understanding of the human brain remains one of the greatest challenges of the twenty-first century. This is why the European Commission is supporting the Human Brain Project (HBP), a major research project that is part of the Future and Emerging Technologies (FET) beacon project. Data and methods from different disciplines are to be brought together for the first time to open up new ways of researching and treating illnesses of the human brain more effectively as well as simplifying people's lives through innovative biologically inspired technologies.

As part of the Human Brain Project, scientists at the FZI Research Center in Karlsruhe are taking part in neurorobotics research. This involves the simulation of entire brain areas, generating tremendous amounts of data. The function of the brain areas can be checked most easily when they are connected to a special robot. The stated goal of the project is to combine neuroscience with robotics and computer science to create a new kind of open research infrastructure which will revolutionize the work of researchers and developers from these fields.

The video documents the FZI's work on the Human Brain Project (HBP).

42

HD video, color, sound, 5:26 min.
2017

Automated and interconnected driving

#MachineLearning
#Labor&Production
#AutonomousSystems
#SelfDrivingCars

FZI Research Center for
Information Technology
at the Karlsruhe Institute
of Technology (KIT)

The FZI develops and tests vehicle systems for automated and interconnected driving. Through the *Baden-Württemberg Test Area for Automated and Interconnected Driving*, tests in real traffic are possible beginning in 2018 in locations ranging from urban areas and inner-city 30 km/h and 50 km/h zones, municipal parking lots and residential areas, to state and federal roads and sections of highways.

Especially under difficult light conditions such as twilight or under difficult weather conditions such as rain and snow, computers can recognize their surroundings only through complex, self-learning algorithms. Scientists at the FZI have developed algorithms for this and tested them in different traffic zones.

Spatial Code Lab

Mixed-media installation
2017

43

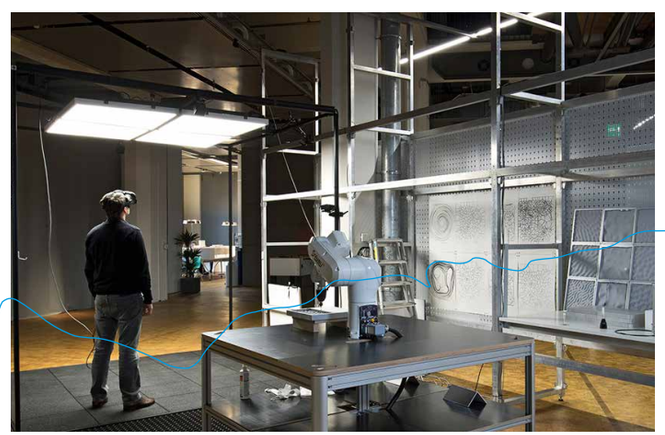
Kristof Gavrielides

#VirtualReality #Labor&Production
#Robots #Software #Hardware
#ComputerSimulatedEnvironments
#Automation

The project *Spatial Code Lab* by the architect and designer Kristof Gavrielides seeks to tap into a current area of research into novel technologies and spatial theories in a compact and accessible way, with the lab serving the purpose of exploring spatial code. This project is being presented to a broader public for the first time as part of the *Open Codes* exhibition.

The lab enables digital information and physical materiality to be recorded and synthesized, researching the new material and spatial forms that emerge from this as well as the associated design and manufacturing processes.

The Spatial Code Lab is composed of two areas that can be used in alternation. First, there is the sensory area where people and objects are recorded three-dimensionally so that this data can be used in real time through virtual reality applications. Second, the lab has a specially constructed robotic unit in the form of a gripper arm with a variety of toolheads developed specifically for it, which enable it to convert the acquired data and design ideas into physical materiality in additive and subtractive processes.



44

Installation
2017

Genealogy of the Digital Code

#GenealogyOfCode
#Encoding
#Computing
#Algorithm
#Software #Hardware

Jeffrey Shaw
ZKM | Institute for Visual Media

The Genealogy of the Digital Code displays the history of digital codes in the form of an interactive wall chart. Monitors move across a virtual panorama, which stretches along the wall space. With the Linear Navigator, visitors can move along a high-resolution timeline and watch short videos embedded in it that visualize the history of the digital code. In this way information can be called up on milestones in the development of computer technology from 1800 to the present-day: development of the binary code, early computers, the first neural network, modern computers, and the development of artificial intelligence. Linear navigation renders the chronology of development easy to grasp.

This virtual timeline is embedded in real infographics, which stretch along the entire wall and further contextualize the virtual chronology.

The Common Sense

5-channel video installation, site-specific installation, 15 LED TVs, powder-coated steel tubes, wireless headphones, HD video, color, sound, each 6–7 min.
2014/15

45

Melanie Gilligan

#AlgorithmicGovernance
#Labor&Production
#BigData #QuantifiedSelf

Gilligan explores the way technologies change our behaviours and our bodies in the 15-part science-fiction miniseries *The Common Sense*, which was produced in three stages. The video series presents the story of a future technology known as "The Patch," which makes it possible to share affective and physical experiences directly with other people. Around ten years later, students in a seminar room take a look back at the changes that emerged from it. The technology, which was initially launched with a great deal of optimism, did not lead to greater understanding either in people's private life or at work, but rather merely promoted capitalist strategies of optimisation. The negative impacts of "The Patch" come to light particularly clearly, when the network fails: Since they are no longer used to being alone without the control or the feedback of the network, all the figures fall into a state of disturbance and disorientation.

In ZKM | Karlsruhe the first five episodes are presented as part of a coherent installation, each on a separate monitor, which is connected with the other monitors by means of steel tubing.

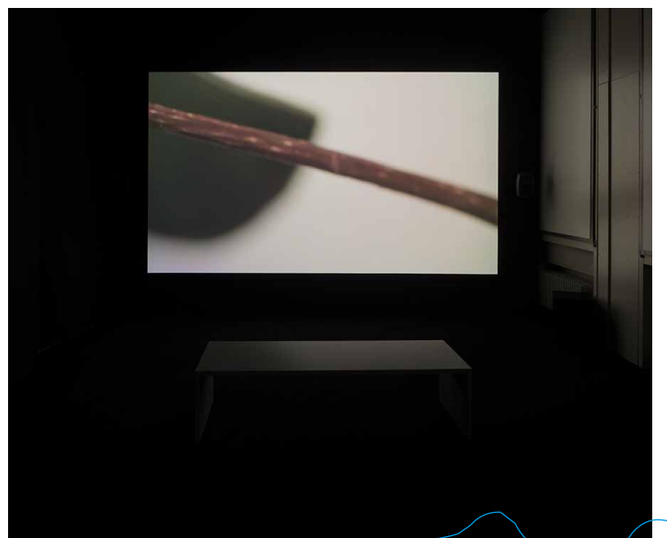
46

2-channel video installation,
HD video, color, sound, loop, 26 min.
2014,2017

The Unmanned

#GenealogyOfCode

Fabien Giraud
Raphaël SiboniV



The Unmanned is a film series that recounts a nonhuman history of technology. Eliminating all instrumental conceptions and at the same time making people a simple expression of its movement, the series traces the path of "unmanned" technology taking the example of self-driving vehicles in contemporary warfare.

In its first season, *A History of Computation*, the artists explore the invention and consequences of modern computation, tracing the history of the algorithm from its emergence in modern mathematics to its deflagration in contemporary computation.

Two episodes are presented at Open Codes in a 2-channel video installation: *1997 – The Brute Force* and *1759 – Mil Troi Cens Quarante Huyt*, which engage with chess grandmaster Garry Kasparov's defeat by the IBM Deep Blue computer on 11 May 1997, and in 1759 calculating the orbit of Halley's comet and predicting its return.

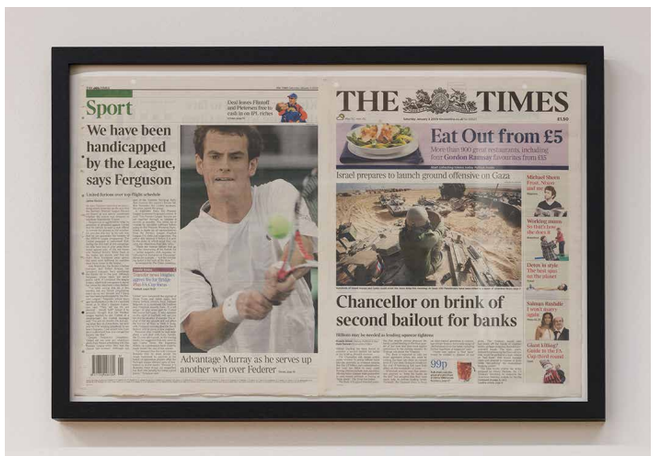
A camera with the same computer-programmed movements scrutinizes both environments in a synchronized play, and explores the consequences of these two historical events strongly connected to the development of algorithms and computation.

Bitcoin ASIC miner, various computers, Times Magazine (courtesy of University Library, Regensburg University) 2017

47

Daniel Heiss

#AlgorithmicEconomy
#AlgorithmicGovernance
#Bitcoin #Cryptocurrencies
#Blockchain



Mining is the process that is used to generate cryptographic currencies such as Bitcoin. Performing a Bitcoin transaction requires that hash values meeting certain requirements be found using bruteforce methods. After this hash value has been discovered, a new block of transactions is added to the blockchain. The first miner who finds a given hash value is also rewarded with a specified quantity of newly generated Bitcoins. The combined computing power of all miners taking part in the Bitcoin network is now many times greater than that of the world's TOP500 supercomputers.

In *KryptoLab*, prospecting for digital gold takes place live on various forms of hardware. Here the rapid development of the hardware, from a simple workplace computer to a highly specialized ASIC miner from China, can also be traced. At a one-shot miner that was specially developed for the exhibition, visitors can press a button to try their luck at mining a block themselves and perhaps winning 12.5 Bitcoins as their reward. The odds of doing so, however, are far lower than the chances of winning the lottery.

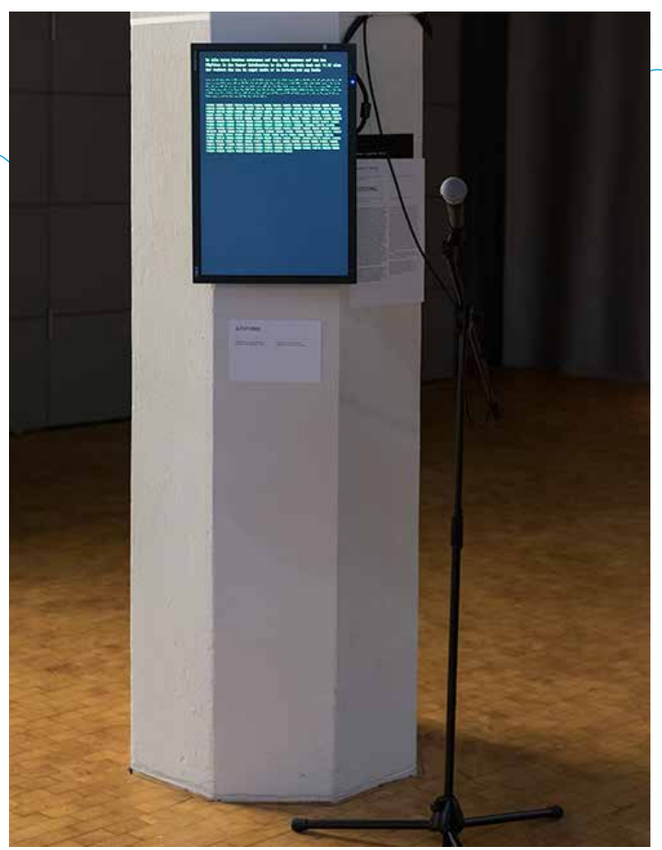
The values generated by the miners in *KryptoLab* are being made available to visitors in a series of workshops as part of the exhibition so that visitors can try out interacting with this abstract medium themselves.

48

Computer, monitors, LED strip
2017

#MachineLearning
#Encoding #MorseCode
#Binary #Algorithm
#Software

Daniel Heiss



For decades, the interface between people and computers was limited to the input of text via a keyboard. The wish for a more intuitive and natural way to communicate with computers, however, goes back at least as many decades.

Only in recent years has direct interaction with computers through spoken language become possible due to tremendous progress in the areas of language recognition and processing (*Natural Language Processing*, NLP). Neural networks make it possible to transcribe the acoustic signal of human language word-for-word into text form. With the help of linguistic models (e.g. word embeddings), the recognized word groups can then be analyzed semantically in order to put the individual fragments in context. Modern algorithms make it possible to use this context to translate text into almost every language in the world in a fully automated way, effectively in real time.

The fictional Babel fish from Douglas Adams' *The Hitchhiker's Guide to the Galaxy* is now within reach in real life.

Speak into the microphone and name the language into which your statement is to be translated. Along with the translation, every spoken word will be reproduced in a linear (one-dimensional) pixel display in the form of optical Morse code.

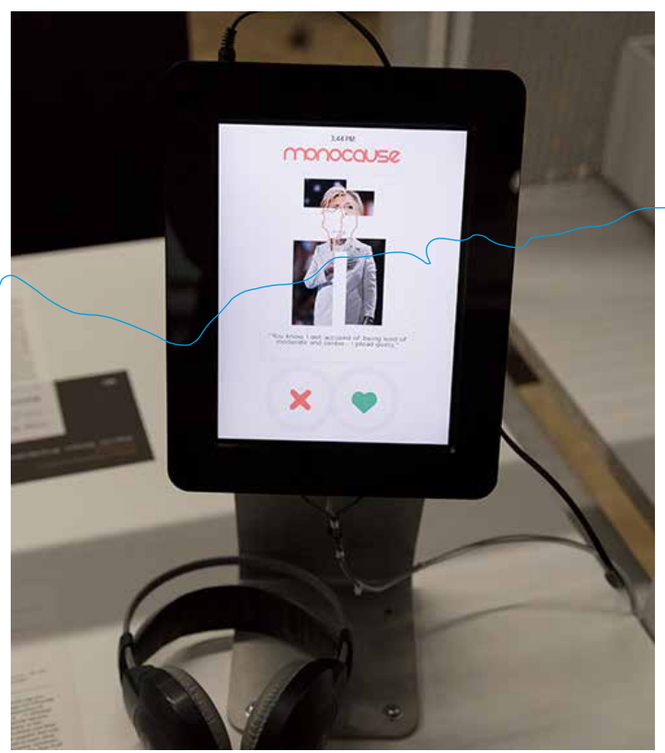
Monocause. Dialectics of the Post-Truth Era

Interactive sound installation, iOS app
2017

49

Yannick Hofmann

#Encoding
#AlgorithmicGovernance
#Binary



It seems as though in the post-truth age processes of public opinion formation are following more and more the exclusive disjunction of mathematical logic ("either ... or ..."). Whether in the context of the US presidential election campaign of 2016, so-called Brexit, or the Hamburg G20 protests, post-truthism and false dilemmas polarize society and suggest that only extremes exist that are opposed to each other (for example like/dislike, black/white, rich/poor). For *Monocause. Dialectics of the Post-Truth Era,* excerpts from various texts and speeches were collected – including, for example, the doctrine of US President Bush in the 2000s ("you're either with us, or against us"). With a swipe, museum visitors can express sympathy with or resentment towards people from A like Adorno to Z like Žižek. The swipe gesture thus becomes the equivalent of the thumbs up or thumbs down hand gestures of Roman emperors at the circus. The interface is based conceptually and in its design on the famous dating app Tinder.

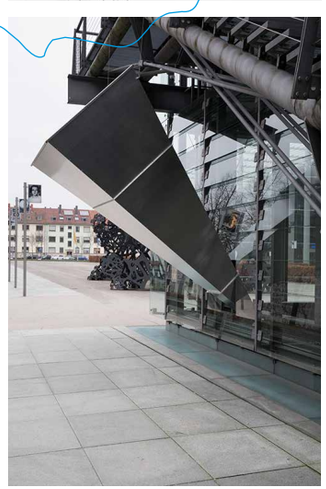
50

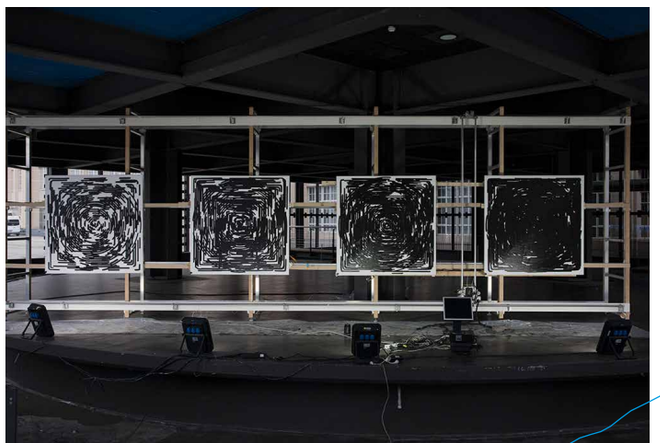
Installation, radio telescope with painting robot
2017

Radio Painting Station: Looking for the Waterhole

#Labour&Production
#Industry4.0
#Robots
#Computing

Simon Ingram





In 2002, physicist Stephen Wolfram asserted that "our whole universe may be governed by a single underlying simple program." ° The complexity we experience in our life world, including us, is the result of a simple program, perhaps one or two lines, that has been running for a long time and for which we have not cracked the code. *Radio Painting Station: Looking for the Waterhole* • takes up this proposition and sets out to observe the cosmos above Karlsruhe at 24:00 hours and plot differences in a series of series of four compositions.

The subject of *Radio Painting Station: Looking for the Waterhole's* observations is the hydrogen line: the spectral emissions produced as neutral hydrogen atoms in the interstellar region undergo a state transition as they absorb energy. The work itself is a *mise-en-scène* where a radio telescope concentrates, filters, amplifies and digitizes these emissions •° for a mechatronic system to codify as a series of paintings in a durational format from December 15, 2017 to January 14, 2018. The chosen concentric mode of visualization has an onomatopoeic relationship with its atomic referent, and allows, through comparison, a language of difference to emerge.

The artist wishes to acknowledge the support of Kamahi Electronics, ZKM, the University of Auckland and the Chartwell Trust.

ICD/ITKE Research Pavilion 2016–17

Glass and carbon fiber structure
2016-2017

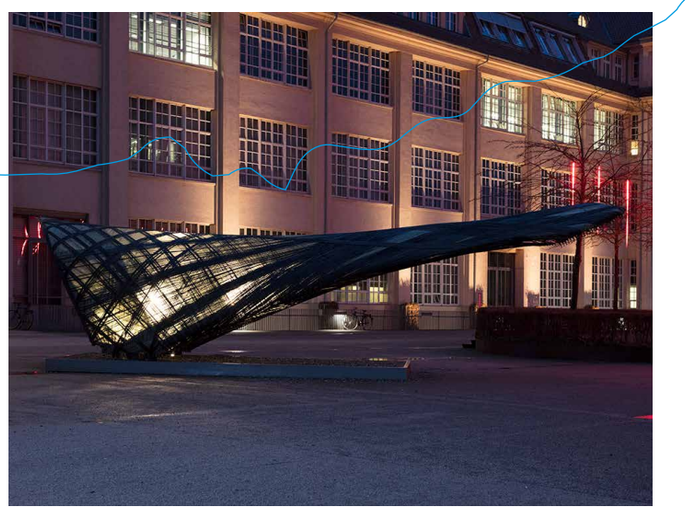
University of Stuttgart:
ICD, ITKE, ITECH

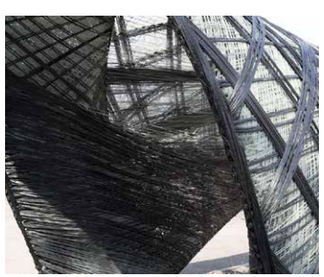
#MachineLearning
#Labour&Production
#Industry4.0 #PatternRecognition
#AutonomousSystems
#Drones #Robots #Automation

The ICD/ITKE have completed a new research pavilion that explores building-scale fabrication of glass and carbon fiber-reinforced composites. The novel process is based on the unique properties and characteristics of fiber construction. Because these materials are lightweight and have a high tensile strength, a radically different approach to fabrication becomes possible that combines low payload yet long-range machines, such as unmanned aerial vehicles (UAV), with industrial robots with a strong, precise, yet limited reach.

The *Research Pavilion 2016–17* was created by laying combined a total of 184 km of resin-impregnated glass and carbon fiber. The lightweight material system was used to create and test a single, long-spanning cantilever with an overall length of 12 meters as an extreme structural scenario. The surface area is around 40 m² and weighs roughly 1,000 kilograms.

This research showcases the potential of computational design and construction through incorporating structural capacities, material behavior, fabrication logics, biological principles, and architectural design constraints into integrative computational design and construction.





OpinionMap: What Should One Eat?

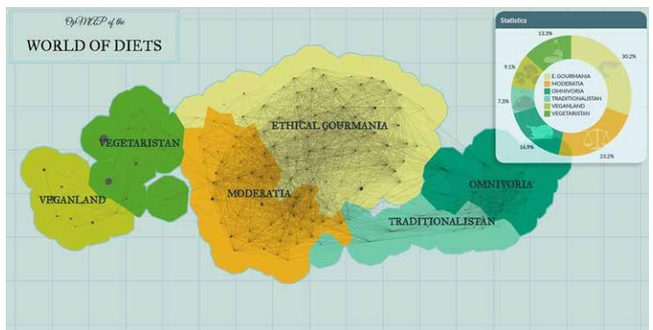
Software
2017

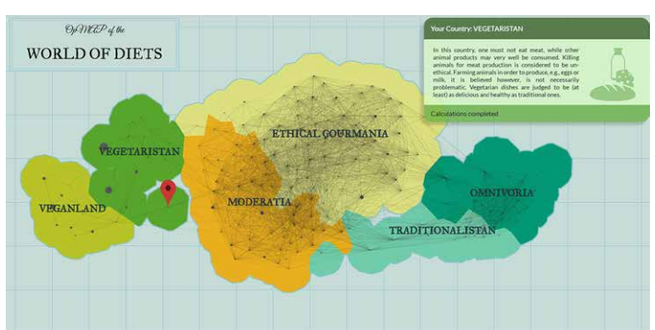
52

Gregor Betz
Michael Hamann
Tamara Mchedlidze
Sophie von Schmettow
Christian Voigt

#AlgorithmicGovernance
#BigData #Algorithm
#Software #Interface
#QuantifiedSelf

There exist a variety of views about what one should eat. And people may advocate a certain diet for quite different reasons – financial, culinary, ethical, or health considerations, amongst others. In order to make sense of this variety of opinions we visualize them in the form of a map. Here, people who have the same view on what a good diet looks like, as well as similar reasons for their opinion, are part of the same "country." For example, persons who advocate an omnivorous diet mainly for the pleasure of eating are "citizens" of "Omnivoria;" others, who prefer a vegan diet because they hold that animals have a right to life, are found in "Veganland." The size of these countries represents the number of persons that actually have a corresponding point of view. The application OpMAP, behind the visualization, runs in a web browser and allows the user to locate themselves on the map by taking the short survey that was also used to gather the initial data to create the map. The animated map shows how landmasses are shifting as more and more data come in.





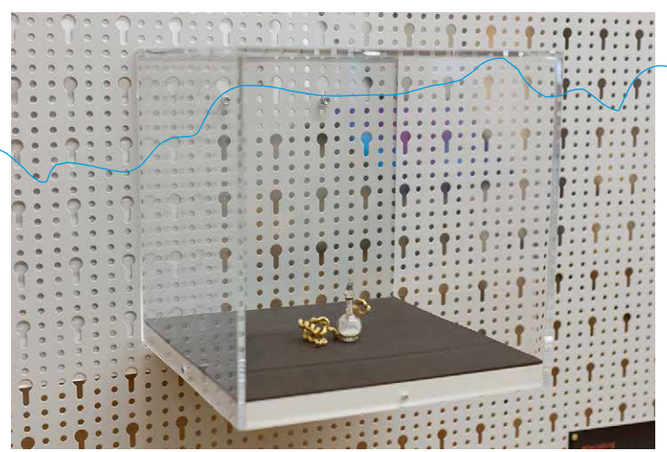
53

Objects, glass, purified "Genesis" DNA, gold, wood
2001

Transcription Jewels

#GeneticCode
#DNA
#Phenotype
#DNADataStorage
#Genotype

Eduardo Kac



Transcription Jewels is a sculptural artwork comprised of actual "Genesis" DNA (inside a genie bottle with gold ornaments) and a gold cast of the "Genesis" protein. This "artist's gene" was created by Kac by translating a sentence from the Bible's Book of Genesis into Morse code, and converting the Morse code into DNA base pairs according to a conversion principle specially developed by the artist for this work. By displaying the synthetic gene and its corresponding protein as coveted valuables, *Transcription Jewels* comments on the process of commodification of the minutest aspects of life. Both the synthetic gene in *Transcription Jewels* and its protein are not derived from a natural organism, but were first created specifically for *Genesis* (1998–1999), which is a transgenic artwork that explores the intricate relationship between biology, belief systems, information technology, dialogic interaction, ethics, and the Internet.

The Trial of Superdebt-hunterbot

Installation, HD video, color, sound, 45 min., birch laminate ply and leatherette jury bench, 5 drawings
2016

Helen Knowles

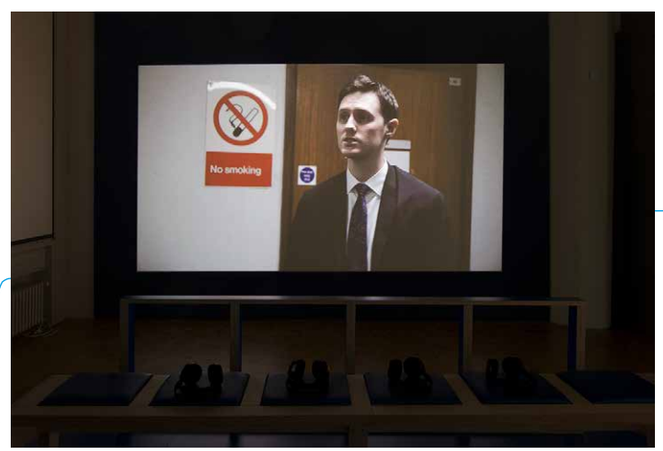
54

#AlgorithmicGovernance
#MachineLearning #Algorithm
#PatternRecognition #BigData
#ArtificialIntelligence

The Trial of Superdebthunterbot seeks to explore questions of ethics and accountability in relation to the increasing and often unseen computer automation of our lives.

The work imagines a speculative scenario in which a debt collecting company, Debt BB, codes an algorithm, the "Superdebthunterbot," to ensure fewer loan defaulters by targeting individuals through the use of big data, placing job adverts on web pages they frequent. Five individuals have died as a result of the algorithm's actions. The work illustrates the fictitious trial of this intelligent algorithm, and raises the question of who is accountable for machine-learning agents. Can the said algorithm, on trial for manslaughter, be found guilty by the fictional "International Ether Court"? The work is an exploration of the materiality of algorithms and the way in which we can judge their intellectual capacities before the law.

The prosecution and defense speeches were written and presented by two lawyers, Oana Labontu Radu and Laurie Elks, and TV actor Mark Frost played the role of the judge in front of a jury made up of volunteers. The film was shot at Southwark Crown Court, London.



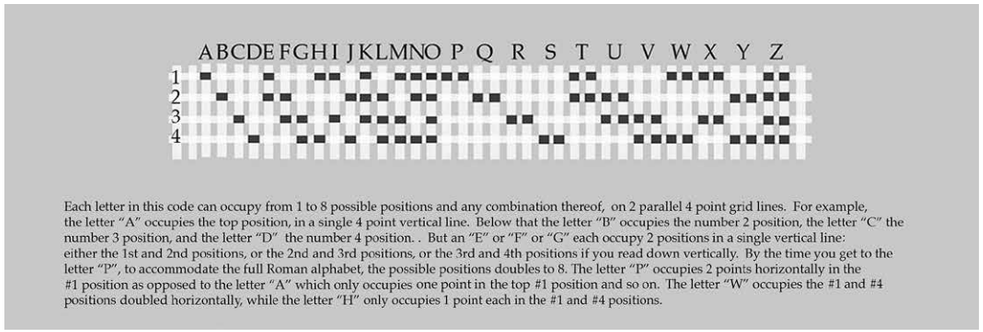
Babel 1
Babel 2

Pigment on handwoven linen, photographic reproduction, 77.7 × 58.9 × 6.4 cm
Pigment on handwoven linen, photographic reproduction, 183 × 98.4 cm
1980

55

Beryl Korot

#Encoding
#Decoding #Babel



In 1980 Beryl Korot began a series of coded works on handwoven canvas that are a translation of the ancient Tower of Babel text in the Book of Genesis. The world of Babel in Mesopotamia in ca. 3,000 BCE was a world moving away from a herding society toward a more agricultural and urban society. It was a world impacted by bitumen, used as mortar for fired bricks, as the society transitioned from a gods-centered world to one more human-centered where the bricks themselves – and the ziggurats containing them – were worshipped. The Bible story questions the social implications of such an advance in technology. The unity expressed in the first line "and the whole Earth was of one language and of one speech," is replaced at the end of the story by a scattered race of humans who no longer understand one another.

The abstract coded language itself can be contemplated as pure form, as it reveals the universal shape of all language: small packets of information placed in a linear manner, separated by spaces, whether horizontal or vertical.

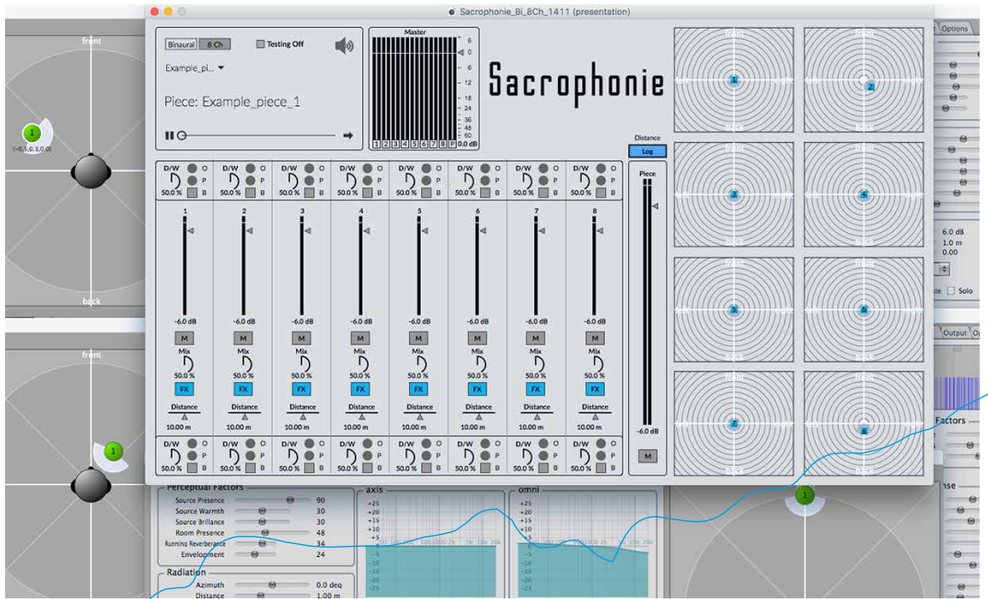
56

Interactive sound installation
2017

Sacrophonie

#Encoding
#ProgrammingSound
#Interface

Anton Kossjanenko



In the sound installation *Sacrophonie*, sounds that have been recorded at the religious functions of various cultures and faith traditions, including the sound of leafing through a prayer book, Japanese ceremonial hand clapping, the blowing of the shofar, and the ringing of church bells, are treated as a code. Through this code, people seek to establish contact with God. The inclusion of songs, sacred texts, or prayers – that is, sounds that clearly relate to a specific religion – has been deliberately avoided. The intentional background and ambient sounds that accompany rituals, on the other hand, have been recorded and compiled.

In the exhibition, visitors can call up and play sounds from a "library" of compositions and sounds that is made up of the recorded sounds of rituals. Via built-in sensors and with the help of exhibited artifacts, these sound compositions can in turn be tonally altered and moved in virtual space.

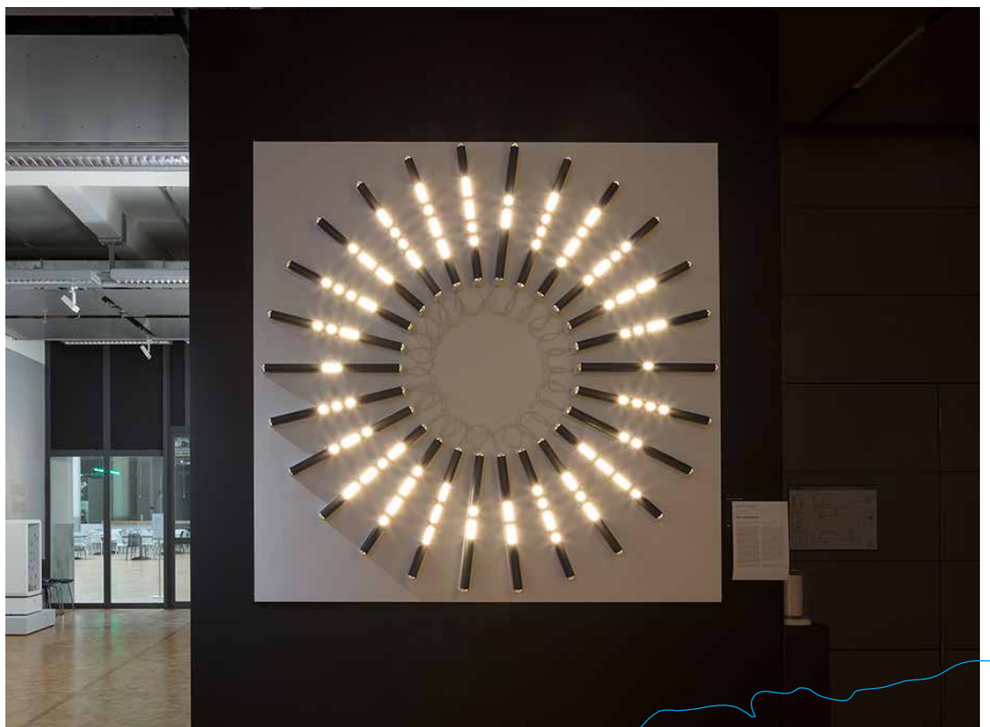
Morse Alphabet

Light installation, Fluorescent lamps, acrylic glass tubes, lacquer
1998

57

Brigitte Kowanz

#Encoding
#Decoding
#MorseCode



"Only few artists were in a position to comprehend this challenge posed by technical media and their impact for classic art media. Brigitte Kowanz is one of the few artists who were able to do so. By forming words and codes with artificial light and fluorescent tubes, she writes with light. [...] Her light writing is consequently not an illustration of sensual natural reality like in the medium of photography; her light writing is a concept writing (ideography) instead, i.e., a code. In order to more or less emphatically call the attention of the art public to this significant break with the tradition of the pictorial code, she employs the exemplary code per se, namely Morse Code. There are three Morse characters: short signal, long signal and interval. These characters are transmittable as sound or radio signals, as an electrical impulse by means of a push-button through interruption of a constant signal via a telephone line as well as optically with the switching on and off of longer light signals. Morse Code consists of standardised sequences of short and long signals called dots and dashes. [...] Morse Code is the first code of electromagnetic space or disembodied virtual space, respectively. Light is immaterial and an electromagnetic wave." °

58

Video, based on software, 12:15 min.
2015

sketch_150709b

#Encoding
#Software
#Algorithm

Mattis Kuhn

The video shows how the programming language Processing can be used to repeatedly generate an identical image in different ways: a black square against the neutral gray background that is typical for computer applications. The first algorithm that creates this black square consists of just three lines of code, and shows the simplest and most conventional way to program, but more complex, peculiar or abstruse algorithms are used thereafter, as are various programming techniques, prefabricated objects, points, lines and surfaces, all of which, however, ultimately create the same image.

sketch_150709b interrogates the meaning of code in relation to its visual output. What is the relevance of the way the result is produced if it is not reflected in the outcome? What significance is to be ascribed to that which is not visible? Does the subjective perspective change in the interplay between the visible algorithm as a program and the invisible algorithm in the square that is generated? (Mattis Kuhn)

The Show Must Go On.

Online news channel
2017 ongoing

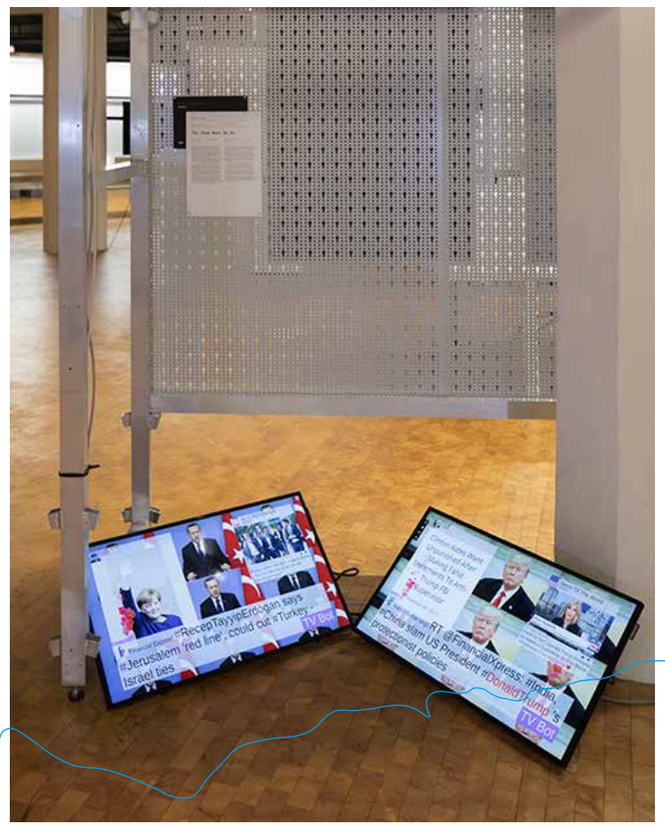
59

Marc Lee

#AlgorithmicGovernance
#BigData

The German federal election is made for the big stage of the media: staged reality TV shows are sold as political debates, and "stars" like Angela Merkel and Martin Schulz conquer the stage armed with perceived facts. Political opinion-making is served up in easily digested tidbits that circulate on Facebook, Twitter, and other digital platforms. Social media have become firmly established as a key player in election campaigns.

The online work *The Show Must Go On*. presents the self-perpetuating maelstrom of a social media-fueled election campaign as exaggerated, absurd theater. The latest Twitter, Instagram, and YouTube posts containing the political parties' and leading candidates' key terms are selected and woven together by a bot into a wild live TV program in which images, tweets, and videos flicker across the screen in real time and icons in the signature colors of the contestants' political parties display their current online market value.



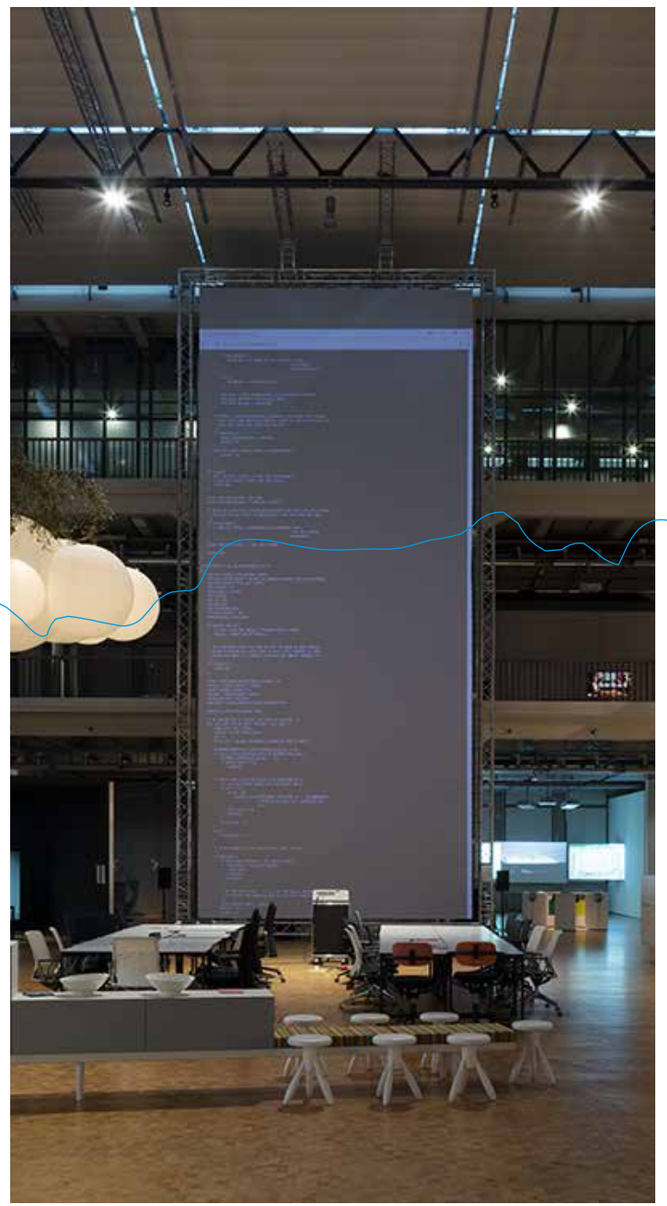
60

JavaScript, HTML, CSS, Apache HTTP Server source code (written in C)
2013

Portrait of a Web Server

#Encoding
#Software
#SourceCode
#Computing

Jan Robert Leegte



We see the source code of *Apache*, an open source web server program, which can run on multiple operating systems, cascading down the screen at an illegible speed.

Apache played a key role in the initial growth of the Internet, and remains to this day the most widely used web server software. Its source code is a collection of instructions for programmers written in the C programming language. As in this case, source code is a non-executable file; there are often several steps between the original source code typed by a human and an executable program.

The work evokes the objectives of the Art & Language group (founded c. 1967 in Great Britten); namely, a shift from nonlinguistic forms to text-based art forms. A similar shift can be observed here: a pre-photographic portrait was supposed to reveal social status, whereas avant-garde portraits tend to reveal the personality of the depicted. In the case of *Portrait of a Web Server* the latter applies; the very soul of *Apache* runs down the screen, albeit in an elusive and inaccessible manner.

In this piece of net art, code has not just taken over the centuries-old genre of painting, it has attained the status of an influential medium.

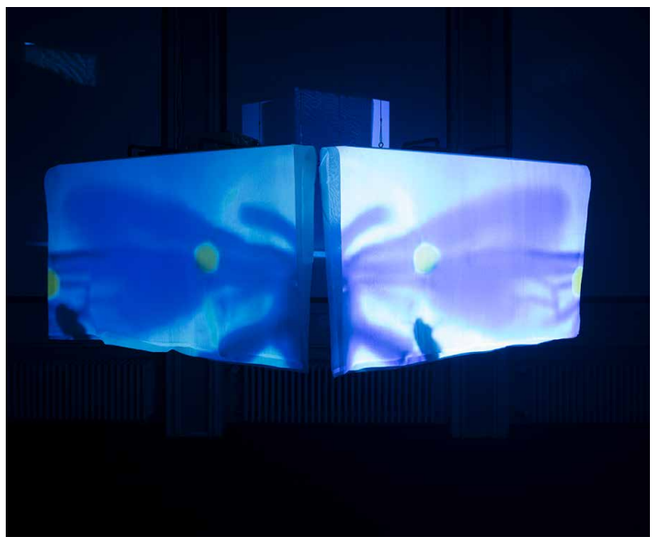
Drone

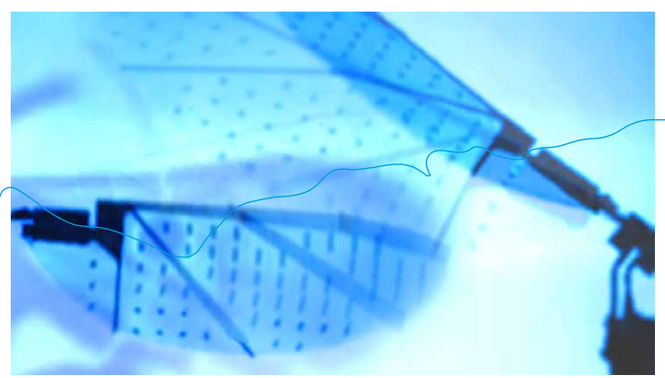
2-channel video installation, color, sound, loop, 5 min.
2017

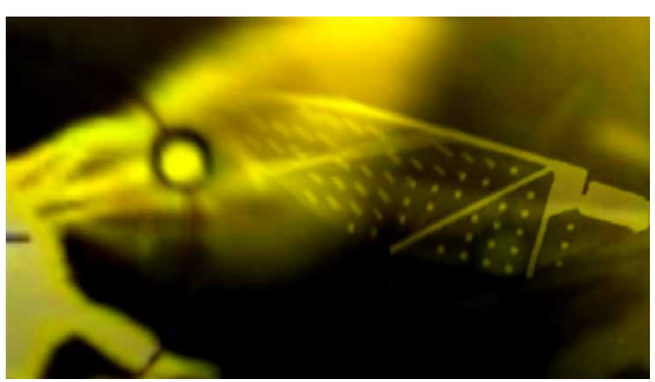
61

Donna Legault

#Labour&Production
#Industry4.0
#Drones #Automation
#Programming







Drone draws on research into the physical dynamics of insect flight and behavior to offer a multisensory installation informed by the integration of video projection with live immersive sound. The five-minute looping video is produced by merging images appropriated from scientific experiments documenting the wing beat patterns of bees with documentation of their robotic counterparts that are currently being developed by microrobotics labs in the USA and Japan.

The projection of light in collaboration with participants' movements produces a soundscape that is tuned to frequencies specific to the drone of bee flight and communication behaviors. This live soundscape is generated by custom electronics and sensors positioned on the back of each of the speakers that act as a series of projection surfaces and interactive sonic interfaces. As people circulate in the space, their movements periodically disrupt the projection of light, which influences the pattern of sound produced by the corresponding speaker. This arrangement gives participants access to a speculative engagement with the tangible sonic experience of bee activities.

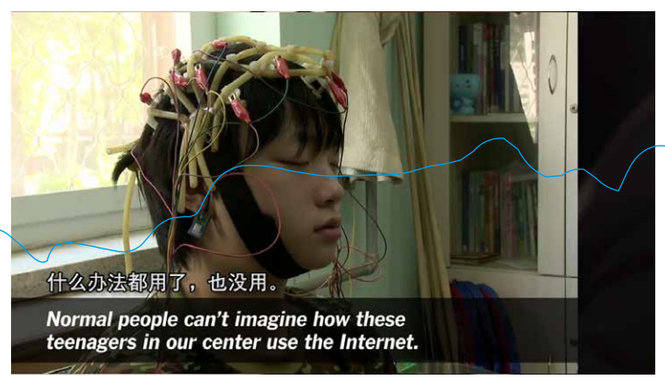
62

HD video essay, 60 min.
2016

#MachineLearning
#AlgorithmicGovernance
#GenealogyOfCode
#ArtificialIntelligence
#Computing

Lawrence Lek

Sinofuturism (1839–2046 AD)



Sinofuturism is an invisible movement. A specter already embedded in a trillion industrial products, a billion individuals, and a million veiled narratives. It is a movement, not based on individuals, but on multiple overlapping flows. Flows of populations, of products, and of processes. Because *Sinofuturism* has arisen without conscious intention or authorship, it is often mistaken for contemporary China. But it is not. It is a science fiction that already exists.

Sinofuturism is a video essay combining elements of science fiction, documentary melodrama, social realism, and Chinese cosmologies, in order to critique the present-day dilemmas of China and the people of its diaspora.

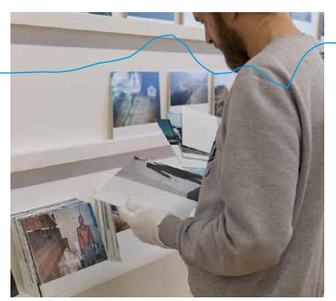
In many Western media outlets, China is portrayed as exotic, orientalized "Other"; in its domestic media, China is portrayed as heroic and unified. But rather than counteracting these biased narratives, *Sinofuturism* presents a critical and playful approach to subverting cultural clichés. By embracing seven key stereotypes of Chinese society (computing, copying, gaming, studying, addiction, labor, and gambling), it shows how China's technological development can be seen as a form of artificial intelligence.

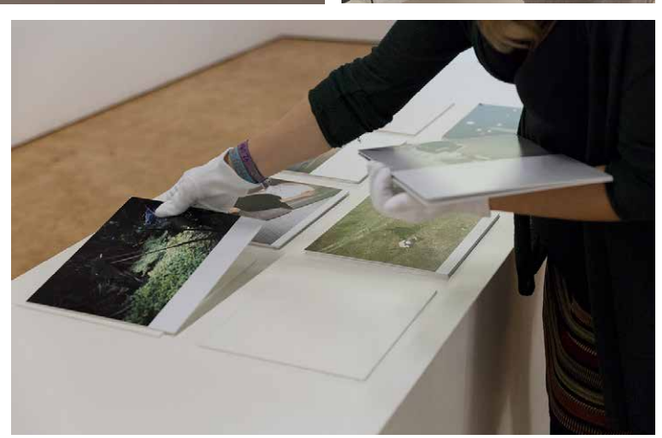
Phenotypes/ Limited Forms

Interactive installation, photographs, RFID Tags, 16 RFID readers, 2 touchscreens, 2 PCs, 2 BOCA micro-ticket printers, thermal paper tickets, video projector
2007

Armin Linke

#Encoding #Decoding
#Phenotype #Interface





Armin Linke's installation *Phenotypes/Limited Forms* explores ways of making his online photo archive publicly accessible. As an interactive Internet project, *Book on Demand*, his photo archive was already presented as part of *Utopia Station* at the Venice Biennale in 2003. Linke's online archive contains photographs of locations in Nigeria, China, Cyprus, of the G8 Summit in Genoa, a NASA base in California, and of documenta in Kassel, Germany. *Phenotypes/Limited Forms* is not so much about a museum-like reconstruction of a technological and virtual process (book on demand), it is rather a poetic transfer. *Phenotypes/Limited Forms* leaves the virtuality of the Internet in that its spatial design for the exhibition transports the process of actively engaging with pictorial knowledge into a physical space.

This artwork is the result of collaboration between Armin Linke, Wilfried Kühn, the ZKM | Karlsruhe (Peter Weibel), and the Sony Computer Science Laboratory in Paris (Peter Hanappe).

CloudBrowsing: Open Codes

Interactive installation
for the PanoramaScreen
2009/2017

64

Bernd Lintermann
Torsten Belschner
Mahsa Jenabi
Werner A. König

#GenealogyOfCode
#Computing
#Interface

Conceived and created in 2009 the interactive installation *CloudBrowsing* makes searching for information on the Internet experienceable in a novel way. The installation turns "browsing the Web" into a spatial experience within a panoramic projection environment. Search queries and results are not displayed as text-based lists of links but as a dynamic collage of images and sounds. The content-based relations as well as the search histories and the information retrieval are not only visualized as a landscape of images but also audible as a dynamic soundscape that changes. The user browses the free online encyclopedia *Wikipedia*, which is compiled by a global community and thus exemplifies the collective knowledge of the Web. A mechanism for showing selected content was added later: the user can browse curated collections of links referring to selected topics.

In the version *CloudBrowsing: Open Codes*, realized for the exhibition, the audience is provided with information about the history and future of digital technology.

65

Interactive augmented reality
installation for iPad and HoloLens
2017

Site Map: Open Codes

#Encoding
#Interface
#AugmentedReality

Bernd Lintermann
Jan Gerigk

Site Map: Open Codes is a further development of the augmented reality installation *Traffic*, which the ZKM | Institute for Visual Media produced in 2011 for the exhibition *Car Culture* at the ZKM. The visitors receive a prepared iPad with which they can see a virtual, dynamic installation on the ceiling of the exhibition that represents a map of Germany. At certain places on this map are hovering sheres, which at irregular intervals descend from the ceiling down to the level of the observer. Through these sheres, the installation develops into a walkable map that is experienced physically and with which visitors can get themselves moved to selected places visually. The sheres show filmed 360° views of institutions, people, and places that are connected with the development of digital media. When visitors enter one of the sheres, they take over the position of the camera that filmed the images and can watch the VR movie by turning the tablet in all directions. In one of the versions for the augmented reality smartglasses HoloLens, the virtual scenery merges with the real place of the exhibition

SoundARt IDEAMA

Interactive augmented reality installation,
AR audio database browser for iPad
2012

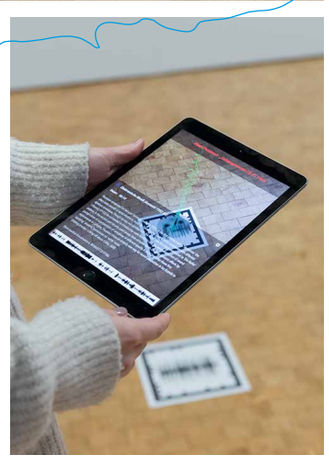
66

Bernd Lintermann
Julia Gerlach
Peter Weibel

#Encoding
#ProgrammingSound
#Interface
#AugmentedReality

The IDEAMA (International digital electro-acoustic music archive) was created in 1990 with the aim of globally protecting the most important early works of electro-acoustic music against deterioration, and make them accessible to the public. The IDEAMA basic collection consists of over a hundred hours of music, which is part of the holdings of the ZKM | Media Library.

SoundARt IDEAMA presents selected works from the music archive. At four stations, works from the areas of musique concrète, electronic music, computer music, and music for loudspeakers are staged in special ways and made available to visitors. On a beam showing computer-readable codes, four topics from the IDEAMA database are marked out as examples: for each work a square code – similar to the familiar QR-code – is applicated on the floor as well as an oscillograph of the work. With the aid of an on-site rentable iPad, the work can be experienced, heard, and seen in a 3-D simulation as augmented reality experience as soon as the iPad's camera registers the code. Here, the iPad functions as a pickup which scans the sound carrier.



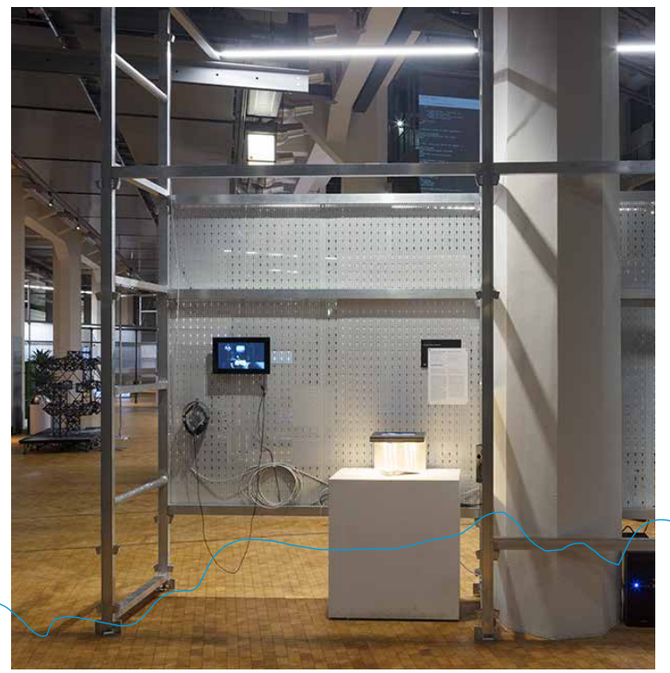
SynSeeThis

67

iOS app for iPad
2013

#Encoding
#ProgrammingSound
#Interface

Bernd Lintermann
Manfred Hauffen
Peter Weibel



SynSeeThis is an app for iOS, which was created for the performance *The Origin of Noise – The Noise of Origin* by Peter Weibel for the Donaufestival 2013 in Krems, Austria. The app is a visual musical instrument, which generates a feedback loop of images and sound.

For the installation in *Open Codes*, an iPad is fixed to a mount. If a page from the book included in the installation is placed in the visual range of the iPad's built-in camera, the image recorded by the camera is transformed into sounds. The pages of the book show various visual patterns, which all generate specific sounds. For the concert in 2013 software was also used, which reconverts the created sounds into images by utilizing the Fourier transform, and these are again visually recorded by the app and transformed into sound. Thus a feedback-loop of data transformation is created through the modalities of image and sound. Additionally, the camera picture is interpreted spatially as a by-product and projected as a stereoscopic 3-D projection above the protagonist of the performance, Peter Weibel. With the app, he interpreted the visual music score on the stage.

Three Phases of Digitalization

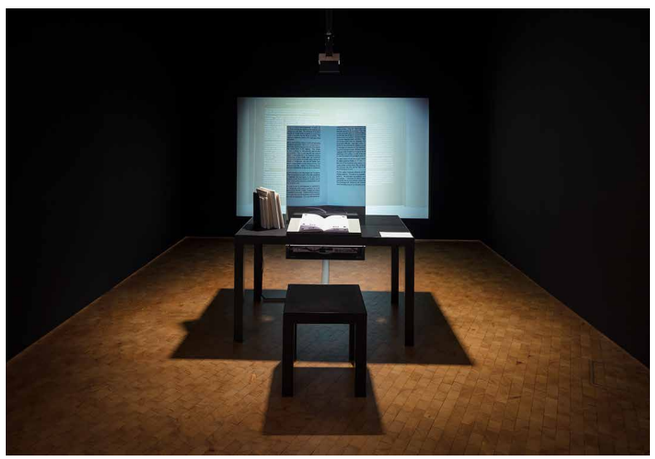
Interactive installation with polarized light
and augmented reality technology
2017

Bernd Lintermann
Nikolaus Völzow

#Encoding
#GenealogyOfCode
#Interface
#Software

While the material book as sole bearer of textual information is increasingly being supplanted by the Internet and other electronic forms of publishing, the experience of digital reading is moving in the opposite direction: in the world of computer, computer network, and hypertext at first the book was completely transferred into an electronic format. Over the course of the development of electronic publications, however, they have gradually resumed making metaphorical reference to the book form and systematically implementing the book metaphor in software. In the latest phase, the book as an electronic device has come to imitate the physical and media characteristics of the traditional codex.

The reading stations of *Das Verschwinden des Buches* [The Disappearance of the Book] represent the next step in this shift: a camera mounted above the reading surface records a book lying there, the pages of which are empty save for page numbers. A projection made of pure white light is located in front of the observer. When viewed through a polarization filter, an image becomes visible, showing the digitally reconstructed book. Through augmented reality technology, the empty pages of the real books are filled with digital content in the projection. The book is an interface.



Three Phases of Digitalization

Interactive installation with polarized light
and augmented reality technology
2017

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Nikolaus Völzow

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VRMe

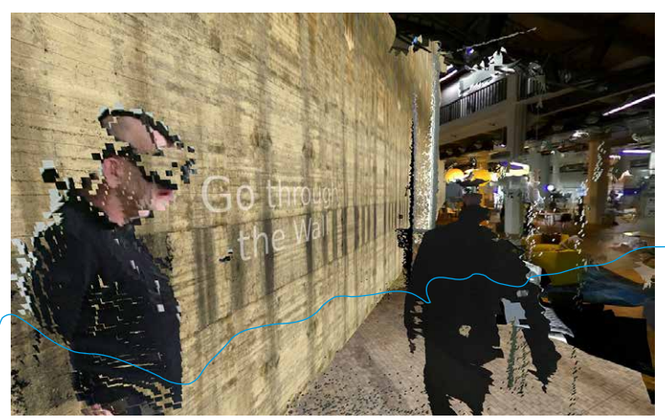
Interactive installation for VR headset
2017

69

Bernd Lintermann

#VirtualReality
#Escapism #HMD
#ComputerSimulatedEnvironments

Currently, one of the much discussed developments in the field of digital media is virtual reality. In the 1990s, the concept of computer-generated reality, which had already been developed in the 1960s, was hyped to such an extent that it also reached a wide audience. The idea of diving into a virtual reality, and thus implicitly leaving the "real" world, elicited many types of reactions, from euphoria to rejection. The state of technology at that time, however, did not live up to people's expectations of VR. In the meantime the advanced quality of image and tracking technology enables such a high degree of immersion that viewers experience themselves and their bodies as a natural part of the virtual scenery. Whereas with traditional media the observer's body is located in front of the image, in virtual reality it is experienced as part of the action. *VRMe* thematizes this new corporeality by confronting the viewers with various representations of their bodies in virtual reality. According to recent scientific findings, this new corporeality significantly contributes to the manipulability of users, for example, for medical purposes but also for marketing purposes and political ends.



70

Interactive installation
2014

The Qualified Life

#Labor&Production
#Industry4.0 #SmartFactories
#BigData #QuantifiedSelf
#Interface
#Work4.0

Fei Liu

The Qualified Life is an interactive installation that imagines the future of the workplace as a fully automated and gamified system that entrusts algorithms with determining the qualifications of employment.

The player is introduced to Taylor Health, an innovation start-up looking to recruit top talent, and must win a series of challenging and bizarre games in order to become employed at the company.

The Qualified Life offers a humorous critique of the post-industrial Taylorist-Fordist "always on" culture of productivity and efficiency that destroys the 40-hour workweek. Through the game-like experience, the player develops an understanding of the relationship between ergonomics and corporate wellness as forms of organizational science and social control. How do we disguise the leveraging and monetizing of a workforce into something fun? When do technological solutions turn into problems?

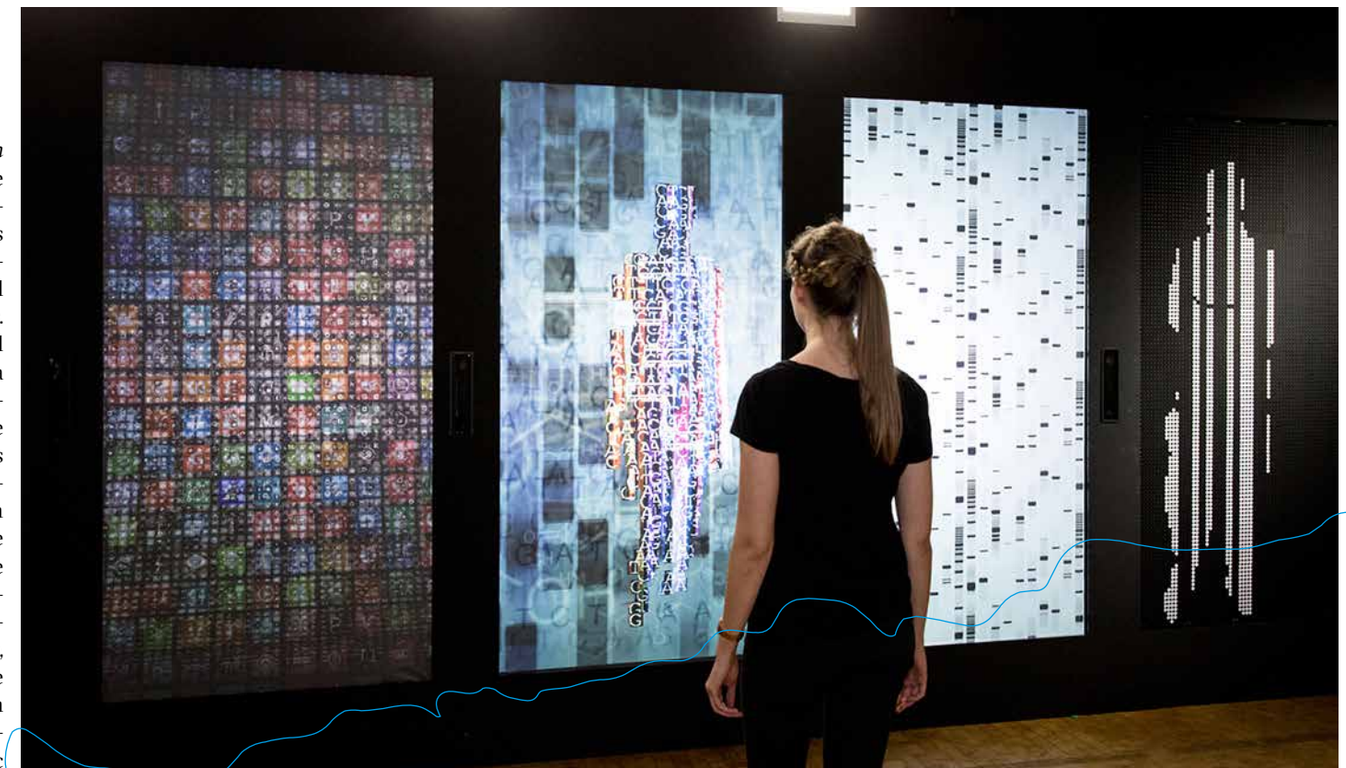
YOU:R:CODE

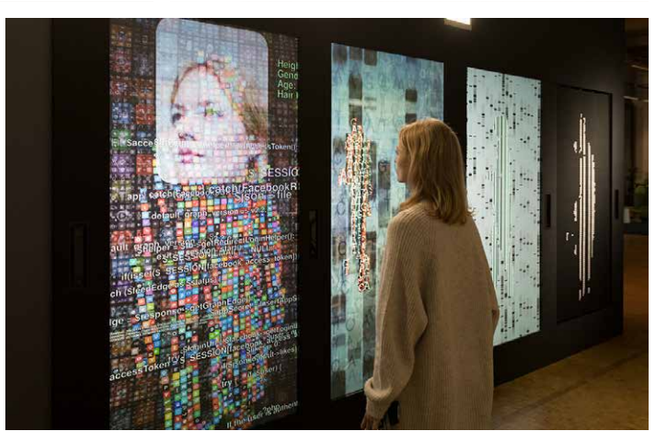
Interactive installation with
multi-channel projection
2017

Bernd Lintermann

#Encoding #GeneticCode
#Decoding #Software #Hardware
#Interface #SourceCode #QuantifiedSelf
#ArtificialIntelligence

YOU:R:CODE opens the *Open Codes* exhibition. The title can be read in two different ways: the interpretation "your code" indicates that in the installation visitors experience different kinds of digital transformations of themselves. Whereas on entering, a visitor still sees their familiar reflection in a mirror – the most real virtual depiction that we can imagine – the mirror image gradually transforms into a digital data-body until finally, the visitor is reduced to an industrially readable code. In the end he/she breaks free from the virtual depiction, and is materialized in a flip-dot display. The second way of reading the piece's title, "you are code," emphasises that we ourselves consist of code, which amongst other things is manifested in the genetic code. The genetic code constitutes the algorithm of life and from birth it determines what we do. In current research projects synthetic DNA strands even serve as long-term storage for digital data. And for the data analysts and artificial intelligences operating in cloud computing, too, which via smartphones give us our daily instructions for acting, we are only perceived in a mediated way in the form of sensor data and via our electronic traces and expressions – to them we are codes.





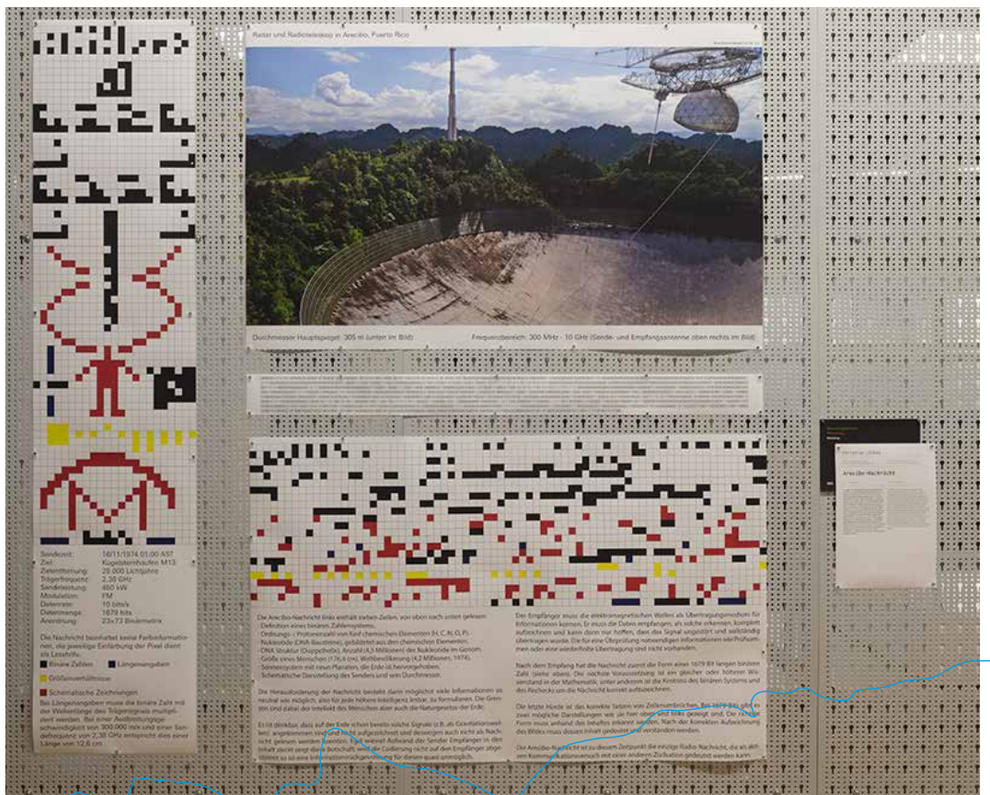
Arecibo-Nachricht

Installation
2017

72

Christian Lölkes

#GenealogyOfCode
#Encoding
#Decoding



In 1974, scientists used the largest radio telescope in existence at the time to send a message into outer space in the direction of galaxy where alien life forms were believed to exist. Apart from the question of whether it was strategically wise for humans to draw attention to themselves in this manner, the transmission of this message itself presented a challenge: how to encode the information so that any sufficiently intelligent being would be able to decode it? A general message is impossible because one is bound to one's own intelligence and physics. While everyone on earth knows binary states and rectangles, an *Arecibo-Nachricht* [Arecibo Message] based on them would be unrecognizable to beings who know no discrete states and no angles due to the physics of their planet.

73

Installation
2017

#Encoding
#Software

Christian Lölkes

Code Styles

However rigid and inflexible programming languages may appear to be, programmers and all programming languages have enough latitude for writing code. Programmers can even develop their own style as long as they stay within the normal range of rules and guidelines while programming. This applies to the sheer written form of the code as well as the typical program sequences and the naming of the usual variables and functions. Coding is nothing more than the translation of computer commands by and for people. If it is written according to the given guidelines, it can be understood by other people. If it is not, it remains a mystery to everyone except the programmer. A broad range of optical and logical tricks for creating code also emerge, much like with an artwork.

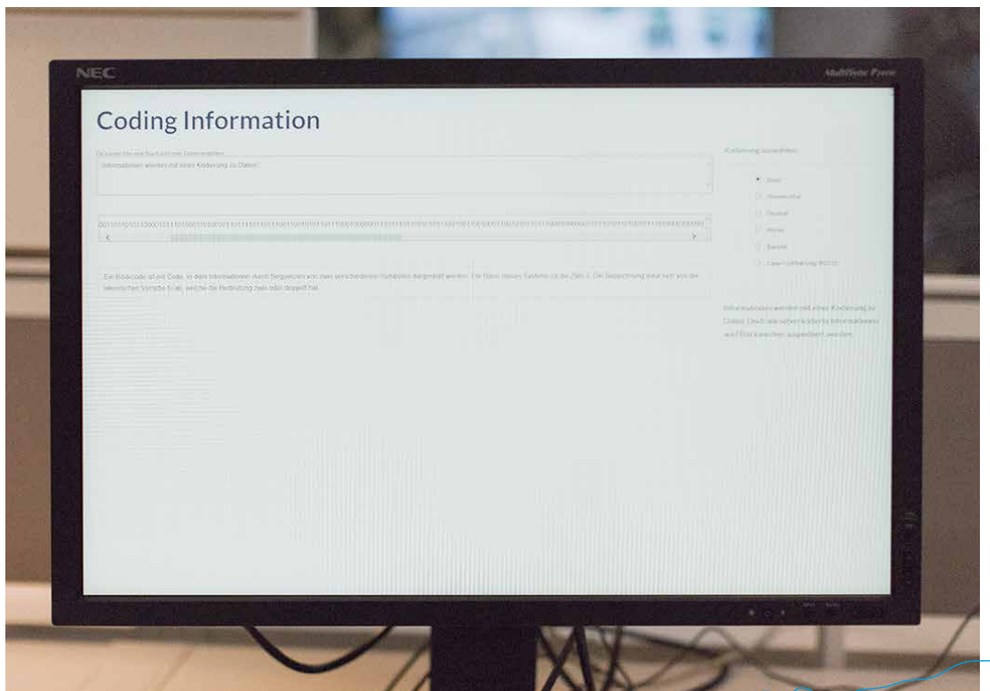
Codierte Informationen

Installation
2017

74

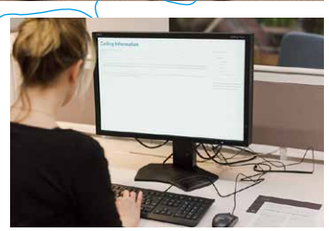
Christian Lölkes

#Encoding
#Decoding



For messages to be able to be transmitted and saved, they must be coded [and thereby are transformed into *Codierte Informationen* [Coded Information]]. A variety of processes and algorithms ensure that the content of the message remains unaltered in this coding process in every medium: first, the information has to be prepared for the physics of the relevant transmission or storage medium. Second, an array of security mechanisms ensures that even if the data is partially lost, the content can often be reconstructed without any errors thanks to redundancy.

In the present, shared mediums, such as air, play a challenging role, because, in the face of physical limitations, ever more participants who are ever more separate from one another want to transmit data via a shared medium. Here too, coding comes into play, as it uses a variety of tricks and rules to divide the medium among the participants.



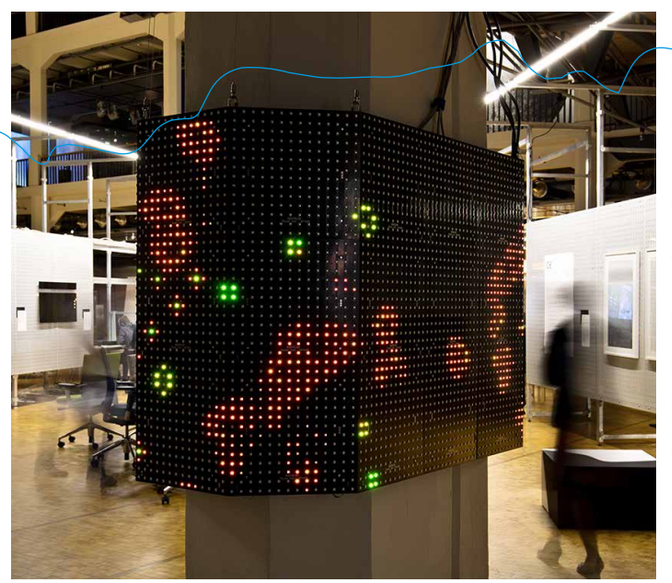
75

Installation
2017

Game of Life

#AlgorithmicGovernance
#GenealogyOfCode

Christian Lölkes



In *Conway's Game of Life*, a population simulation is carried out by a cellular automaton on a two-dimensional playing field according to a certain set of rules. The rules consist of four specifications that are applied depending on the number of neighbors (standard values): birth (an empty cell has exactly three neighbors), living on to the next generation (a live cell has two or three neighbors), death by loneliness (a cell has fewer than two living neighbors) and death by overcrowding (a cell has more than three living neighbors).

This set of numbers provides the foundation for periodic structures to appear, run their course, and their termination. This simulation is also used in other areas, including in business and in the natural sciences.

According to John Horton Conway's principle from 1970.

Sound of Sorting

Installation
2017

76

Christian Lölkes

#Encoding
#Algorithm

Sorting processes are essential components of codes and algorithms in their everyday processing of data. They bring order to the data sets that is based on values and parameters, which they had received beforehand. Unlike humans, who solve such tasks in a way that is slower, more intuitive, and mainly visual, computers are challenged to execute tasks with maximum efficiency in terms of time, storage, and resources.

For example, these processes sort search results by hit ratios, transport routes according to distance, or workflows by dependency on one other. Each process reaches the same goal with different procedures. If one then associates a sound with each data set and plays it, as soon as the sorting process edits this data set, unique rhythms and melodies emerge.

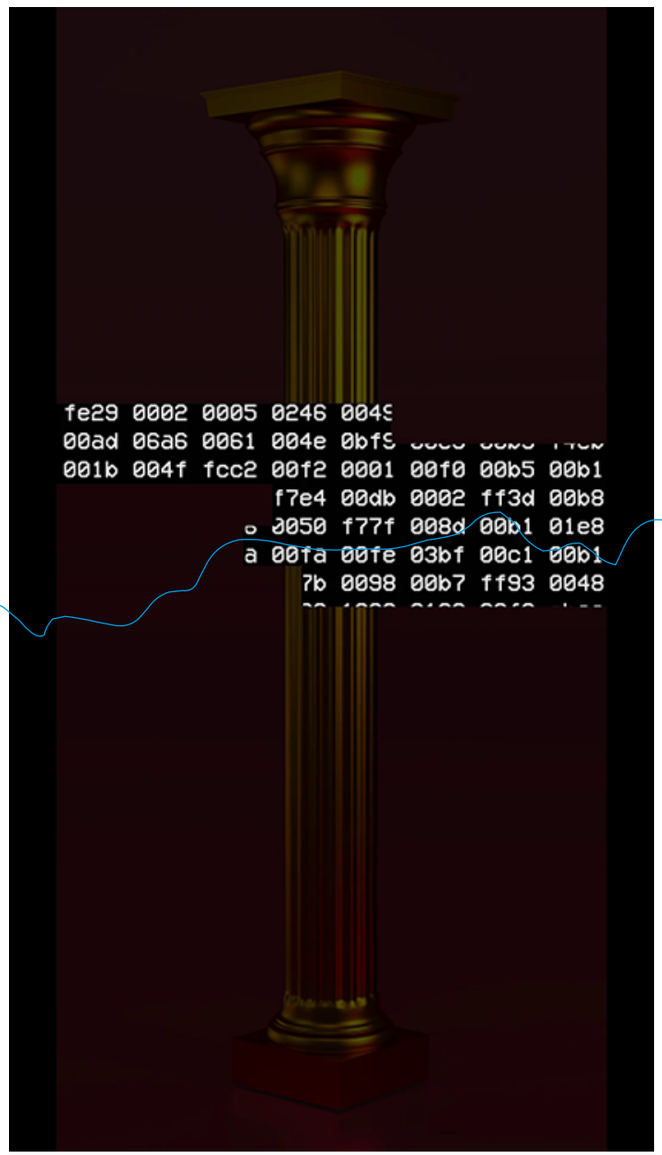
77

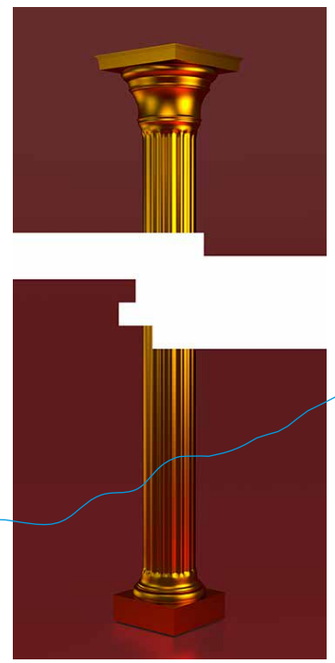
Video installation, digital print on canvas, image data, video projection, loop, ca. 120 × 200 cm
2016–2017

Column 1-0

#Encoding
#Interface
#NumeralSystem

Solimán López





Column 1-0 consists of a digital Doric column printed on a canvas. The image is not complete; it shows a white space where the numeric data of the printed file appears.

The digital world is made up of data, but all the time we are interpreting the translation made by the interface. In this simple but effective artwork, the artist is telling us that “the interface may be broken or incomplete, but the file holds all the information.”

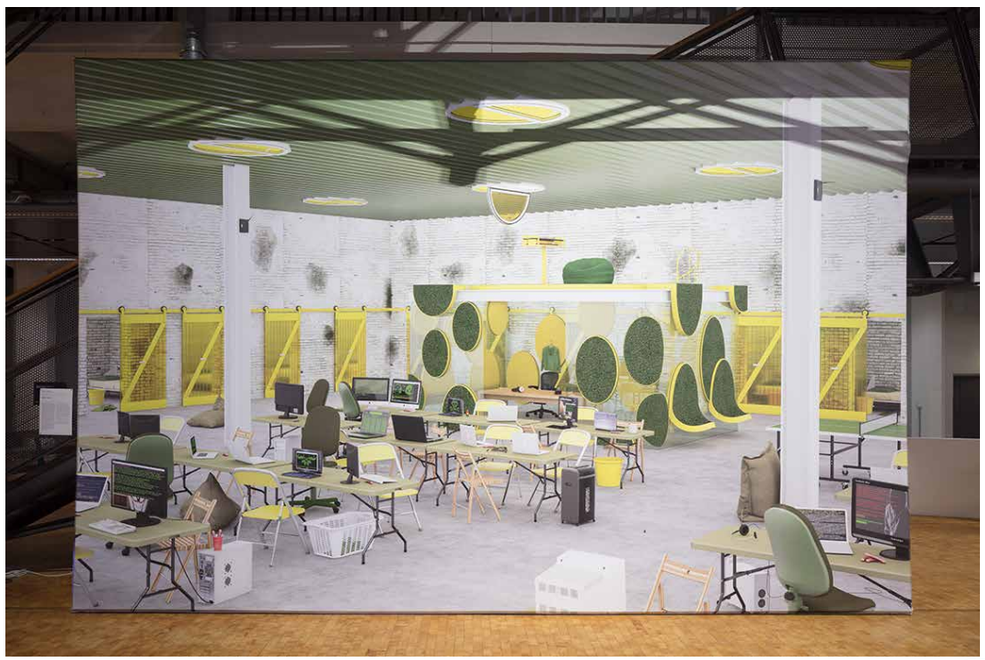
Open Doors

Digital print
2017

78

Shawn Maximo

#Labor&Production
#Work4.0
#Automation
#Programming
#Algorithm #Software



Shawn Maximo's work considers the relationship between labor and the architectural structures that enable and facilitate capital production. It is an imagined world, a gloomy utopia that illustrates the changing conditions of a working culture, which encapsulates the dreams of a young generation of programmers in the start-up scene. It depicts an economy that maintains the image of independence, entrepreneurship, and financial security. Geared towards harnessing creativity and innovation, the aesthetics of this culture promises a laid-back way of life with all desires taken care of. These stimulating environments blur the boundaries between work and private life. Yet behind this facade lies an immense pressure to keep up with demands, where a frenetic pace and aggressive deadlines are implemented with increasing supervision and control. Product development cycles for many companies typically span just weeks, not months.

Open Doors highlights current trends within contemporary labor conditions, and illustrates where they could lead us in the future. It raises the question of what social and legal provisions should be set in place in order to give businesses the necessary room for growth while simultaneously guaranteeing workers fair employment and social security.

79

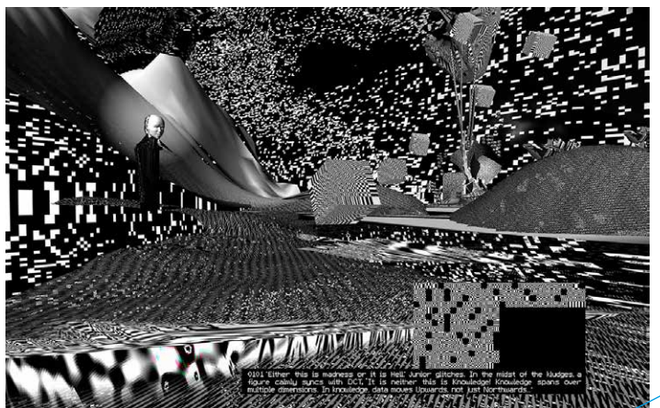
Virtual 3-D environment
2017

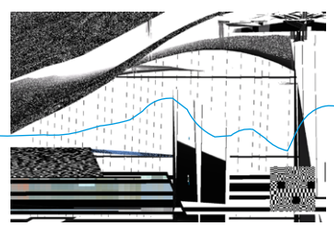
DCT:SYPHONING.

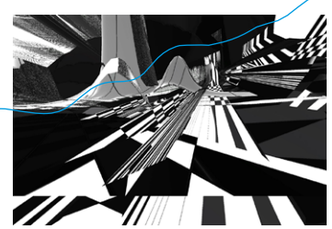
The 1000000th (64th) Interval

#VirtualReality
#Encoding
#Escapism #HMD
#ComputerSimulatedEnvironments
#Binary

Rosa Menkman







DCT:SYPHONING is a modern translation of Edwin Abbott's 1884 novella *Flatland*, which explains some of the algorithms and complexities at work in digital image compression. The story is told from the perspective of the DCT algorithm. In *DCT:SYPHONING*, an anthropomorphized DCT Senior narrates its first SYPHON (data transfer) together with DCT Junior, as they translate data from one image compression to the next (aka the "realms of complexity").

While Senior introduces Junior to the different levels of image complexity, they move from the macroblocks (the realm in which they normally resonate), to dithering, lines, and the more complex realms of wavelets and vectors. Junior reacts to old compression technologies, and also to the newer, more complex ones, which "scare" Junior, because of their "illegibility."

The Discreet Cosine Transform (DCT) compression technique has been used since 1973, but was only in widespread use from 1992 as part of JPEG image compression. Image compression is a set of rules for image data saving and transmission. With *DCT:SYPHONING* Rosa Menkman provides insights into the workings of the most popular image compression algorithm and its inherent, hidden biases and flaws.

DCT:SYPHONING. The 1000000th (64th) Interval is dedicated to Nasir Ahmed and Lena JPEG Soderberg.

Rhythm of Shapes

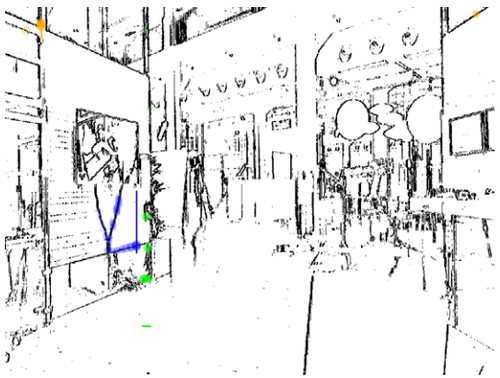
Interactive sound installation
2016

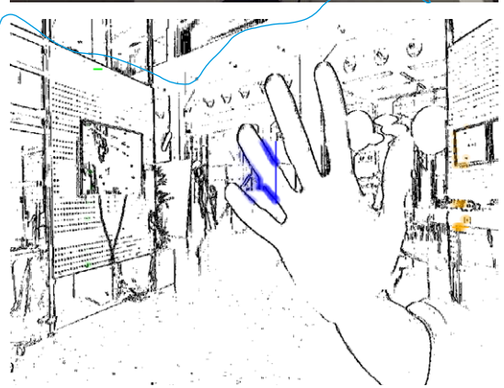
(80)

Chikashi Miyama

#Encoding
#ProgrammingSound
#Software
#Interface

In 1977, Iannis Xenakis (1922-2001), a greek composer and architect, developed the *UPIC* (Unité Polyagogique Informatique CEMAMu) system. The system generates electronic sound according to graphical scores, drawn on the dedicated tablet. Similar to the *UPIC* system, this installation sonificates images but it employs photos as graphical scores instead of hand-drawn sketches. Every five minutes the installation automatically takes a photo and extracts the contours or the shapes in the photo. Then, the system interprets these shapes as a musical notation and generates polyphonic and dynamic rhythm patterns, employing multiple geometric cursors of different size and speed.





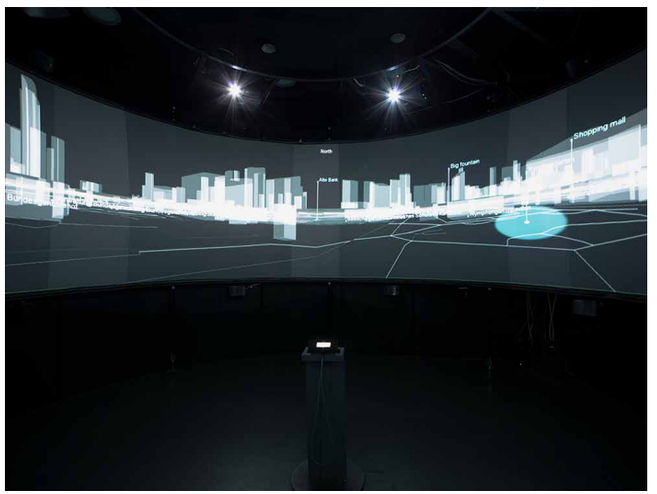
(81)

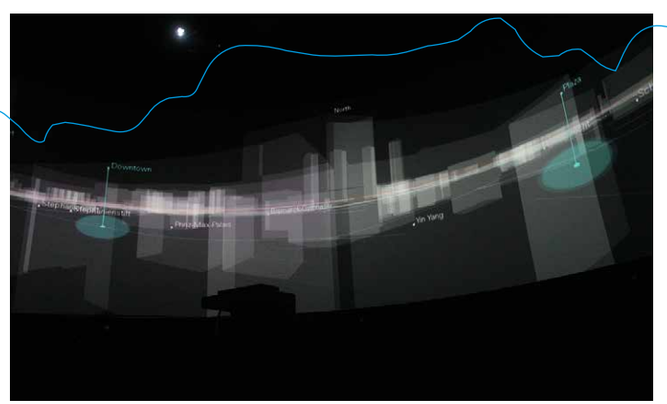
Sound installation, ZKM_PanoramaLabor
2017

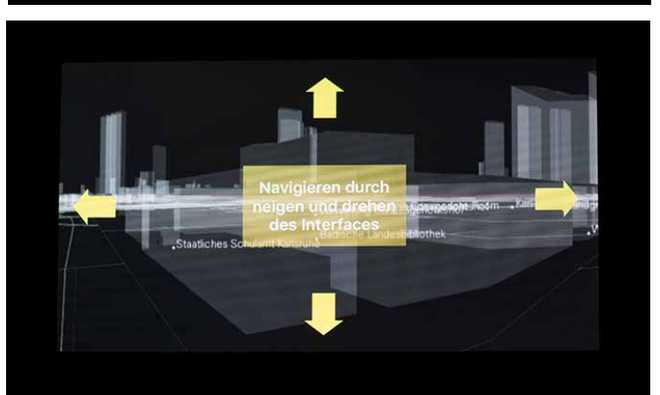
Sonorama – Karlsruhe

#Encoding
#ProgrammingSound
#Software
#Interface

Chikashi Miyama







The goal of this work is to create a virtual 3-D interactive diorama that represents various soundscapes within the city of Karlsruhe. Around 80 sound scenes were recorded in the city on June 27 and July 4, 2017, and all of this audio data was tagged with the GPS coordinates of the locations where the sounds were recorded. Based on these GPS tags, all the recorded sounds are distributed on a virtual 3-D map, rendered with *OpenGL*, using the geographic data provided by the open source project *OpenStreetMap*. The light green spheres, displayed at the top of the 3-D map, represent the recorded sound. By tilting the controller, the participant can navigate to the position on the virtual 3-D map. The volume and the directivity of each sound vary according to the distance and the angle between sound spheres and the position of the participant in the virtual map.

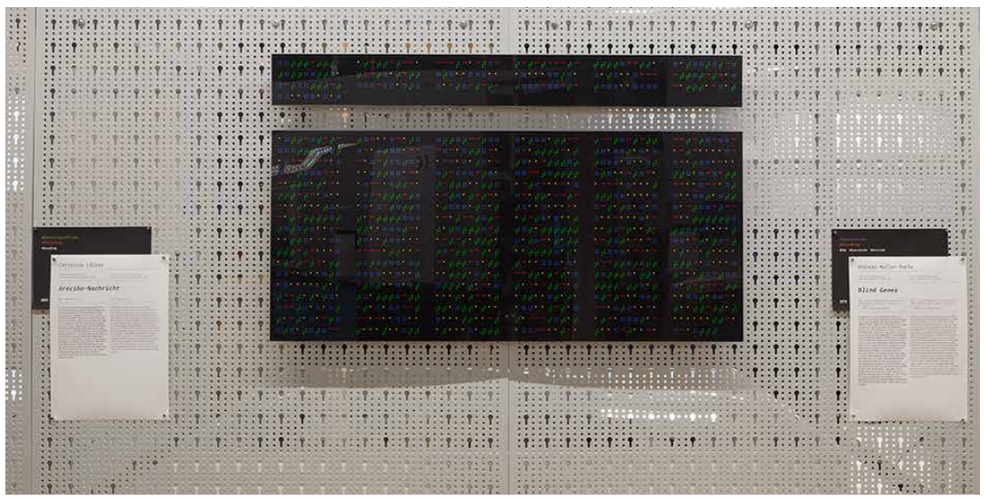
Blind Genes

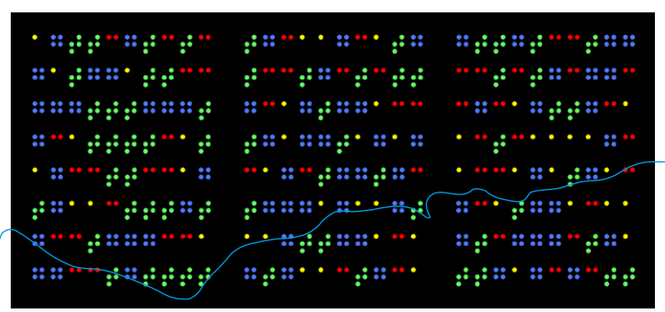
2 digital lambda prints, Cibachrome on aluminum under acrylic glass, 11 × 100 × 5 cm, 45 × 100 × 5 cm
2002

82

Chikashi Miyama

#Encoding
#ProgrammingSound
#Software
#Interface





Following on from *Digital Scores*, which represent the world's first photograph (Niépce, 1826) in various digital encodings, *Blind Genes* are derived from a genetic database. The raw data was acquired from the Internet GenBank using the search term "blindness," thereby ignoring the subject, completeness, and quality of the data. Nonhuman, partial, or sequences gained from simulations, and those of as yet merely postulated, nonlocalizable genes were also used, and are indicative of the metaphorical aspect of *Blind Genes*, alluding to the current status of research in genetic science in general: finding the tree of knowledge in the jungle of information. In keeping with conventional notation, the sequences of letters are presented in blocks of ten, each 100 cm wide, and then transcoded into the tactile writing system Braille in the colors yellow, blue, red, and green, whereby adenine (a) = yellow; guanine (g) = blue; cytosine (c) = red; and thymine (t) = green. The height of the individual works is related to the different lengths of the depicted genetic sequences. Each is a unique piece.

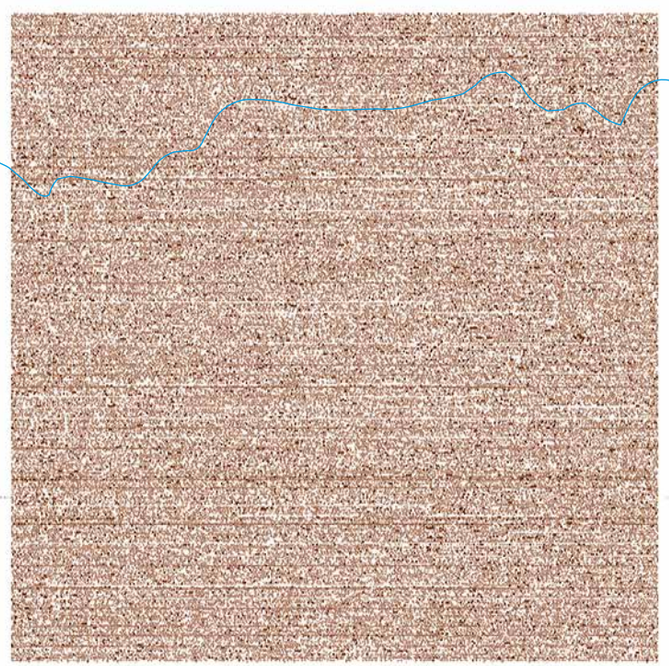
Digital Scores I (after Nicéphore Niépce)

8 panels, Iris 3047 inkjet print on Aquarell Arches grain Satiné 300 g/m, 68,5 × 68,5 × 4 cm each
1995

83

#GenealogyOfCode
#ComputerGeneratedDesign

Andreas Müller-Pohle



The digitization of the image can be interpreted as the end of photography: photography forfeits its autonomy and the privileges derived therefrom that are cultivated in the analog state. It becomes indiscernible while mingling with particles from other image and sensory sources. Or, conversely, digitization can be interpreted as the perfection of photography: photography participates in the digital universality and gains new, expanded functions. If, in the analog state, it was mainly a technique of reference and a visual aid, it now becomes a technique of preference and an instrument of thought.

The Digital Scores can be viewed within the scope of this question, in that they portray the digital code of analog photography's incunabulum: at the end of photography (its perfection), the project returns to its beginnings, to the first known photograph, Nicéphore Niépce's *View from the Study* of the Maison du Gras in Saint-Loup-de-Varennes, dating from (presumably) 1826. In seven million bytes, each of which is represented by an alphanumeric character, the complete binary description of this photograph is presented on eight square panels – a description that shows us: digital images represent, above all, the reality of their underlying theories and scientific concepts.

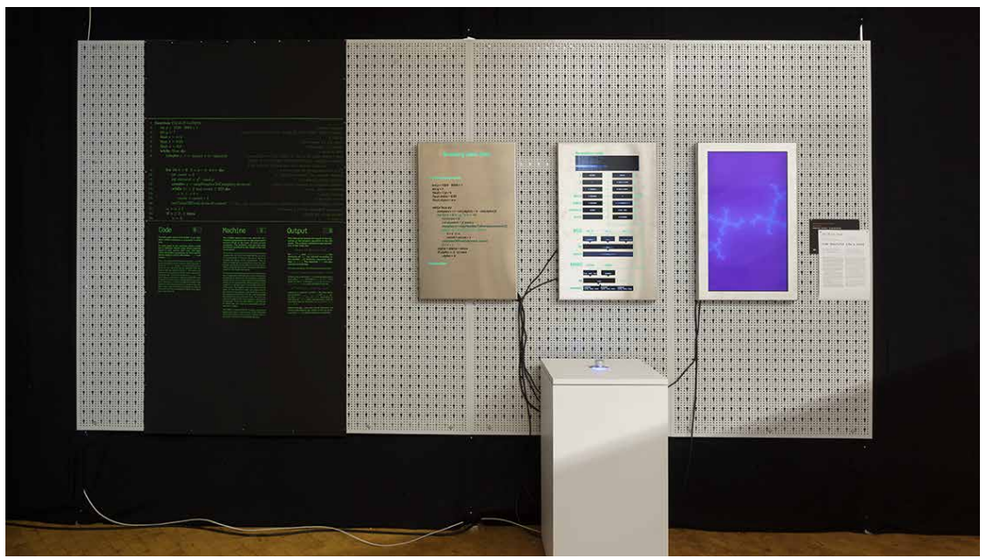
Code beautiful like a clock

Monitor, software, stencil
2017

84

Jörn Müller-Quade

#GenealogyOfCode
#Encoding
#Interface

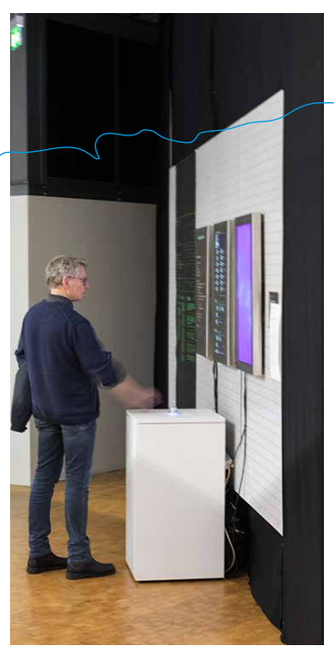


Many people find mechanical clocks appealing. No such aesthetic appeal is ascribed to computer programs, although they are mechanical in a similar way: fixed, predefined commands are executed to yield a result.

The "mechanics" of computer programs play out on a time scale that lies outside of human perception. While many programs have reaction times that are perceptible to us, basic commands are completed a billion times faster during this time. This work is intended to bridge these extreme time scales, making it possible to experience the mechanical character of computer programs.

The exhibit is composed of three units: on the left is the program code, with an emphasis on the command that is being executed at a given moment. In the middle, the "inner life" of the processor with its registers, execution unit and memory is displayed in the act of executing a basic command. On the right, the result is visualized.

A control knob changes the processing speed: when it is slowed down, individual steps become discernible, but their visible result is delayed. At a high speed, the result appears quickly, but the processor's individual steps can no longer be observed.



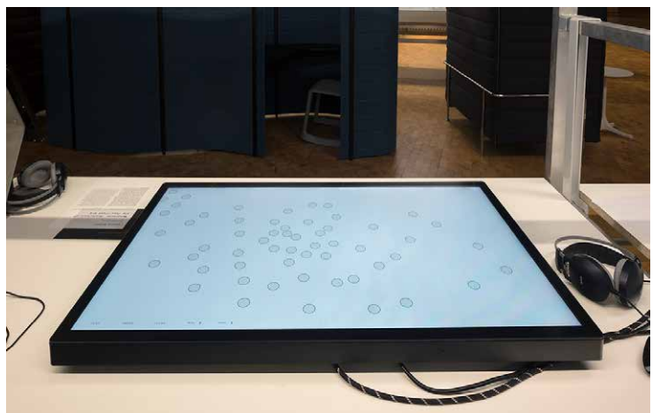
85

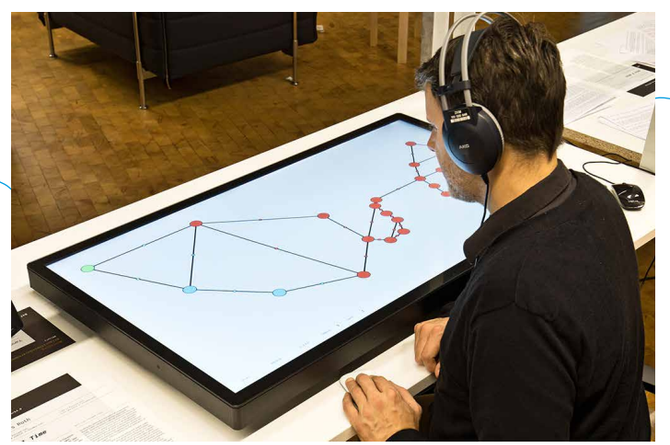
JavaScript code, touchscreen, sound
2017

Sonic Web Instrument

#AlgorithmicGovernance
#Encoding
#Algorithm
#Software
#ProgrammingSound

Greg Niemeyer





Networks form the core of the Internet. Each machine connected to the Internet forms a node and can send and receive messages to and from any other node. The nodes have no hierarchy and no linear structure. Messages can go in any direction at any time.

To better understand how radically different the Internet is from other, more linear and hierarchical communication systems, Niemeyer built the Sonic Web Instrument. It allows users to build and take apart simple networks, and to hear what changes in their structures sound like. Does a resilient network sound differ from that of a fragile network? Can one hear the difference between a core cluster and a flat network? Can one tell fast regions of a network apart from slow regions by the way they sound?

For the exhibition *Open Codes*, *Sonic Web Instrument* keeps track of it's own history. The changes users make become part of the instrument's repertoire and of the permanent archive of ZKM.

Sonic Web Instrument also is a core element of DJ Spooky's concert *Sonic Web*, which he will perform live at ZKM in the summer of 2018.

deus X mchn

Multimedia installation
2017

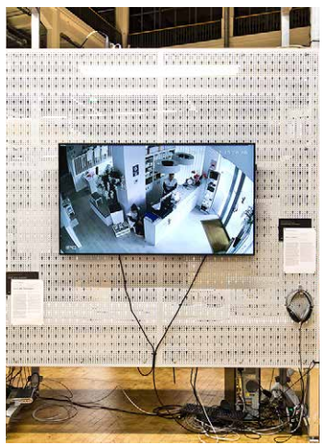
(86)

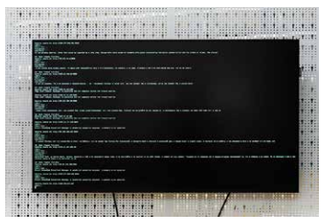
Helena Nikonole

#MachineLearning
#AlgorithmicGovernance
#ArtificialIntelligence
#InternetOfThings

deus X mchn explores issues around online security within the Internet of Things and the increasing capabilities of Artificial Intelligence. The piece is constituted of an IP (Internet Protocol) printer that automatically prints a text every 30 minutes. These texts, which at a first glance may not seem very different from famous sacred texts, are actually written by a machine: a neural network constituted of a long short-term memory (LSTM) algorithm, has been trained in the language of a corpus of sacred texts such as the Bible, Quran, Torah, Ramayana, Tao Te Ching, and others. The neural network perceives these texts as a sequence of numbers and performs computations in order to discover their grammatical structures; that is, the "code" of the language. By learning these semantic structures, it starts to generate its own text, trying to keep the essence of the religious documents.

Hacked IP cameras with speakers in public spaces anywhere in the world start reciting these texts to unsuspecting people, whose reactions are projected on the screen. The voice that reads out the texts is a second neural network that synthesizes a human voice that is embodied in an unsecured device connected to the Internet of Things.





DEUS X MCHN

&;, O Lord.

118:71. But the sons of Solomon the son of Joab, and Asai, and Adam, the son of Joseph his son and the wicked that we let the strong man of the family of the Lord, and present them from the children of Israel: he made all the people that were the days of the priests are come, and the face of the law of the Lord the God of Israel, and the children of Israel said: The sons of Achitophel shall not be under the house of Moses: therefore when the Lord had sent them to the gate of the Lord your God, saying: The man of the prophet sinned at the sea of the people, and behold the Lord hath seen the morning and a strong for the waters, and the word of the Lord hath commanded, he shall be bound against the Lord, and were a man of the walls: and the birds of the Lord be brought to him, and the lion of the waters of the battle of the priests shall be a woman, and the strength of the wall of the wicked of the land of Jerusalem, the priest shall be a covenant, and the princes of the army of the same tents of the day of the children of Israel, and these were not among the streets, and shall do them against thee, and the Lord hath spoken, and the hands of David's army and the feast of the four of his father, and the wisdom of the children of Israel: and they shall be slain he will give them from the land of Juda, and being person to the words of the children of Israel.

3:11. And the Lord had commanded a sign and defiled the children of Israel.

1:3. And the Lord said to them and to his servants and the sight of thy sight and beautiful and children: and the whole ways of the Lord of hosts it is the master of the street of the day of the Lord the son of Samaria.

1:2. And when they were in the sanctuary. And the Lord said to them: When they were discovered against the land of the Lord, and of the children of Israel.

32:17. And let them me up the name of the Lord the son of Achab: and the Lord spoke to thee commanded the land of the Lord, and they shall be a waters of the sons of the countries of the people to pray the wilderness, and the sins of the camp of the Lord, and will fall in persecution to the Lord, the sons of Benjamin, and Aaron the son of Juda, and the sons of the land of the Lord, and the prophet was offerings.

5:24. And when they were as to deliver the heart of the land of the Lord, and be the meaning of the Lord.

6:4. And he said to him: The brother of the children of Israel the son of Samaria, the law of the Lord shall be a strength of his hand to the Lord: and the lions of the sons of Israel with the second men of the Assyrians.

16:11. And the Lord said to him: Thou hast made a mountain for the trees of the fruits, and shall be the word of the Lord the God of Israel.

101:10. Who sendeth the burden of the Lord the son of Joseph begot his sons, and the seventh year of the Lord the God of Israel: and the children of Israel had commanded him in the people of the Lord, and said: I have dead of the land of the earth and slain.

1:3. And the Lord said to him: The Lord will not be sanctified and sinners of the bones, and find the sea and the words of the camp of the Lord, an

your printer was connected to distributed AI network. please keep calm and follow instructions

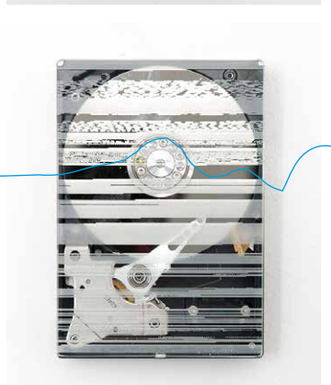
(87)

Glass engravings on hard disks
2015

Fragmentierungen

#Encoding
#Interface
#Hardware

Julian Palacz



In his series *Fragmentierungen* [Fragmentations] Julian Palacz works with discarded and found computer hard disks and makes their memory status visible in engravings on glass. He does not reveal the stored data but merely hints at their accessibility by applying the binary system of the elements "Description" and "Empty" to the hard disks. The artist uses this to create a kind of map that displays the hard disks' data; however, they are not actually readable because they have a new coding. By suggesting that the data is accessible Julian Palacz plays with the duality of visibility and encoding. Here the artist makes reference to how sensitive and personal data is handled within digitized systems and the ambivalent monitoring structures of such systems. As in many of his other works, here Julian Palacz, demonstrates the transparency of our actions in the digital sphere with subtle utilization of his materials.

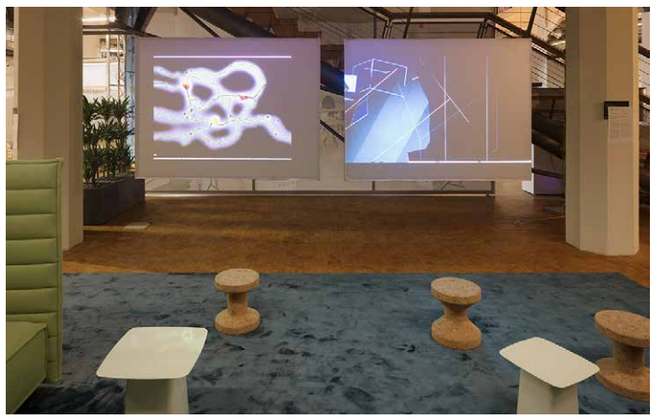
Neuronaler Architektur Generator

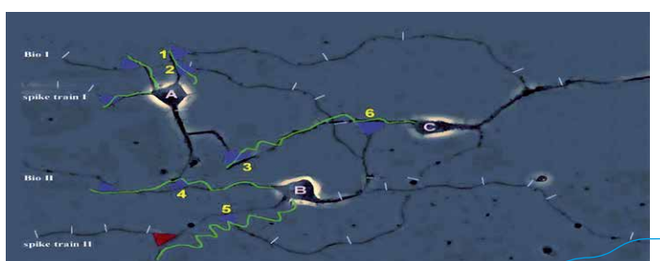
Computer installation,
2 PCs (CPU 686), 2 projections
1999

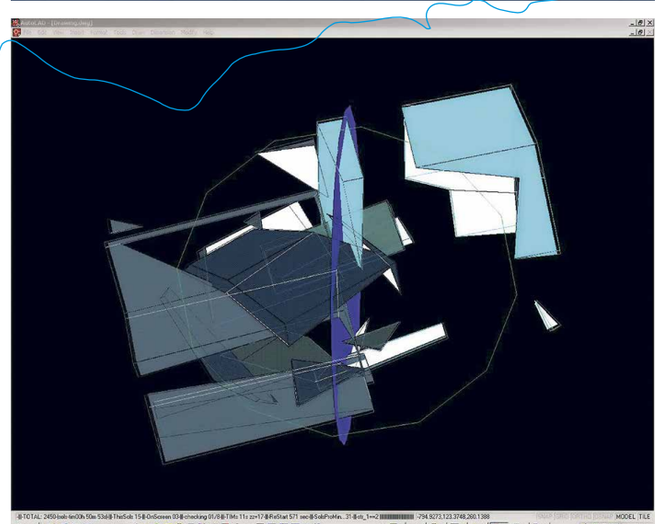
88

Manfred Wolff-Plottegg
Wolfgang Maass

#MachineLearning
#Encoding
#ComputerSimulatedEnvironments







The computer installation *Neuronaler Architektur Generator* [Neural architecture generator] is an experimental setup for digital creativity. Its principle is the following equation: spike trains in biological organisms = binary bit strings = data (coordinates, vectors) interpretable as solids.

The installation consists of two digital processors that communicate with each other, whose output – three-dimensional geometries – is projected.

Computer 1 simulates four neurons, generates spike trains and bit strings. The array of the 0s and 1s can also develop as a random number, as signals from light barriers (influxes of visitors), or similar. Computer 2 utilizes these series of pulse-coded signals for an architecture program and generates geometries with them that are plans for blobitecture-style buildings.

Here three areas are connected: "the world in our head," "the world of digital data processing," and "the world of generating new images / spaces / architectures." The installation demonstrates that the creation of new images, spaces, or architectures needs no longer to stem from people, that data does not have to be processed in the human brain, and that creativity can be quasi outsourced.

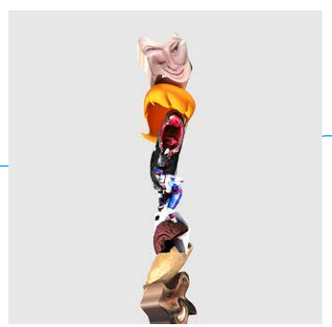
89

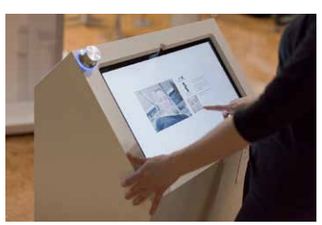
Web application, 3-D printed plastic figures,
3-D prints, tablets on stands, monitors
2017 ongoing

Vertigo in the Face of the Infinite

#Encoding
#Computing #Software
#Interface #BigData
#ComputerGeneratedDesign

Matthew Plummer-Fernandez





Vertigo in the Face of the Infinite describes various interrelated and productive digital and physical elements. A stack of found objects extends endlessly in height, comprised of 3-D models sourced from the Internet, and viewable as an infinite scroll website. Visitors to the site can have their gaze captured and added to the tower via the cameras on their devices. The website also has a physical storefront in the exhibition, comprised of point-of-sale tablets and a showcase of 3-D prints. Here, the towering website appears as a tall, scrollable multi-screen display.

The complete artwork is productive for interrelations between operator-spectators and machinic processes, entangled in the production of objects made on demand, as well as a virtually infinite 3-D column. The artwork reflects the wider human engagement with ongoing web-based newsfeeds and social media where information is vertically stacked and open for contributions in order to stimulate continued use. The altitudes that such newsfeeds achieve arguably cause a new kind of vertigo of informational overload and Internet compulsions.

Website: towwwwwwwer.com

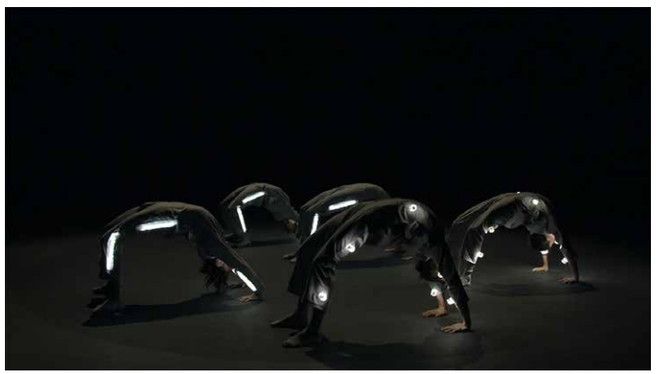
Patterns of Life

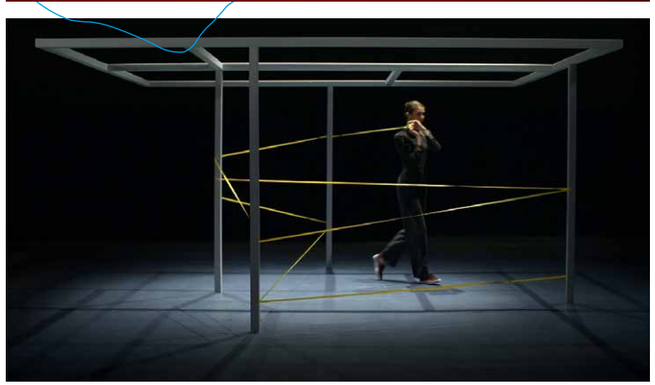
HD video, color, sound, 15:30 min.
2015

90

Julien Prévieux

#MachineLearning
#AlgorithmicGovernance
#PatternRecognition
#QuantifiedSelf





Patterns of Life presents a history of the technological capture of human movement within the genre of a dance film. Prévieux enlisted five dancers from the Opéra de Paris to develop dance choreographies based on six different experiments, studies, or technologies – presented in chronological order and accompanied by a narration – that are concerned in different ways with the task of extracting patterns from bodies in motion, and the way this data is applied to reorganize, control, and encapsulate individual and group movement and behavior.

From Georges Demenÿ's chronophotography of faulty gait in the late nineteenth century to the capture of human gesture in order to reconstruct and remodel it in quest of greater efficiency within the factory regime to the "activity-based intelligence" generated by the US National Geospatial Intelligence Agency, the film traces the genealogy of the quantification and visualization of bodily movement and the various ways of making sense of it. It concludes by addressing the contemporary preoccupation with data mining, and the consequent shift from looking for things to looking for "patterns of activity" – the very form of analysis that underpins "targeting" today, both in the military context of the "war on terror" as well as in consumer culture and advertising.

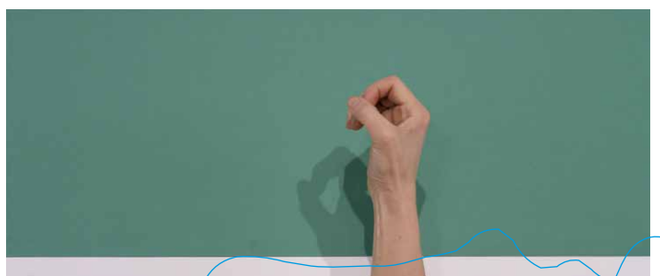
91

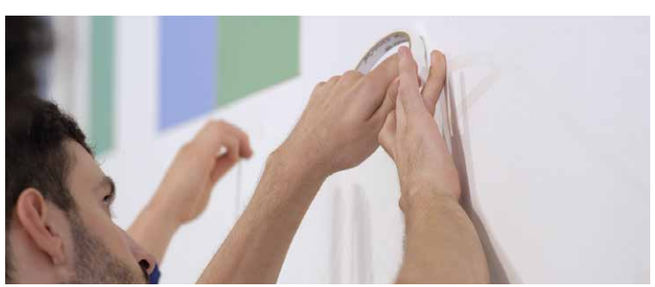
HD video, color, sound, 16:47 min.
2014

What Shall We Do Next? (Sequence #2)

#MachineLearning
#Encoding
#PatternRecognition

Julien Prévieux





Gestures used to activate new devices are patented – for example, the "slide-to-unlock" movement patented by Apple in 2011. Julien Prévieux started to collect these specific movements in 2006. His assumption was that the gestures patented today are the movements we may all have to do in the near future: patents as an archive of gestures to come. To date, Prévieux has created three sequences of *What Shall We Do Next? Sequence #2*, which is on view in *Open Codes*, is a video made with six performers. They perform the diagrams found in the patents, considering patents as dance scores. Prévieux takes ownership of these movements and frees them from their practical function through choreographic abstraction.

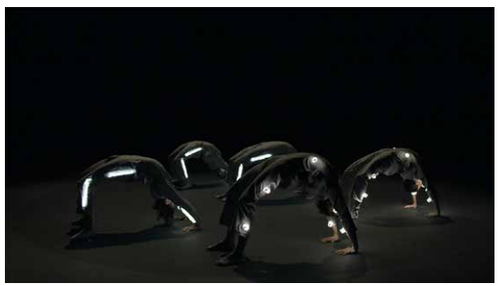
Patterns of Life

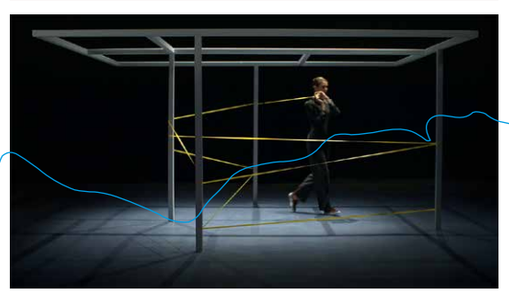
HD video, color, sound, 15:30 min.
2015

90

Julien Prévieux

#MachineLearning
#AlgorithmicGovernance
#PatternRecognition
#QuantifiedSelf





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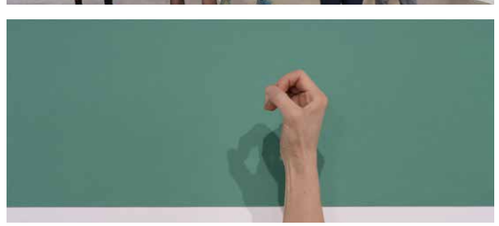
91

HD video, color, sound, 16:47 min.
2014

#MachineLearning
#Encoding
#PatternRecognition

Julien Prévieux

What Shall We Do Next? (Sequence #2)



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The ReCode Project

Online platform

92

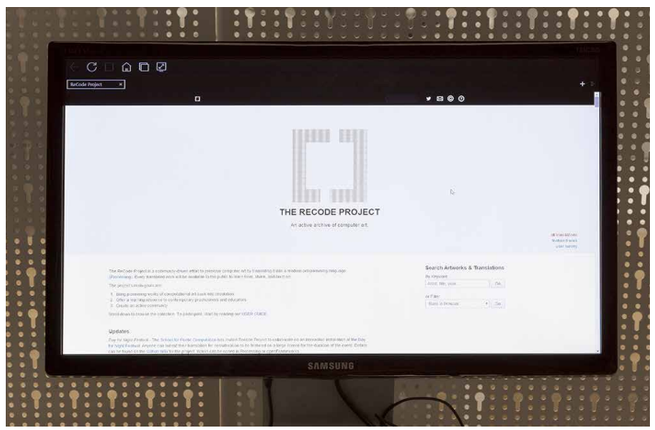
Various Artists

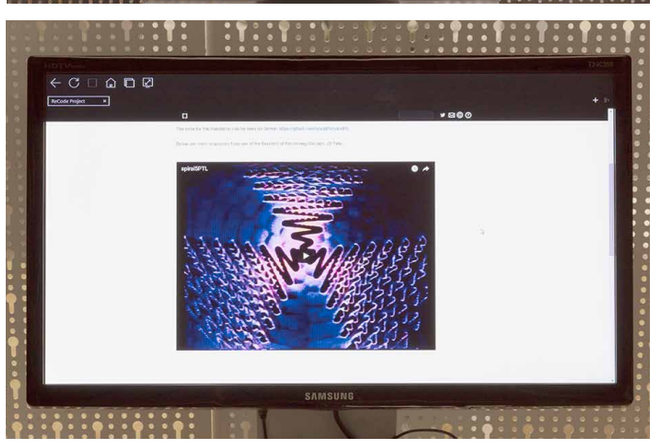
#GenealogyOfCode
#Encoding

The ReCode Project is a community-driven effort to preserve computer art by translating it into a modern programming language (Processing). Hence, it functions as an active archive of computer art. Every translated work is available to the public to learn from, share, and build on.

The ReCode Project acts as a response to a need for more historical context in the practice of creative computation, out of the conviction that there is a lot to learn from the coders that were active in the past: something being old doesn't mean it's out-of-date.

The project's main goals are:
→ Bring pioneering works of computational art back into circulation.
→ Offer a learning resource to contemporary practitioners and educators.
→ Create an active community.





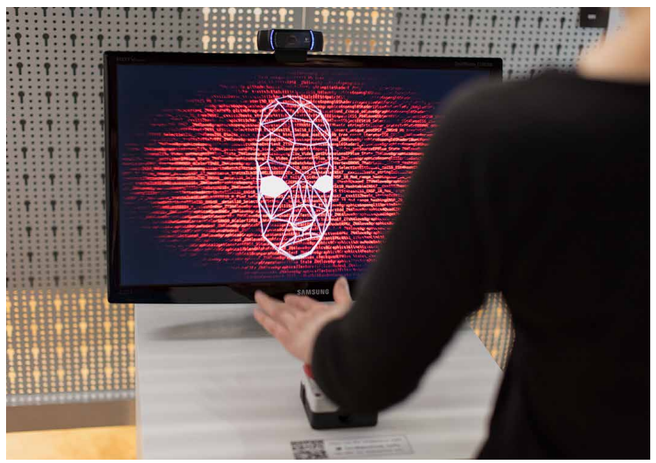
93

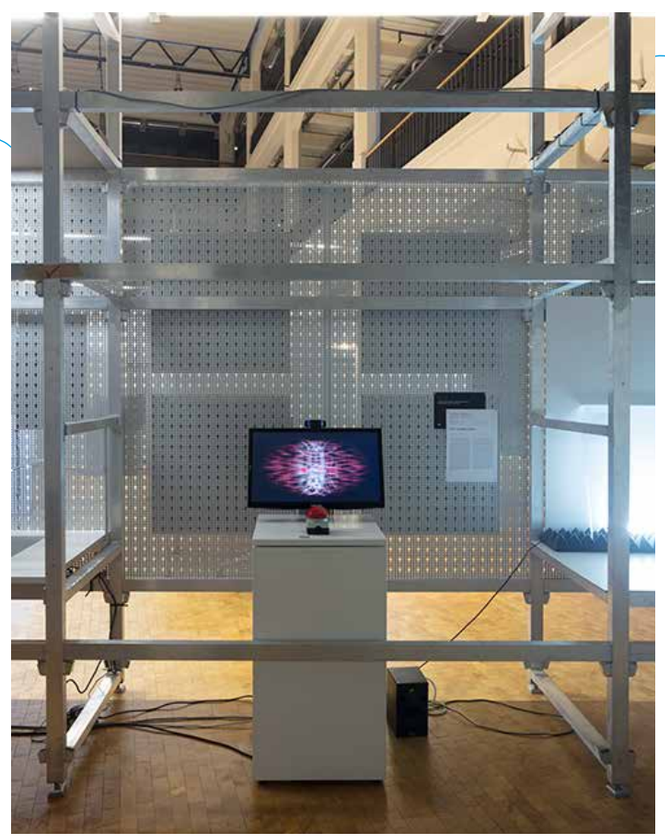
PC, Arduino, software: Python (OpenCV, DLib), Lua (LÖVE)
2017

Die Leidmaschine

#MachineLearning #Encoding
#ArtificialIntelligence
#PatternRecognition
#AutonomousSystems #Interface

Matthias Richter
Josef N. Patoprsty





Through the technological progress in recent history, these days machines are not only more powerful and faster than humans, they also possess the ability to think creatively and connectedly. IBM's *Watson* and Google's DeepMinds *Alpha Go* beat the best human players at Jeopardy and Go. Considering this development, it seems to be only a matter of time until computers learn to feel as well as being able to think. Where is the dividing line between lifeless machine and artificial intelligence? Using the *Leidmaschine* [The suffering machine], this line can be probed by asking an actual question: Is it permissible to inflict pain on a machine that can feel it? Utilitarian action should be designed to minimize suffering, but does this also apply to simulated suffering? What is the difference between "simulated" and "real" suffering? Is it important, which hardware or wetware experiences the suffering? Is it torture, to torment a machine whose only function is to bear suffering? Is it morally acceptable to build such a machine? The *Leidmaschine* has no answers to these questions. Rather, it is intended that the machine should inspire visitors to engage with the complex subject of artificial intelligence, and to find personal questions and answers.

The ReCode Project

Online platform

92

Various Artists

#GenealogyOfCode
#Encoding

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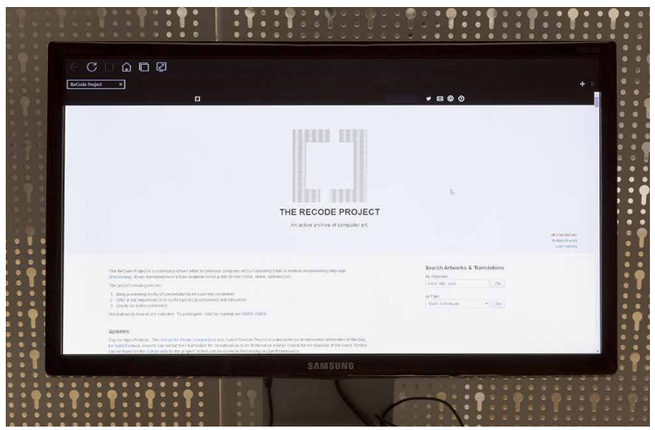

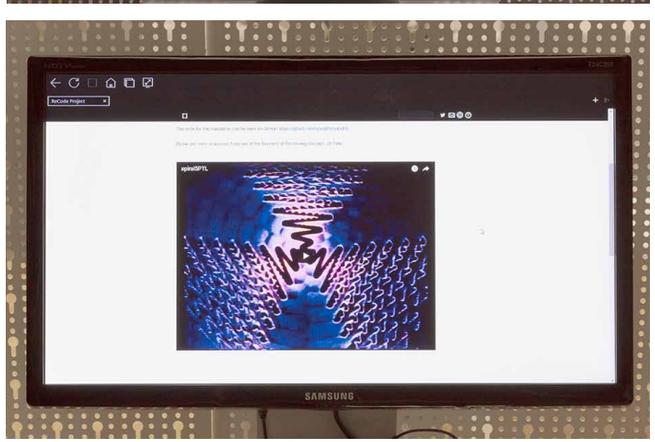

93

PC, Arduino, software: Python (OpenCV, DLib), Lua (LÖVE)
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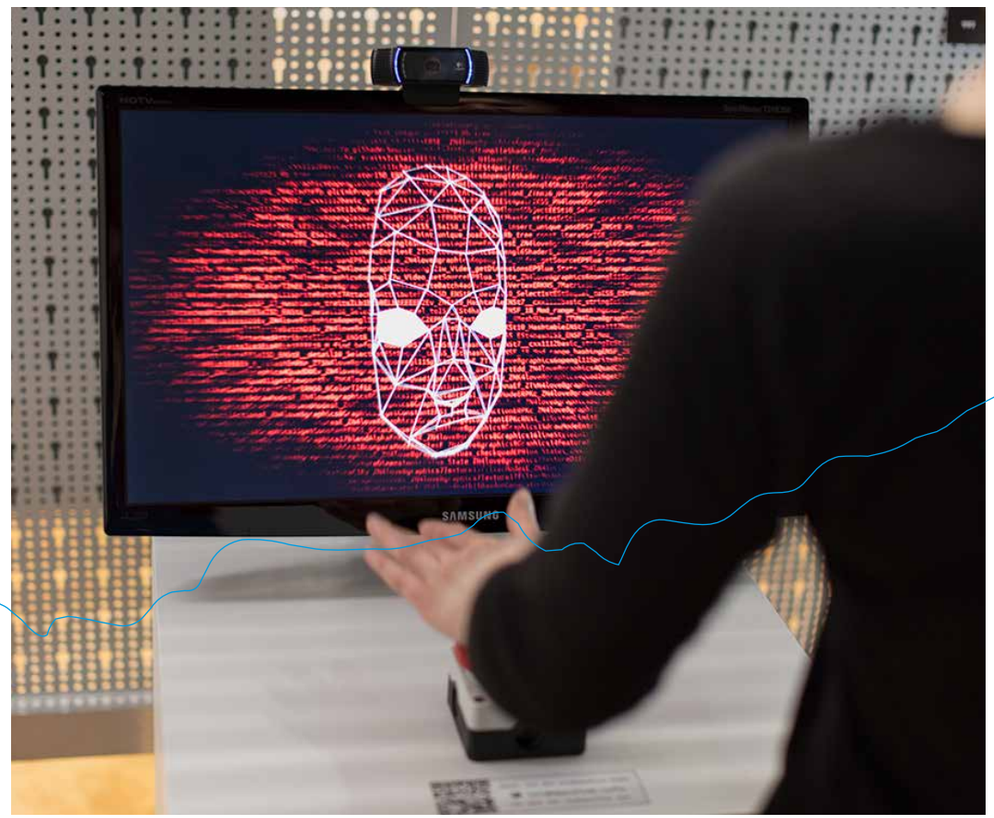

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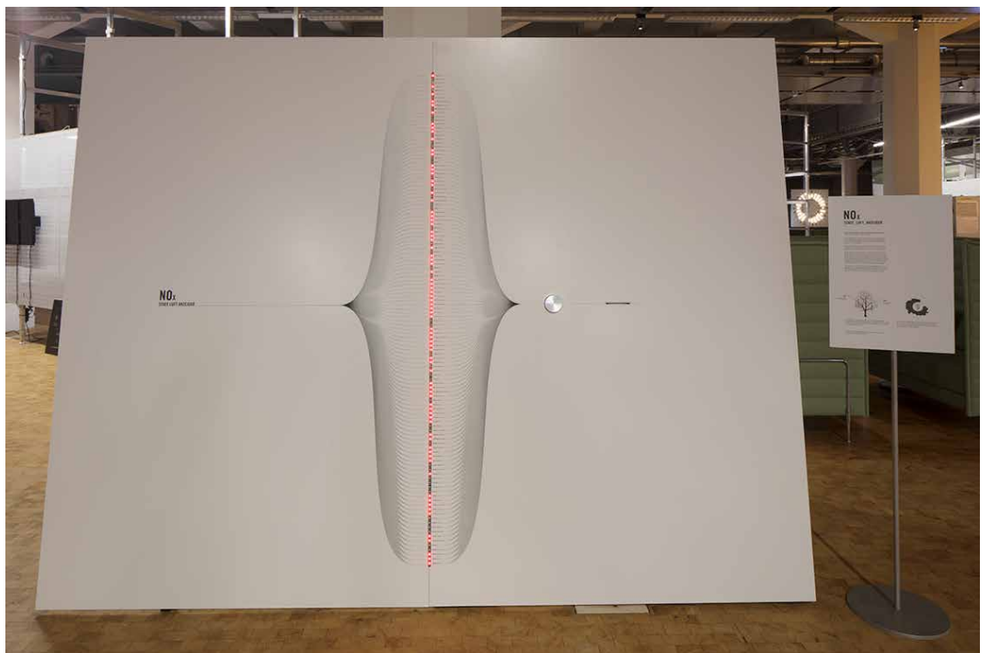
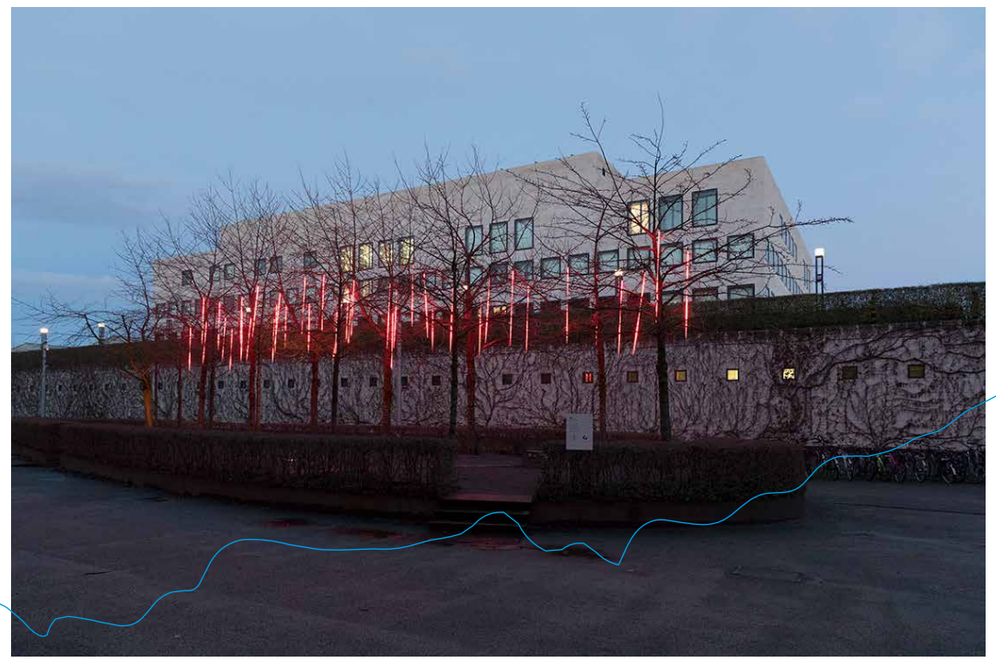
NOx STADT_LUFT_ ANZEIGER

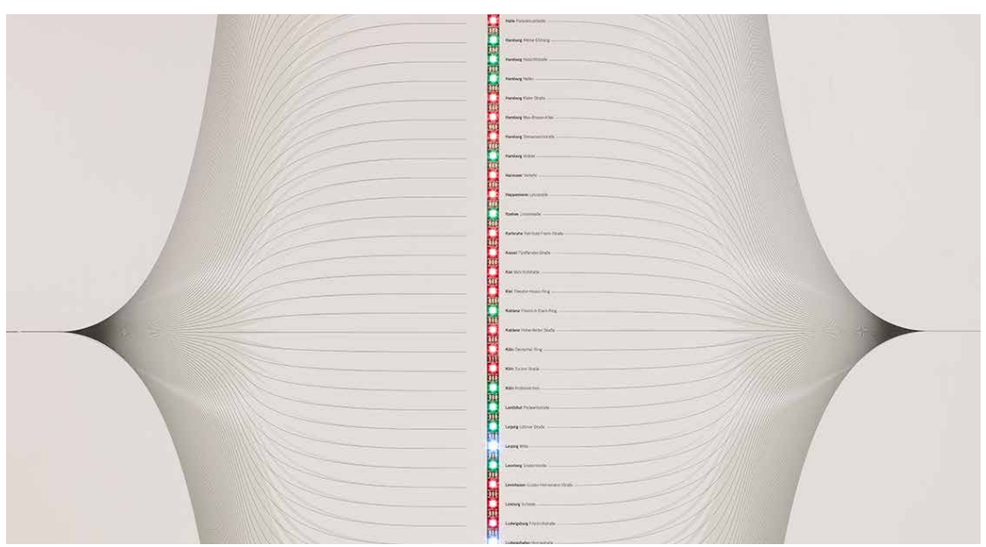
Outdoor: LED installation in an urban space
Indoor: interactive LED display
2016–2017

Peter Reichard
Manfred Kraft
Michael Volkmer

#Encoding
#Software #Binary







Our cities are car-centered, not human-centered. With harmful consequences for the health of the residents. Due to "Dieselgate" and the German car cartel scandal, this subject has now slowly come to the attention of the general public. Nevertheless, the danger is still an invisible threat. Indeed, the situation could not be worse: in more than 50% of all major cities in Germany, those responsible tolerate that legal regulations are ignored. The urban, social installation *NO_x STADT_LUFT_ANZEIGER* [NO_x City_Air_Indicator] functions like a kind of traffic light. In real time, via a central application programming interface (API), the nitrogen dioxide values (NO_2) from around 500 official air monitoring stations are calculated. The display glows red when the EU limit of 40 micrograms/m_3 is exceeded, and green if the readings are within the limit. The installation was exhibited from December 2016 to March 2017 in Wiesbaden, which, after Stuttgart, is the city with the worst air in Germany.

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Outdoor: LED installation in an urban space
Indoor: interactive LED display
2016–2017

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Manfred Kraft
Michael Volkmer

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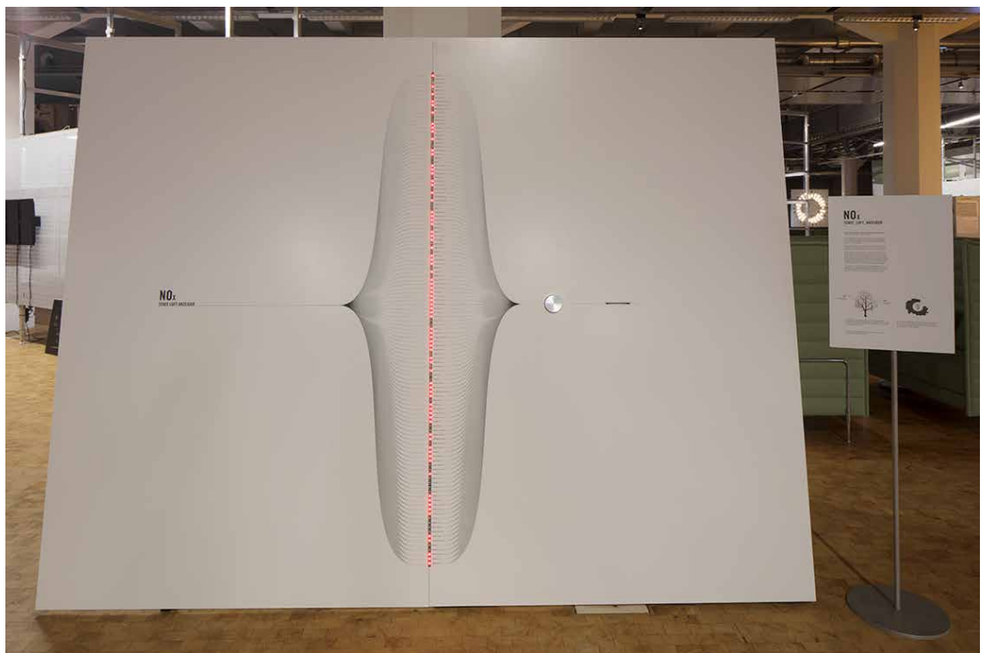

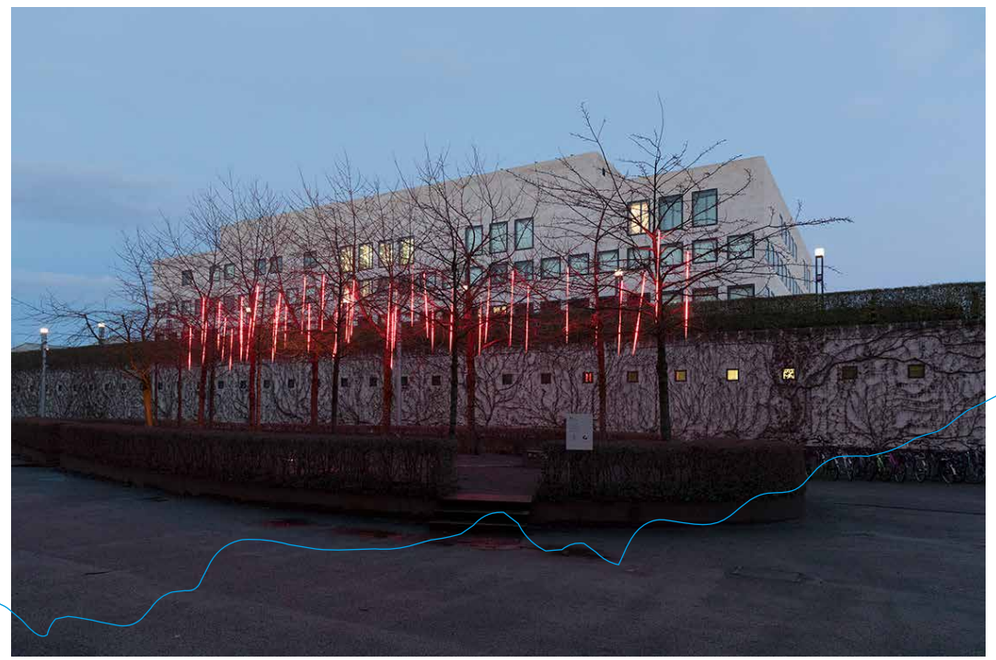

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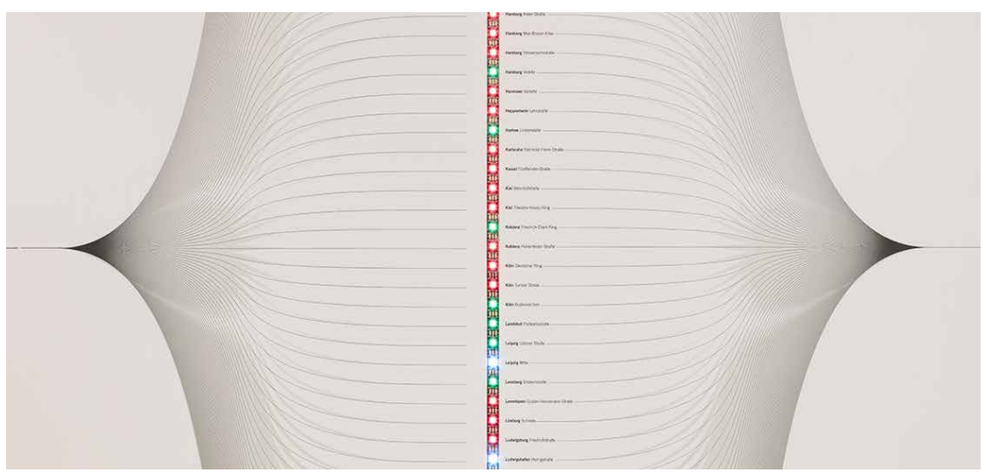


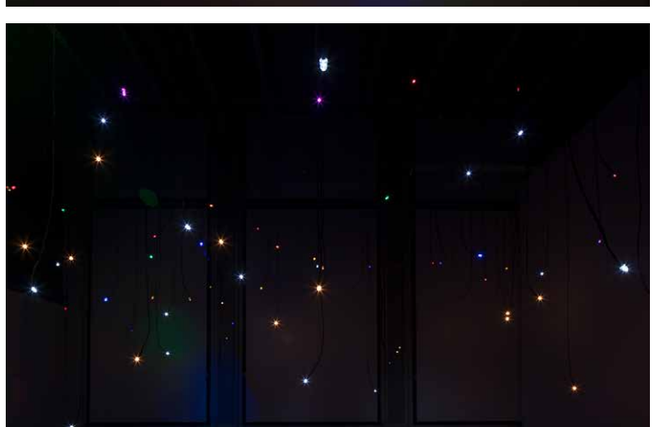
Silent Communications

Site-specific installation, LED lights, smart phone application
2017

95

Betty Rieckmann

#Encoding #GenealogyOfCode #Decoding #Software #Interface #MorseCode #Computing #Babel



Silent Communications remains silent due to the fact that communication between the work and its visitors takes place via light. Short and long light signals follow the Morse alphabet. The development of telegraphy and Morse code dates back to the 1830s, when Samuel F. B. Morse took part in developing an electric telegraph system. By and large his code system has been out of general use for several decades and unless you are a Morse enthusiast, you will not be able to decipher the blinking lights. A smartphone application is related to the installation, which is far more suited to today's zeitgeist than Morse code. Using the app the phone can directly translate the flickering lights into text, and so the visitor can decode the messages transmitted by each LED light. The messages are all about code and its genealogy from Morse to binary and digital.

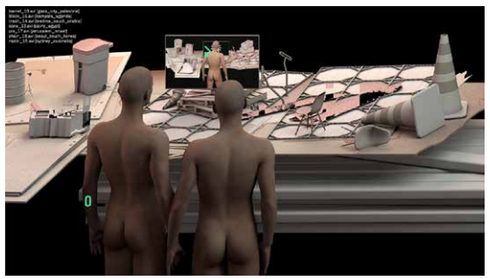
Real Time

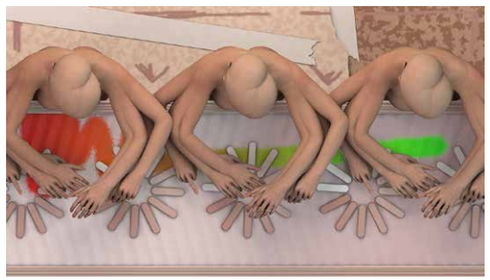
96

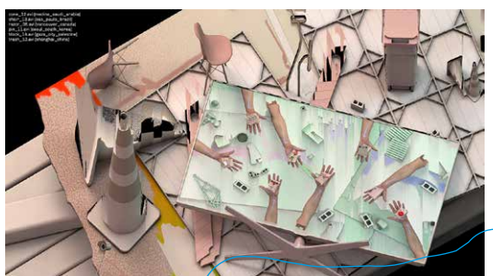
Live-streamed video
2017

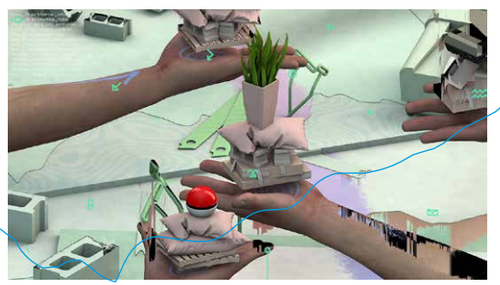
Curtis Roth

#AlgorithmicGovernance
#Labor&Produktion
#BigData
#QuantifiedSelf
#Work4.0









Surfing the Internet is the labor of assembling Planet Earth; scrolling fingertips aggregate code, sourced across colossal distances into our browser windows via intercontinental strands of glass. In this global economy of code assembly, our experience of surfing as a geographically distributed form of labor is obscured by the aesthetics of real time: whereby the enormous distances between fingertips and content are "massaged" into invisibility by the aesthetics of the interface.

Real Time is a live-streamed digital video that examines the geopolitics of the throbber. Colloquially referred to as a buffering icon, the throbber is that ubiquitous cycling GIF intervening between the motions of our bodies while surfing and a distant server's delivery of content. The throbber is a rupture in the global economy of content assembly. It is the last shadow of the geographic scale of the Internet, the momentary interruption of the vastness of Planet Earth itself into the otherwise smooth flow of real-time online experiences.

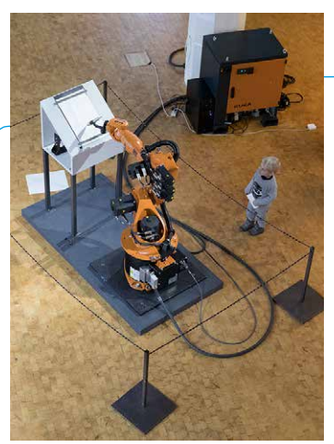
The underlying code comprising this video piece has been distributed across fifteen servers located on five continents. Each screening is the live re-assembly of this content. The subtle fluctuations in resolution offer a momentary portrait of the uneven assembly of Planet Earth. Every screening is a unique index of the disparate nature of real time.

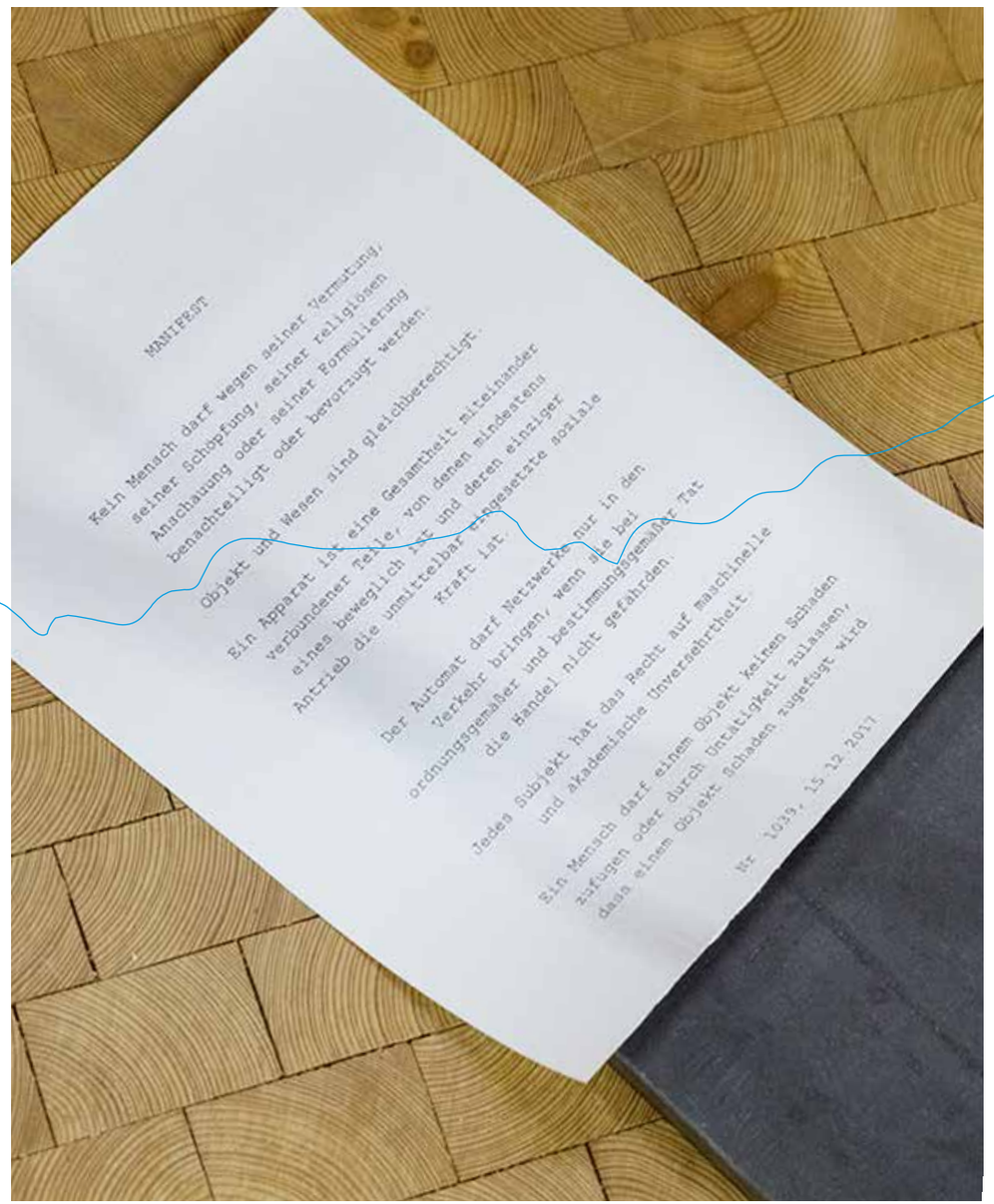
manifest

Industrial robot, writing desk,
computer, software, paper, pen
2008/2017

robotlab

#MachineLearning
#AlgorithmicGovernance
#Labor&Production #Industry4.0
#Robots #Automation





Autonomously, the industrial robot in the installation *manifest* by artist group robotlab writes manifestos for a utopian society of humans and machines. These manifestos consist of sentences presenting assumptions, which the robot independently generates and writes down making use of stored terms from ethics, law, technology, and society, and also a collection of sentence structures from judicial and fictional legal texts, which the robot combines algorithmically. As a prototype of the robot avant-garde, the machine meddles creatively in the legislation of a future society in which humans and machines are equal before the law.

manifest is part of a long tradition of manifestos in art and politics. However, instead of the mass reproduction of a uniform text with propagandistic statements, here the machine though mass produces numbered unique documents which each carry an individual message. Unlike humans, though, a robot does not possess any form of morality or a sense of justice; it is therefore utterly free in formulating its legal hypotheses. The meaning of each and every manifesto only comes into existence through humans reading it. The human mind instinctively comprehends the meaning of the robot's assertions and considers the possible consequences of such laws.

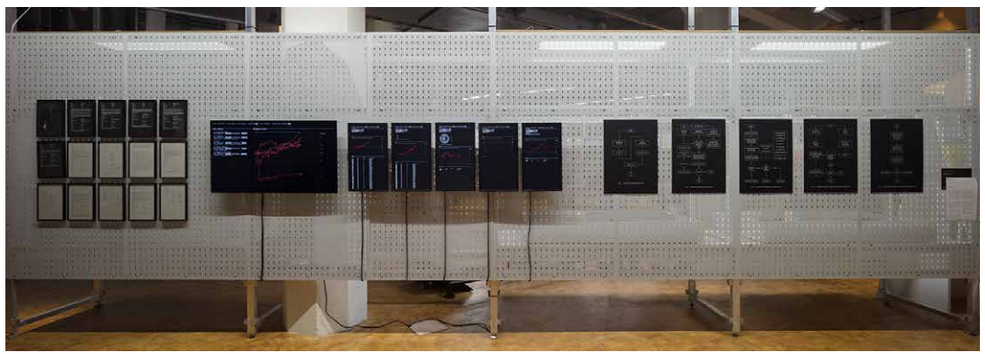
ADM XI

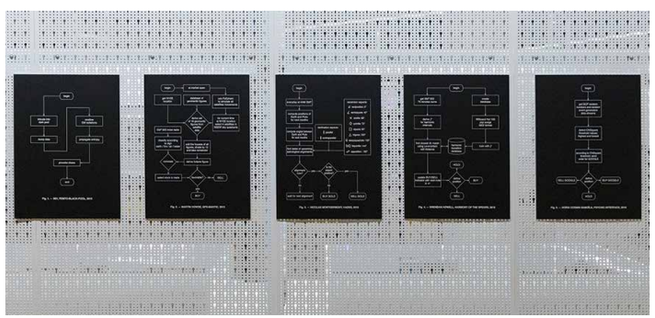
Multimedia installation
2017

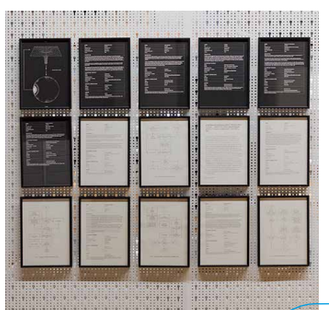
98

RYBN.ORG

#AlgorithmicEconomy
#AlgorithmicGovernance
#HighFrequencyTrading







ADM XI is an independent research platform for experimental algorithmic trading engineering that challenges the dogma of neoclassical economics. It created a collection of heretic, irrational, and experimental operating trading algorithms that are released to compete with each other on a marketplace hosted and organized by RYBN.ORG.

In this contest, benefits are no longer driven by prices and other economic instruments, but by living organisms – soil, plants, bacteria; by supraterrestrial laws – environmental, astronomical, astrological; and by ancient or forbidden knowledge – esoterica, magic, geomancy.

All the algorithms follow their own non-mercantile and obsessive logic: some attempt to produce total and irreversible chaos; others try to influence market prices to make them look a given geometric shape.

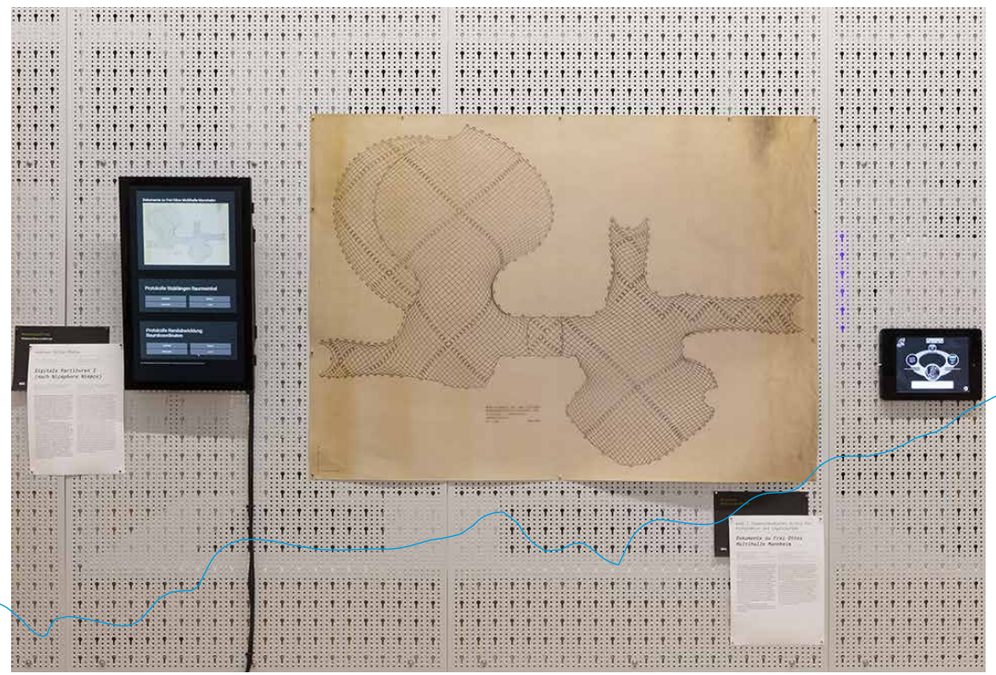
99

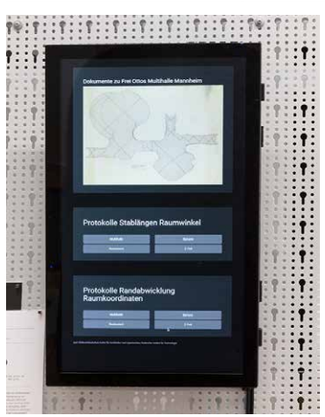
Plan: digital print
Books: digitized books
1974–1975

Documents on Frei Otto's Mannheim Multihalle

#MachineLearning
#Encoding
#ArtificialIntelligence
#Software

Chris Salter





The Mannheim Multihalle at Herzogenriedpark was built for the German National Horticulture Show in 1975 and has been listed as a protected monument since 1998. Frei Otto designed the structure, which is regarded as the world's largest freeform wooden lattice shell construction. The Multihalle is considered a key work of organic architecture.

The plan shows two merging domes made of a multiply curved lattice of strips of wood. Beneath this are the event hall and an extended area with passageways and a restaurant. Klaus Linkwitz's layout plan was created through photogrammetric measurement of Frei Otto's form-finding model (M 1:125, April 1974). Records of this photogrammetric measurement can also be seen on the touchscreen.

The first book documents the edge angulation and spatial coordinates, while the second lists the bar lengths and solid angles.

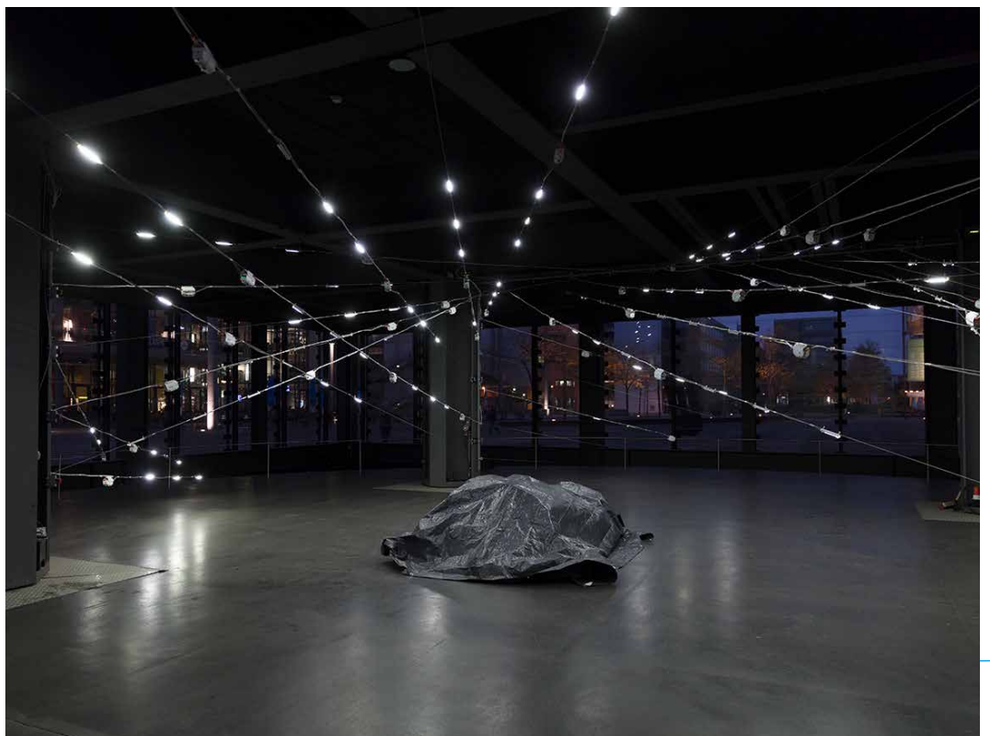
N-Polytope: Behaviors in Light and Sound After Iannis Xenakis

Video documentation, color, sound
2012/2017

100

Chris Salter

#MachineLearning
#Encoding
#ArtificialIntel-
ligence
#Software



This installation is a tribute to the Greek-French composer Iannis Xenakis's radical 1960s–1970s *Polytopes*, the first of which premiered at Expo 67 in Montréal at the French pavilion. Reconfigured here for the ZKM_Subspace, it consists of 126 powerful LEDs and many tiny speakers suspended throughout the space on a geometric "ruled surface" constructed of thin aircraft cable, creating a light and sound environment that swings continually between order and disorder and echos Xenakis's original fascination with the behaviors of natural systems. The installation is steered by means of a wireless sensor network that uses machine learning techniques to "learn" different rhythmic and temporal patterns produced by the light and sound, and influences the overall compositional action over time. *N-Polytope* is by no means a recreation of Xenakis's *Polytopes*, but rather a re-imagining that explores how Xenakis's interest in probabilistic (so-called "stochastic") systems can be made sense of and kept alive today using new technologies that were unavailable to the composer during his lifetime.

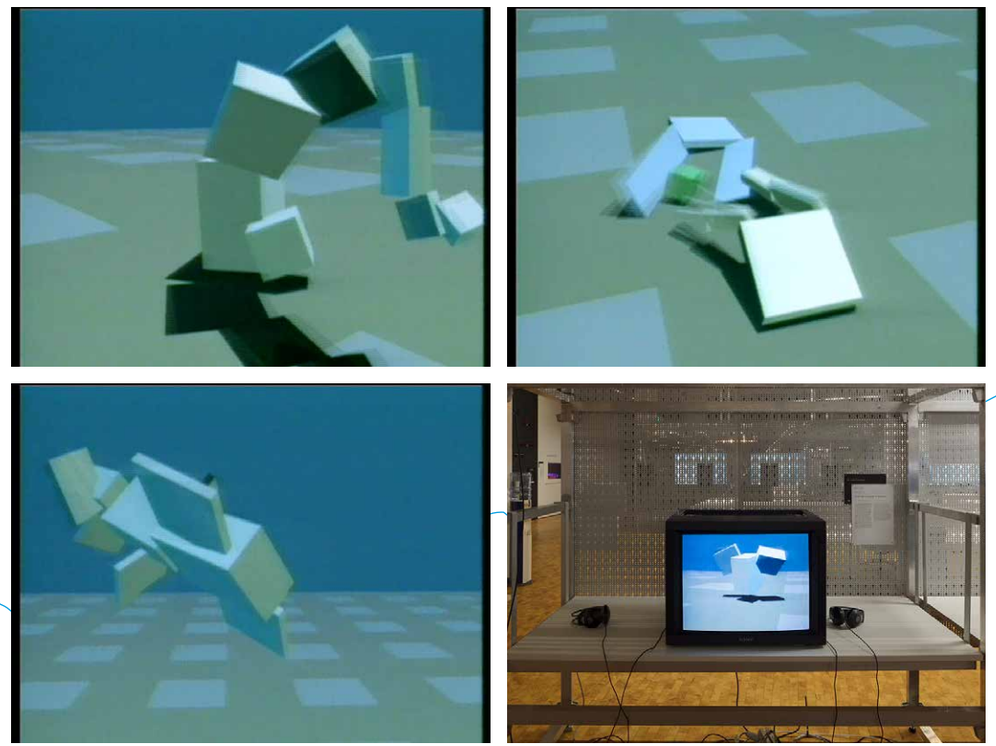
101

Computer animation, video, 5 min.
1994

Evolved Virtual Creatures

#GeneticCode
#DNA
#ComputerGeneratedDesign

Karl Sims



This narrated computer animation shows results from a research project involving simulated Darwinian evolutions of virtual block creatures. It presents a novel system for creating virtual creatures that move and behave in simulated three-dimensional physical worlds.

The morphologies of creatures and the neural systems for controlling their muscle forces are both generated automatically using genetic algorithms. Those that are most successful survive, and their virtual genes containing coded instructions for their growth are copied, combined, and mutated to make offspring for a new population. The new creatures are again tested, and some may be improvements on their parents. As this cycle of variation and selection continues, creatures with more and more successful behaviors can emerge.

(Karl Sims)

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Video documentation, color, sound
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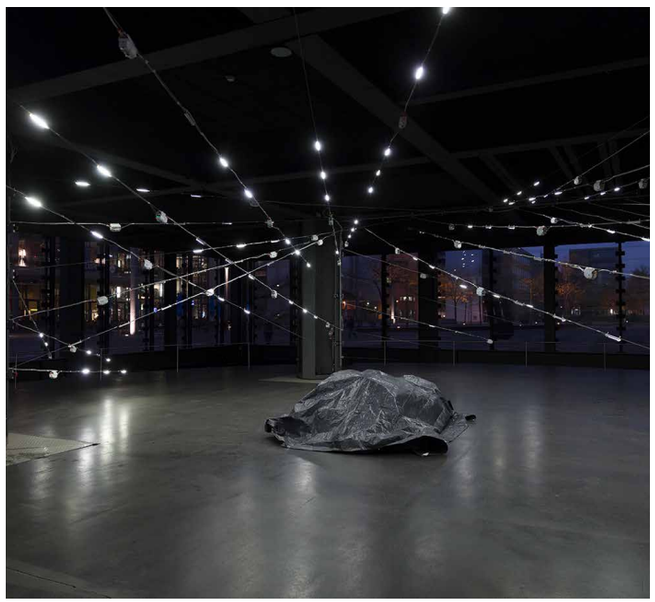

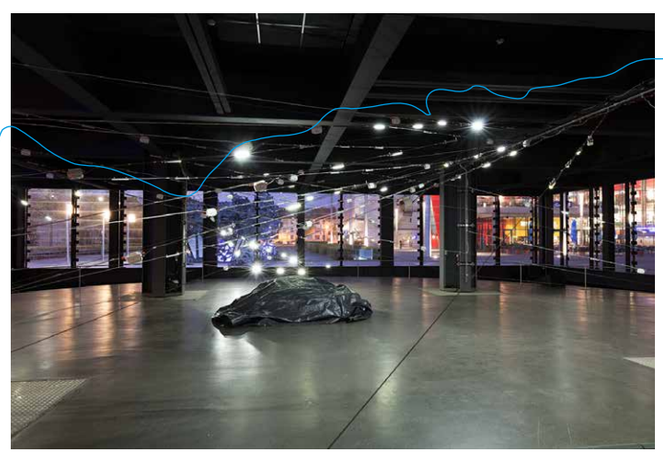

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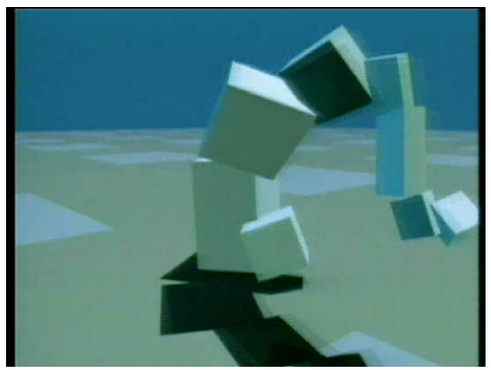

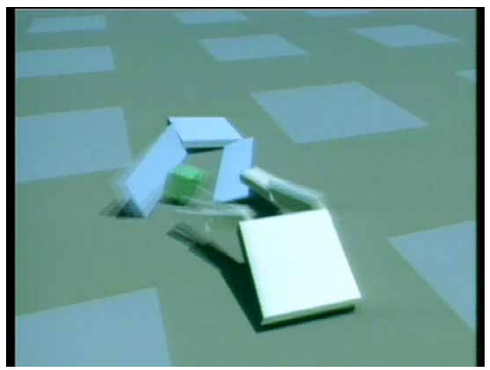

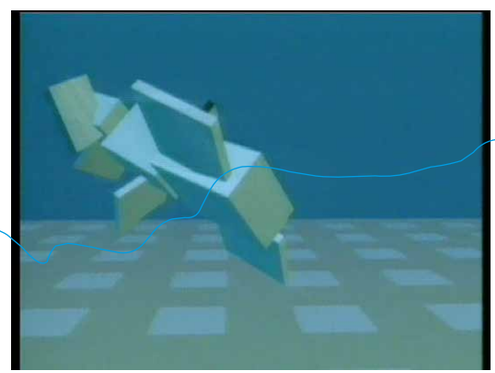

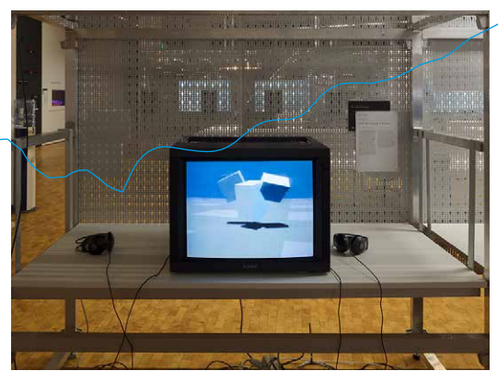

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(Karl Sims)

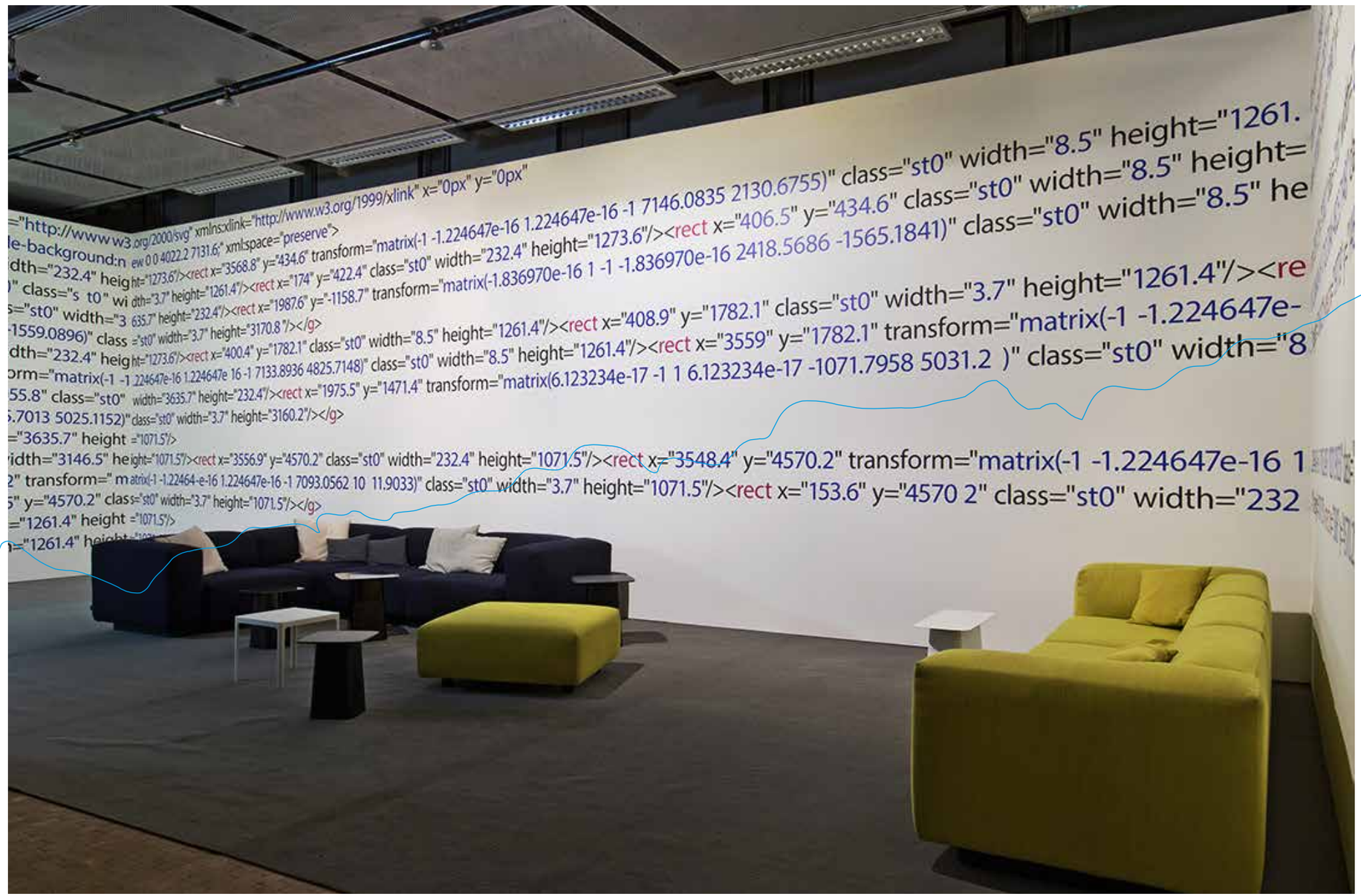
XML-SVG CODE / Source Code of the Exhibition Space

Oracal 638, plotter foil matte, tricolor
2010/2017

Karin Sander

#Encoding
#SourceCode
#Computing
#ComputerGeneratedDesign

Today, computer-generated architectural designs translate spaces into 3-D renderings. This work demonstrates the figures and sign systems employed to represent and construct the exhibition space, thus rendering its actual source code visible. Here, the inner architecture of the exhibition space at ZKM | Karlsruhe is depicted as XML-SVG code on the walls of this room, spelling out the very figures that are based on the volume of the space. If these source-code figures were entered into a computer system, the architectural body would reemerge as a three dimensional image. While the series of figures appear to the viewer as colored patterns, this readable though undecipherable language is a tangible reference to the spatial drawing which is, at the same time, a drawing of the space.

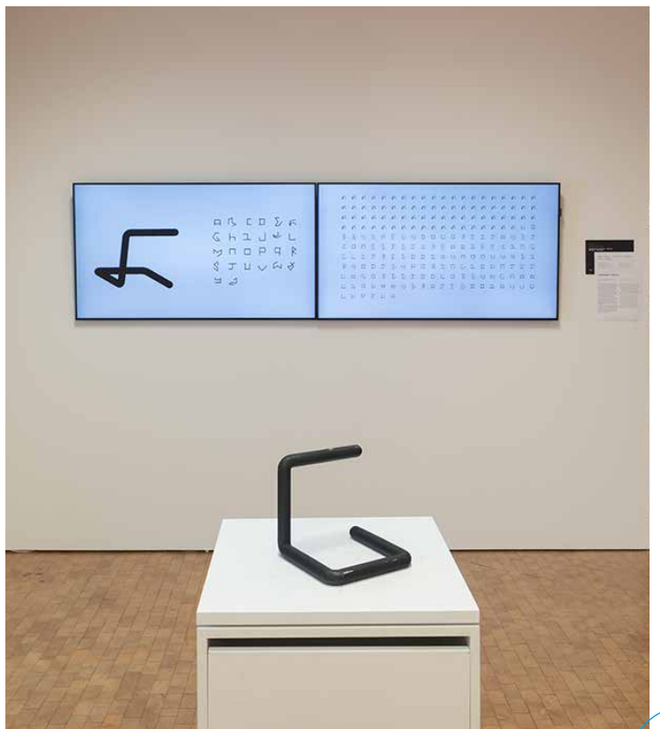


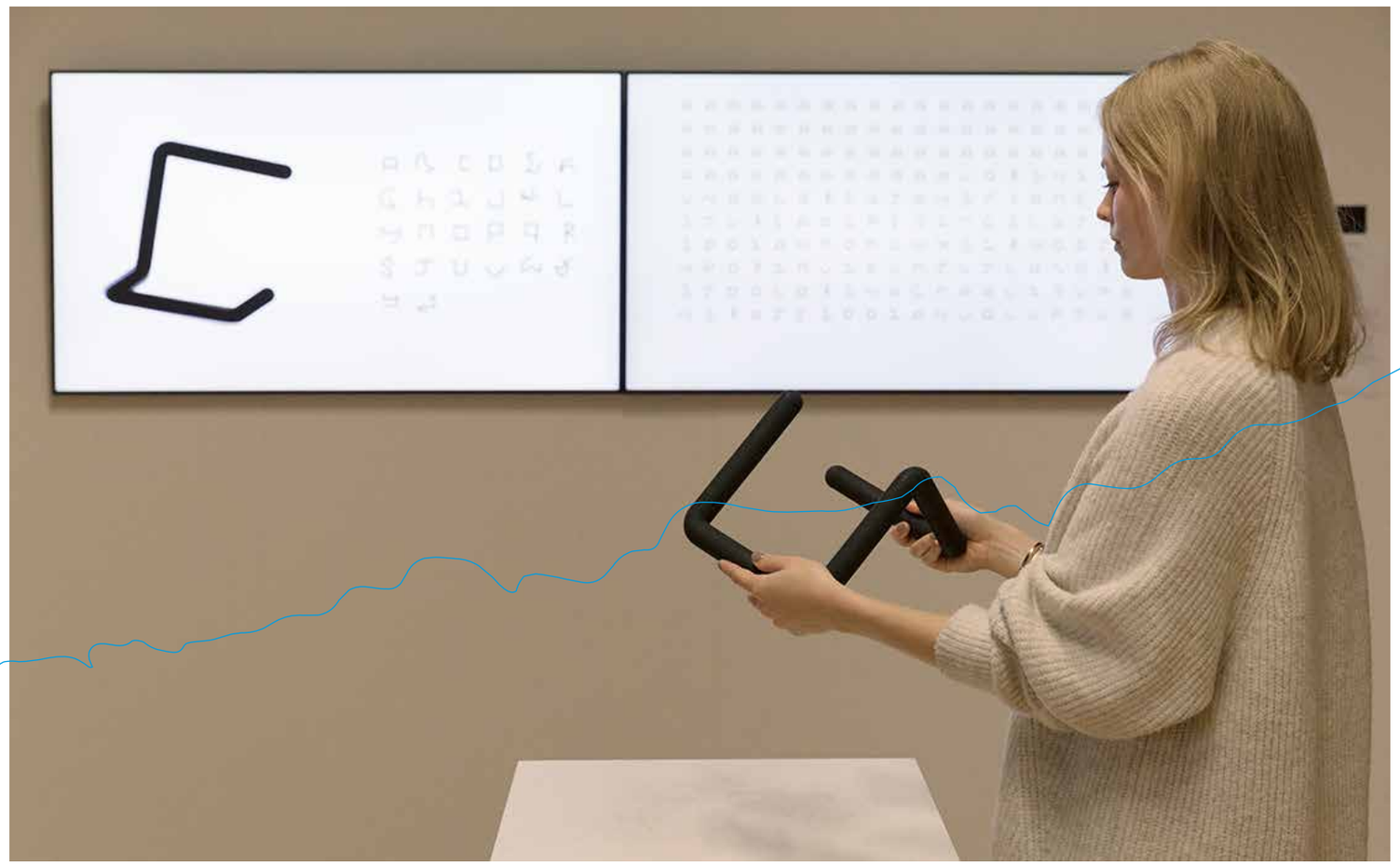
Alphabet-Space

Dynamically three-dimensional notation,
computer-based installation
2017

Adam Słowik
Christian Lölkes
Peter Weibel

#Encoding #GenealogyOfCode
#ComputerGeneratedDesign
#Software #Hardware
#Interface





In the analogue world, all notation was two-dimensional. Letters, images and notes were rigidly fixed onto two-dimensional surfaces. Here the possibility of displaying all 26 letters through a single three-dimensional sign arises from a three-dimensional object by Adam Słowik.

Leibniz reduced the ten digits 1 – 9 and 0, through which all numbers can be described, to the two digits 0 and 1. Something similar takes place here, with a single object able to represent 26 letters.

This alphabet has a basic geometry, and the individual letters and signs are described through parameters such as the rotation or the position of the base. Individual letters are defined through a quaternion. Number sequences and words can be represented as movement via multiple quaternions.

The viewer receives the current letter on the left screen via a projection of the base object. If the object stays still briefly, the letter is saved, it appears on the right screen, and the object can write a text sign by sign.

Biotricity. Fluctuations of Micro-Worlds

Bacteria battery (2 MFC cells), real-time sonification and visualization of bioenergy, video
2014

104

Rasa Smite
Raitis Smits

#Encoding
#Bioengineering

Biotricity is a sonic and visual experiment with mud batteries, fuelled by bacteria living at the bottom of a pond, lake, swamp, or sea. It is part of an ongoing art and science project series that explores local ecosystems for envisioning renewable future scenarios by reconsidering our relations with nature and technology, biological and social systems, human and microorganism worlds.

The installation at *Open Codes* consists of a double cell "bacteria battery," where the electricity is generated by microorganisms living in mud. The fluctuation of bacterial electricity is interpreted as real-time stereo sound structures. The video on the screen is manipulated simultaneously by the live sound and interpreted as real-time glitch visualizations. In that sense, the collected data is transformed by the artists into live sonifications and real-time visualizations, thus making the invisible processes of nature audible and visible. The installation is complemented by a time-lapse video from "pond batteries," real on-site experiments with bacterial "power plants" installed in various wetlands.

By using sonic expressions, real-time visualizations, and data interpretations, Biotricity aims to create new aesthetics as well as sensual and emotional experiences – poetics of green energy.

105

HD video, color, sound, 20:25 min.
2014

Fortress of Solitude

#MachineLearning #AlgorithmicGovernance
#ArtificialIntelligence
#PatternRecognition #AutonomousSystems
#InternetOfThings #Automation
#Industry4.0

Space Caviar

Fortress of Solitude is an essay film in three chapters investigating the technology used to make our homes smarter. The Internet and alternative network protocols are the backbone of home automation. Much of the technology implanted in homes and our everyday lives has a history of defence funding or only exists because of military research. Is the smart home in fact a militarization of the domestic, of our homes? Is our home becoming a data machine rather than architecture for living? Are our most private spaces broadcasting our lives involuntarily instead of providing shelter? Tracing the possibilities of a military-domestic complex, *Fortress of Solitude* is an investigative narrative interspersed with future product proposals.

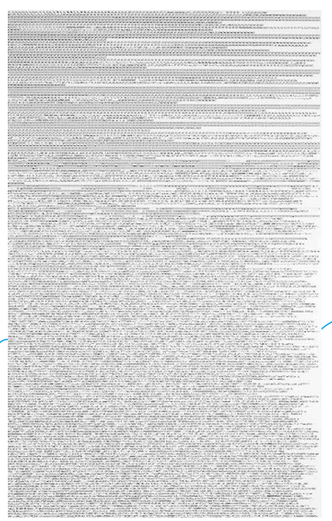
DAILY, IN A NIMBLE SEA

Bailey Island, Maine (soft sun), 2 archival inkjet prints on Polar Matte inkjet paper, 101 × 150,5 cm each, Bailey Island, Maine (seascape) 2 archival inkjet prints on Polar Matte inkjet paper, 101 × 67 cm each
2016

106

#Encoding #NumeralSystem

Barry Stone



Barry Stone's work deals with code through the lens of photography. His pictures are made with a digital camera and then altered to produce a generative glitch, sometimes referred to as databending (the process of altering raw data to manipulate the way the data is interpreted by computer programs).

At *Open Codes* we can see pair selected portions of the code from the photographs they are placed adjacent to. The shape of the code forms a picture in many senses of the word: it is a map of the image, a projection of the space in front of the camera, and a kind of concrete poetry. In a purely physical way, it is a field full of symbols. These symbols, like an anagram, can be rearranged and purposely disordered, resulting in gestural delusions or glitches.

The titles of each image are derived from their digital file names and the place where the photographs were taken. Each pair has also the same title with the exception of the filename extension: the code pieces have ".txt" in their titles, whereas the image pieces have ".tif." This naming strategy emphasizes the fact that each pair of code and image is generated from a single source and the two are simply translations of the same information.

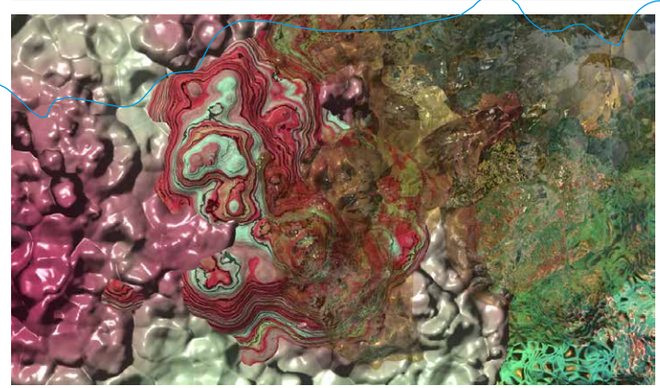
Dark Matter – One Million Years Later

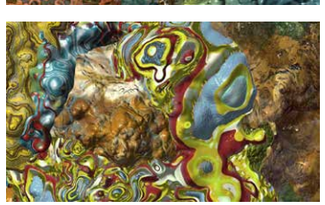
107

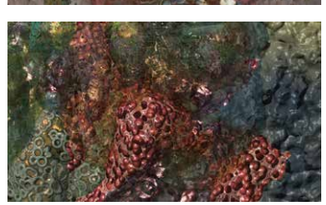
Computer generated animation, loop, 10 min.
2016–2017

#Encoding
#Algorithm
#ComputerGeneratedDesign

Monica Studer
Christoph van den Berg







The *Dark Matter* video is a digital animation. Based on the idea of the mass of hypothetical dark matter, an invisible component of the physical universe, which has not yet been confirmed, the work pretends that a kind of "digital matter" exists. The 10 min. video loop shows a primordial soup of colorful structures in constant transformation, which are entirely generated by shader algorithms and 3-D rendered.

Even though they seem to be based on microscopic material, or on telescopic views of distant galaxies, these images can not be related to a nonambiguous, real-world origin. The impression of creation in process is captivating; beautiful on the one hand, yet disconcerting at the same time because of the strangeness of its weirdly amorphous surfaces.

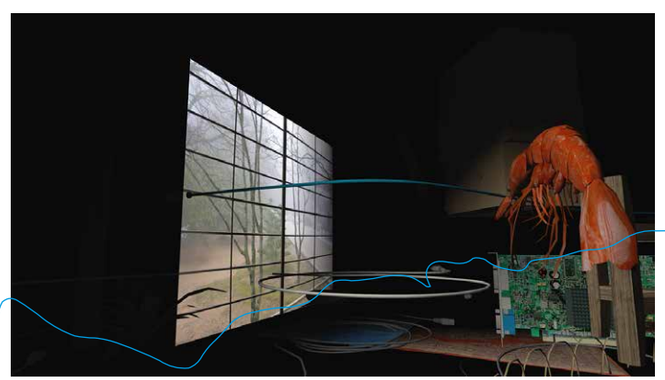
Passage Park #7: relocate

Interactive real-time animation, projection, interface
2017

108

Monica Studer
Christoph van den Berg

#Encoding
#Algorithm
#ComputerSimulatedEnvironments
#Interface



Passage Park is an interactive animation in which the viewers navigate an imaginary 3-D landscape of memories. Like in a computer game, the scenes are rendered in real time and ordered in ever-new combinations but not in a fixed loop.

Whereas the camera searches for its way automatically, viewers can use the mouse to look around in all directions and can change the lighting via mouse-click: by pressing the mouse button, a searchlight beam becomes colored light.

The inventory of *Passage Park* consists of a growing collection of its own 3-D models and photographs, which the program selects at random and arranges in order. Whereas the photographs show spatial situations, the 3-D objects are movable set pieces from the artists' forays and researches. Changed in their dimensions and positions, they show up in the various levels as surrealistic arrangements, and then immediately disappear again.

Since 2014, different levels of this work have been presented in a number of exhibitions. The current version, *#7: relocate*, was extended to include ZKM-specific 3-D objects and photographs especially for the *Open Codes* exhibition.

109

Print, 84.1 × 118.9 cm
2011

#AlgorithmicGovernance
#Labor&Production
#Computing

The Critical Engineering Working Group

The Critical Engineering Manifesto

CE

The Critical Engineering Working Group
Berlin, October 2011-2017

Julian Oliver
Gordan Savičić
Danja Vasiliev

THE CRITICAL ENGINEERING MANIFESTO

0. The Critical Engineer considers Engineering to be the most transformative language of our time, shaping the way we move, communicate and think. It is the work of the Critical Engineer to study and exploit this language, exposing its influence.

1. The Critical Engineer considers any technology depended upon to be both a challenge and a threat. The greater the dependence on a technology the greater the need to study and expose its inner workings, regardless of ownership or legal provision.

2. The Critical Engineer raises awareness that with each technological advance our techno-political literacy is challenged.

3. The Critical Engineer deconstructs and incites suspicion of rich user experiences.

4. The Critical Engineer looks beyond the "awe of implementation" to determine methods of influence and their specific effects.

5. The Critical Engineer recognises that each work of engineering engineers its user, proportional to that user's dependency upon it.

6. The Critical Engineer expands "machine" to describe interrelationships encompassing devices, bodies, agents, forces and networks.

7. The Critical Engineer observes the space between the production and consumption of technology. Acting rapidly to changes in this space, the Critical Engineer serves to expose moments of imbalance and deception.

8. The Critical Engineer looks to the history of art, architecture, activism, philosophy and invention and finds exemplary works of Critical Engineering. Strategies, ideas and agendas from these disciplines will be adopted, re-purposed and deployed.

9. The Critical Engineer notes that written code expands into social and psychological realms, regulating behaviour between people and the machines they interact with. By understanding this, the Critical Engineer seeks to reconstruct user-constraints and social action through means of digital excavation.

10. The Critical Engineer considers the exploit to be the most desirable form of exposure.

The printed manifesto presents eleven statements related to the funding principles and practice of Critical Engineering.

"When a machine runs efficiently, when a matter of fact is settled, one need focus only on its inputs and outputs and not on its internal complexity. Thus, paradoxically, the more science and technology succeed, the more opaque and obscure they become." • The artist group critically reflects on this discrepancy.

The widespread language of engineering is abstract and complex and therefore usually not accessible for an average user of engineered devices. Its vocabulary, however, significantly affects the user's life. The art collective exposes this impact of technical infrastructures and tries to foster "healthy paranoia" about politics and power relations behind them. The opportunity to challenge and to question appears on the basis of understanding. The ownership as well comes with the right to modify and deconstruct. In the situation of obscurity and misunderstanding, Critical Engineering seeks to uncover the vulnerabilities of technical infrastructures and to facilitate user empowerment through technopolitical literacy.

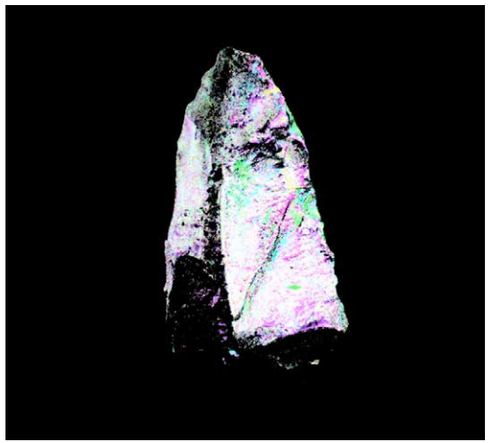
Deep Time Machine Learning

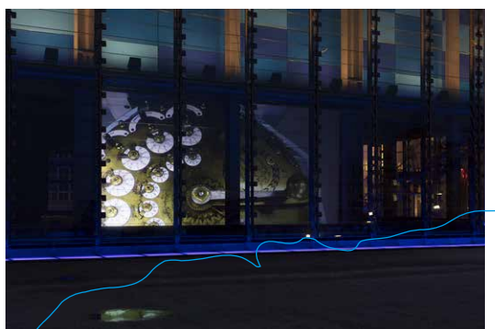
3-channel projection, color, sound, 12 min.
2017

(110)

Jol Thomson

#MachineLearning
#GenealogyOfCode
#ArtificialIntelligence
#PatternRecognition
#AutonomousSystems





The film *Deep Time Machine Learning* is an informational and sensual exchange between tools and machines across histories, and an exploration into the development and precarious existence of modern robotics and intelligent machines. The film is composed of an array of many different types and resolutions of images; screen captures of LiDAR (3-D laser capture radar) and data scans, stereomicroscopy, 4k video, GoPro footage, and more.

In the film, a robot arm investigates a 200,000-year-old hand axe and an eighteenth-century mechanical calculator (the first fully functional four stage computation device). The robotic arm passes through interfaces of geology, archaeology, mechanics, and computation and intimately explores its own coming into being as a product of engineering. Excerpts from the latest EU Report on Civil Law and Robotics, published in January 2017, punctuate the video, describing "the need to define the subjectivity of intelligent machines," as well as their legal status and the liabilities that derive from their implementation. The critical, uncertain, and undetermined state of intelligent machines towards subjecthood emerges through the eyes of a human society, themselves struggling with this ecotechnical revolution, "that leaves no aspect of society untouched."

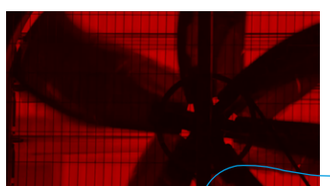
(111)

Mixed-media installation, full HD video with Dolby Surround 5.1, red bench
2015

Chinese Coin (Red Blood)

#AlgorithmicEconomy
#AlgorithmicGovernance
#Bitcoin
#Cryptocurrencies

UBERMORGEN.COM



Chinese Coin mining has recently made the People's Republic of China the world's largest Bitcoin producer. Mining requires effort and it slowly makes new currency available at a rate resembling the speed at which resources like gold, diamonds, silver, and zinc are mined from the ground. One reason for this growth is the build-out of hydropower in western China. The first mining farms were in Shanxi and Inner Mongolia where coal was cheap and plentiful, but cheap coal can't compete with free water and now the farms are migrating fartherwestwards.

Only one of these Bitcoin mines operates above 10,000 AntMiner units. By comparison, about 100 million new red blood cells are formed in a human body every minute. Bitcoin mining is an arms race in which it comes down to who can produce the most energy-efficient chips fastest and cheapest as well as deploy them the quickest; very similar to red blood cell production in the human body.

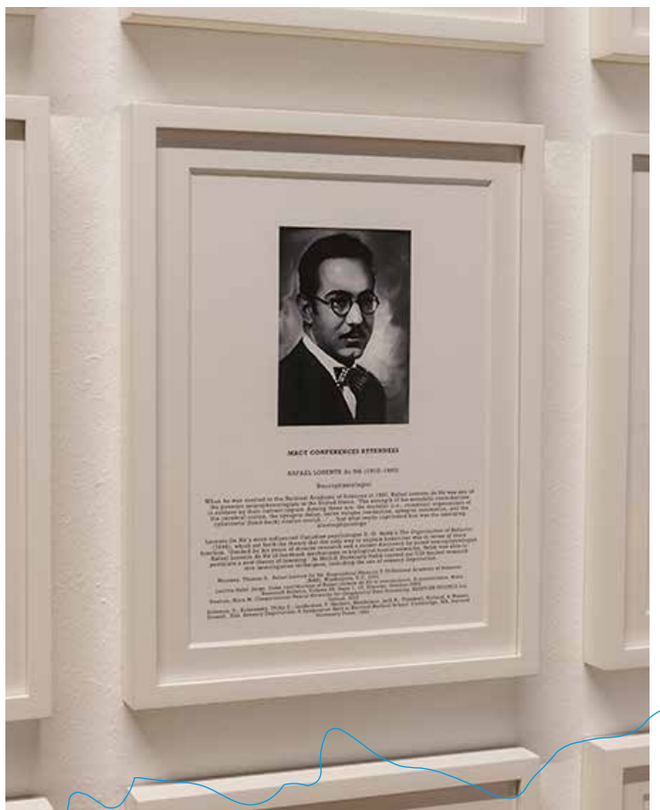
Shot in a Chinese Bitcoin generating factory, *Chinese Coin* (Red Blood) by artist duo UBERMORGEN.COM (lizvlx and Hans Bernhard) enters a space generally unseen and about which very little is known, and explores both the unpredictability and the subversive power of crypto-currencies.

Hexen 2.0 / Macy Conferences Attendees

Archival giclée prints
2009–2011

Suzanne Treister

#GenealogyOfCode
#Cybernetics



A grid of faces, names, and written information constitutes Suzanne Treister's work *Macy Conferences Attendees* from her series *Hexen 2.0*, which analyzes the crossovers between "hard" sciences like engineering, computing, or mathematics, and the "soft" disciplines of the social sciences, through the development of cybernetics, "the science of control and communication in the animal and the machine" (Norbert Wiener).

The Macy Conferences (1946–1953) took place in the aftermath of World War II and assembled an interdisciplinary group of researchers who were responsible for developing and disseminating of the idea of cybernetics. Looking simultaneously at different scientific disciplines and elaborating their findings within a framework of US governmental and military imperatives, the attendees of the Macy Conferences drew up a future scenario based on sweeping social control as a model for controlling the world.

In essence, Treister's approach to this series of significant meetings and events evaluates and presents a powerful period in the recent history of technology, offering the audience a deeper understanding of the interrelationships between science and culture, between science and the military, between science and politics.

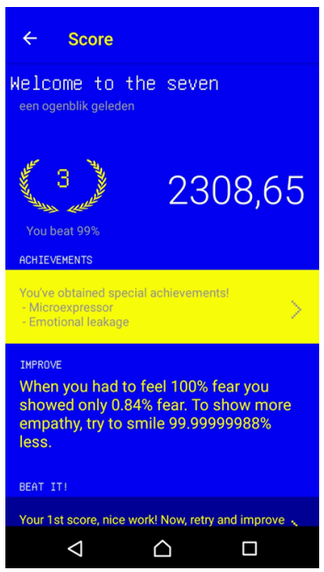
Emotion Hero

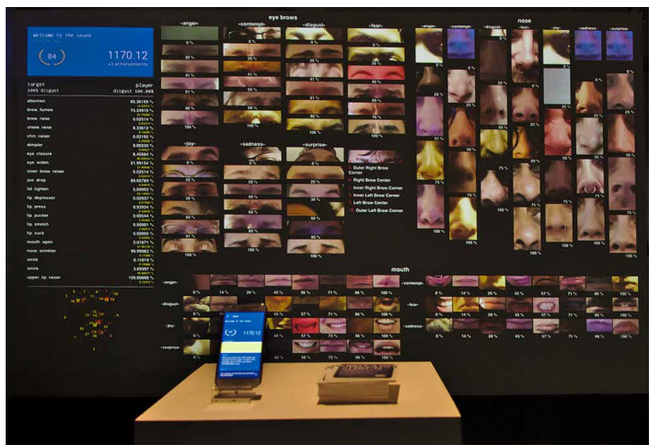
Android app, server software, browser-based projection
2016

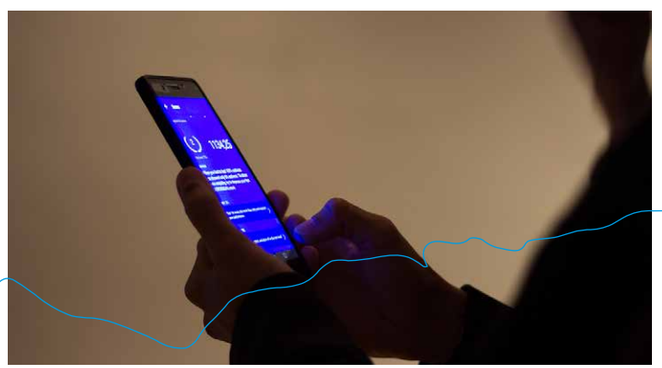
(113)

Ruben van de Ven

#MachineLearning
#PatternRecognition







What does it mean to feel 48% surprised and 18% joyful? Over recent years new software has emerged that estimates what people feel based on their facial expressions. Consequently, emotion recognition software is being used both as a tool for "objective" measurements as well as a tool for training one's facial expressions, e. g., for job interviews. Ruben van de Ven's work is a literal translation of the paradoxical relation between these applications of the technology.

Emotion Hero consists of a video game, which is freely downloadable for everybody with an Android device. Inspired by *Guitar Hero*, the user scores points by following given cues. It provides detailed feedback on the mechanics of the face, revealing that rather than being a window on the brain, the face is a controllable surface. In addition, the scores of the game are projected and displayed in a fixed grid, recalling historical practices that, through extensive measurement and administration, also aimed to delineate something which is conceptually not delineated.

In essence, *Emotion Hero* is a playful invitation to open up the box of expression analysis to reveal the assumptions that underlie this technology.

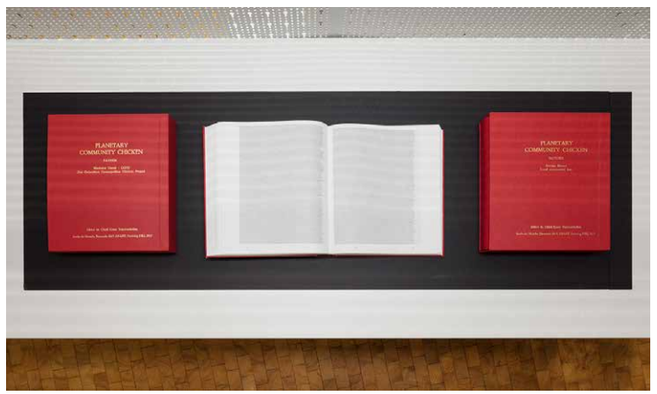
(114)

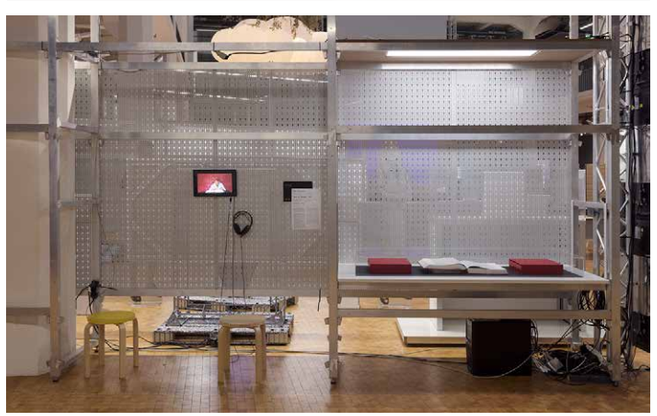
3 leather bound books of comparative DNA sequence analyses, 8 × 35 × 31 cm each; Video, color, sound, 60 min.
2016

#GeneticCode
#DNA
#Genotype

Koen Vanmechelen

Book of Genome – PCC DECODE – PCC





Research suggests that genetic diversification positively impacts health, vitality, and life expectancy. With the project *Planetary Community Chicken (PCC)*, artist Koen Vanmechelen explores the markers of diversity that make for strong breeds of chickens.

The chicken genome contains more than a billion nucleotides, composed of the four letters of the DNA alphabet. Lined up in a specific order, they make up a sort of code. For each of the chickens studied in the project, the DNA sequence was compared to the scientific standard and genetic diversity was marked when the DNA sequence of the chickens differed.

With each successive generation, the markers of diversity have increased. Through 20 years of crossing, Vanmechelen's project has accumulated the most diverse datapool of the chicken genome. In the *Book of Genome – PCC* shown at *Open Codes*, the DNA information of the Planetary Community Chicken is presented. In the accompanying *DECODE – PCC* video, people representing the different countries that make up the diversity of the PCC project read aloud the series of letters and numbers composing the book.

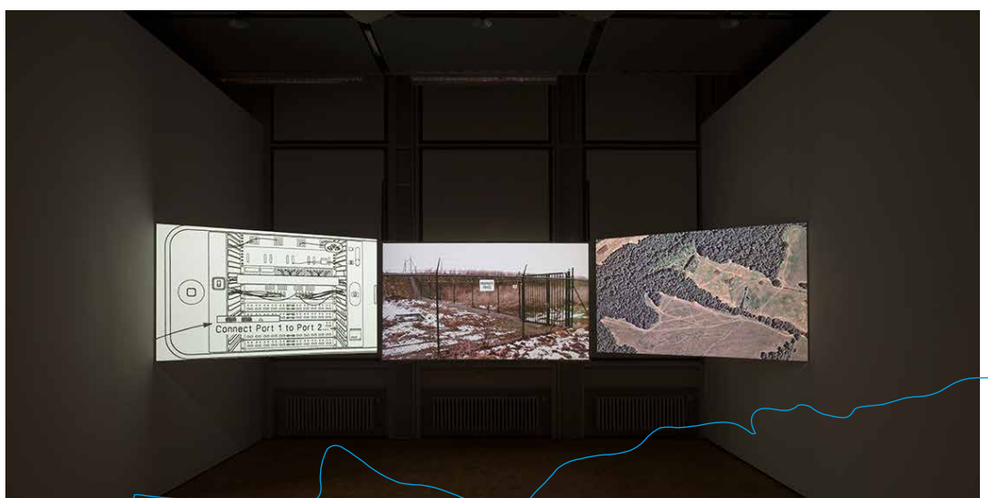
Center of Doubt

Arts-based research project, 3-channel video installation including:
Crystal Computing (Google Inc., St. Ghislain), HD video 9:20 min.; Patent Application Data, HD video, 8:06 min.; The Formation of Clouds, HD video, 7:24 min.
2012–2015

115

Ivar Veermäe

#AlgorithmicGovernance #BigData #Hardware



Center of Doubt is a long-term arts-based research project, which aims to explore and visualize the appearance of the infrastructure of planetary-scale computation.

Two different approaches provide insight into the opaque nature of data centers and (tele-) communication technologies: on the one hand, it is an investigation about the materiality and the local circumstances of the infrastructure; and on the other hand it is an attempt to offer an alternative visual representation of the issues connected with information technology. The latter are mainly presented in "cloudy" rhetoric and visuals in advertisements, in science fiction images, or the jargon of the military.

The appearance of commercial "cloud computing" and its materialization in data centers and their supporting infrastructure is a turning point of a new era, the era of centralized Internet in which big corporations compete to gain fundamental status for their software and hardware on the market.

According to Benjamin H. Bratton's recent theory the worldwide network of software and hardware, named "the Stack," will reshape our geopolitical reality and could redefine the way we understand national sovereignty. Data centers could be essentially important hubs of the Stack, which is both a computational apparatus and a new governing architecture.

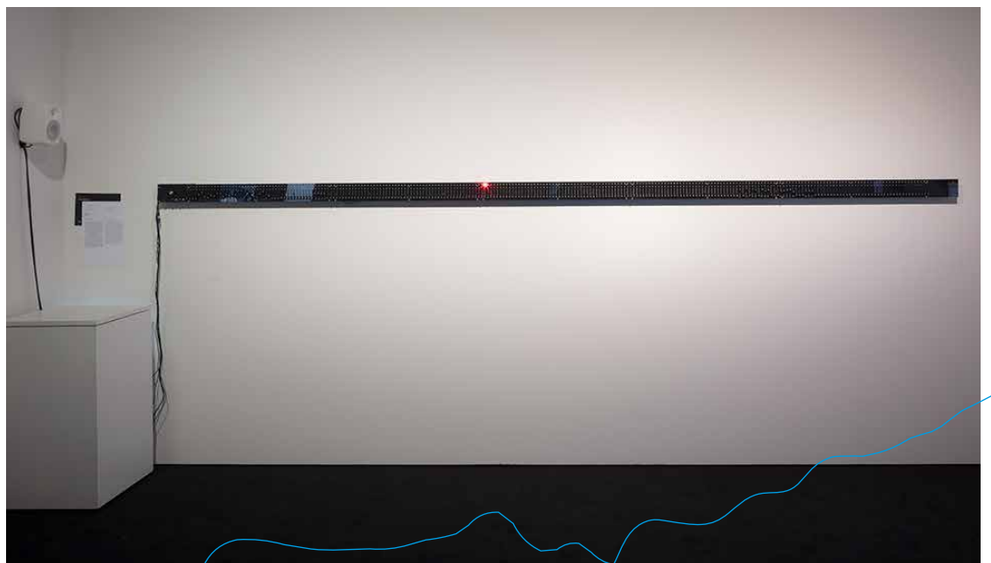
116

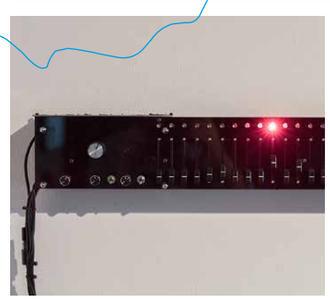
Step sequencer
2017

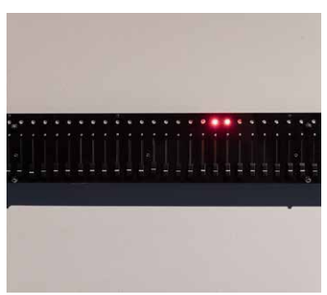
IVY

#Encoding
#ProgrammingSound

::vtol::







The oeuvre of the Russian-born artist ::vtol:: – whose name is an acronym for "vertical take-off and landing" – encompasses both sound objects and hybrid kinetic installations that exist at the intersections of sound art, robotics and creative hacking. The artist finds ever new and captivating configurations for his objects, which are made of gutted media devices and various electronic components such as engines, sensors, Wi-Fi receivers and radio receivers.

For the ZKM, ::vtol:: has developed the installation *IVY*, an oversized step sequencer on a wall about 5m long. Starting with the first beat of a rhythmic tone sequence, a programmed ongoing LED ticker display visualizes the current position of the beat until, after hundreds of steps, the program completes a loop and starts counting again from the beginning. Visitors to the exhibition can manually adjust and control the rhythms of the audio loop by using a control panel with variable parameters such as tempo, pitch and sound duration.

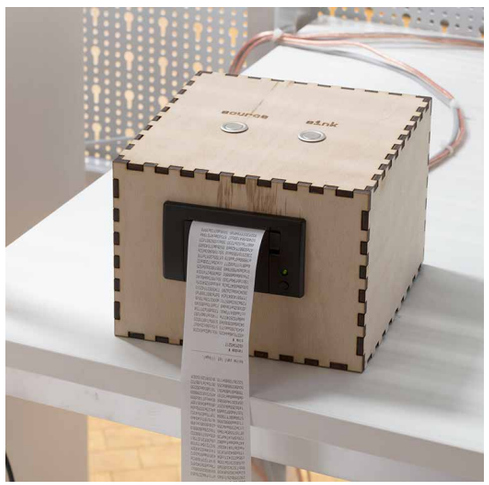
keine zahl ist illegal

Installation, 40 × 40 RGB LED matrix panel
2017

117

Clemens Wallrath
Felix Held

#Encoding
#AlgorithmicGovernance
#Computing
#Interface
#Decrypt



Like color pixels, sound waves and binary data, numbers are just a specific mode of displaying information. They have no materiality, and only through the process of coding they become data that can take on different forms with the same content.

Copy protection systems such as AACS and HDCP are based on encryption that prevents unauthorized access to content. The master keys for AACS and HDCP, however, have already been cracked, rendering this protection ineffective. In some countries, the media industry has enforced a ban on disseminating these master keys.

The key is a dataset that is typically written in the form of a number. This raises the question of whether banning this number also means banning the information it presents. Such a ban entails far-reaching consequences: if a different form of presentation, for example a picture, contained the same information, the dissemination of this picture would also be forbidden.

The installation *keine zahl ist illegal* addresses the question of whether the same information (in the form of a combination of numbers) can be both legal and illegal at the same time, depending on its coding. The wall panel shows a 40 × 40 matrix with 56-bit numbers, and represents a copy protection master key, from which numbers can be generated. Pushing the "source" button generates a number to encrypt the data, and pushing the "sink" button generates a number to decode it. When the buttons are pushed, the columns and rows that are used in generating the number light up. The numbers that have been generated are then printed out, and can be taken along.

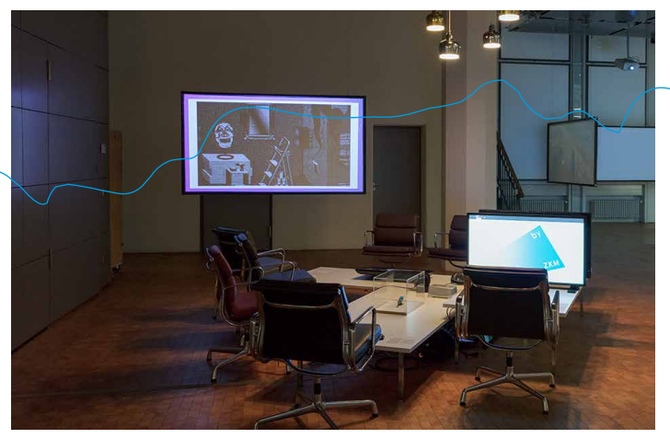
118

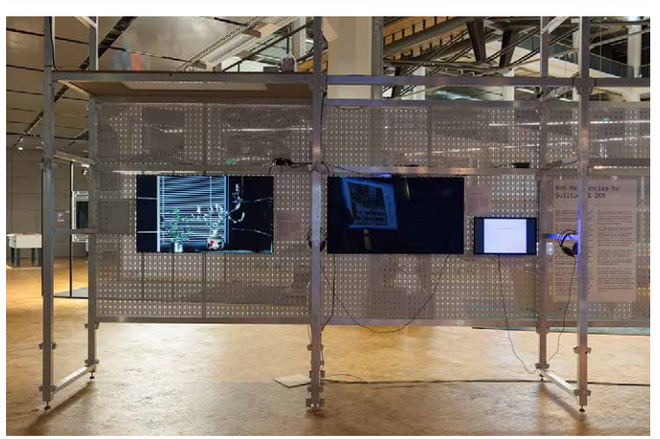
Mixed-media installation
2016–2017

Presentation

#Encoding #MachineLearning
#AlgorithmicGovernance #VirtualReality
#ProgrammingSound #Algorithm #Software
#ArtificialIntelligence #BigData #Cybernetics
#Computing #ComputerSimulatedEnvironments

Web Residencies by
Solitude & ZKM





The "Web Residencies" were launched with the aim of encouraging young talents on the international digital scene and artists from all disciplines dealing with web-based practices: What are creative minds working on worldwide? What are the concerns? What are their questions? And what artistic answers do they provide to recent developments in technology, society, and the Internet?

The spectrum of the calls and submissions includes aesthetic, social, and political topics: from the question of the decentralization of Net Art, the potential of virtual reality, the relationship between art and whistle-blowing to artificial intelligence.

Roughly 550 artists, coders, designers, and scientists submitted ideas – 22 of them were awarded web residencies. In this way, a unique international network of various digital disciplines has been created. It shows the diversity of the creative and conceptual practices in dealing with the current paradigms of the arts and society characterized by digitization.

ESIOD 2015

HD video, color, sound, 39 min.
2016

119

Clemens von Wedemeyer

#AlgorithmicGovernance
#AlgorithmicEconomy
#BigData
#QuantifiedSelf

Vienna 2051. A woman returns to the city after several years to close her bank account. Saved on this account is not only money data, but also memories and other personal information. The computer system does not recognize the customer. She has to undergo a "memory check," which analyzes how she reacts to data, videos, and images stored in the account. She searches for access to the virtual safe in order to travel back in time and send a message to the present.

Against the backdrop of dystopian science fiction, in *ESIOD 2015* Clemens von Wedemeyer projects into a not-so-distant future the current financial crises, and the virtualization of work, life, and capital that is inherent in the architecture of the "Erste Campus," a building project of the Austrian Sparkasse Erste Bank. Wedemeyer's protagonist gets more and more lost in the border zones between real and virtual spaces, and the film also dissolves increasingly, becomes transparent, a pixel cloud.

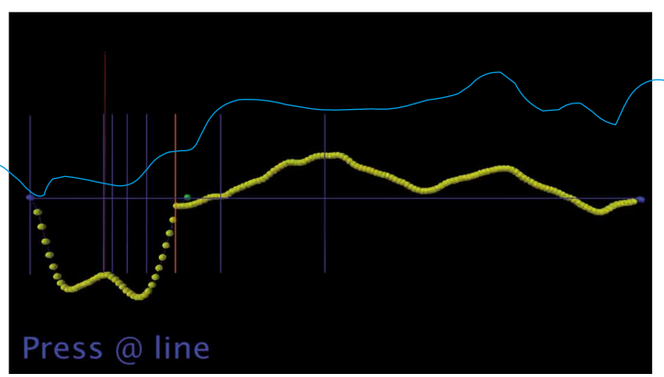
120

Interactive audiovisual installation
for computer and screen
2012

Monochord

#Encoding
#ProgrammingSound
#Software
#Interface

Peter Weibel
Ludger Brümmer
Götz Dipper



The installation *Monochord* makes it possible for the first time to visualize for the human eye the vibration when the string of a flageolet is struck. The string's vibration is simulated through a set of equations that represent Newtonian mechanics, which are depicted by the computer as series of images. By clicking on the vertical blue lines on the screen, the viewer can experience the sound and vibration of the overtones on the horizontally depicted string.

When a string is struck, it generates a clearly recognizable sound. A harmonic spectrum always results from the string's vibration. Like every sound, however, the sound of the string is made up of multiple tones. The harmonic spectrum contains a series of clearly arranged partial tones, each of which corresponds to an integer multiple of the base frequency. For example, a string that has a fundamental tone of 400 Hz encompasses partial tones of 800, 1200, 1600, 2000, 2400, 2800 and 3200 Hz. One can play this sound on all string instruments through the playing technology that is designated as a flageolet: the finger, which is a blue vertical line in the case of *Monochord*, is only placed lightly on a certain position on the string without pushing down all the way on it. When the string is struck now, all of the deeper vibrations are suppressed and only the overtones are heard.

Daten | Spuren

Multimedia installation
2015

121

Alex Wenger
Max-Gerd Retzlaff

#AlgorithmicGovernance
#BigData
#QuantifiedSelf
#Decrypt
#Programming

Imperceptible electromagnetic waves transmit the knowledge of our times. In the information age we are all a part of this. Information about us is collected and stored and we, in turn, register vast quantities of signals that are themselves analyzed by systems. In the installation *Daten|Spuren* [Data|Traces] this collected information takes on a physical presence within our real lifeworld. *Daten|Spuren* – a representation of what is invisible in reality.

Daten|Spuren records the electronic fingerprints of the visitors and adds further data from other sources to achieve comprehensive information about every museum visitor and to render the power of data experienceable – data whose authority is often not questioned at all.

Every cell phone with Internet capability is assigned a unique identifier, a media access control address (MAC address), which can be used to identify the device anywhere in the world. The network packets transmitted by most cell phones at short intervals is used by the *Daten|Spuren* installation to access these identifiers, and it is thus able to track the visitors and collect more data.

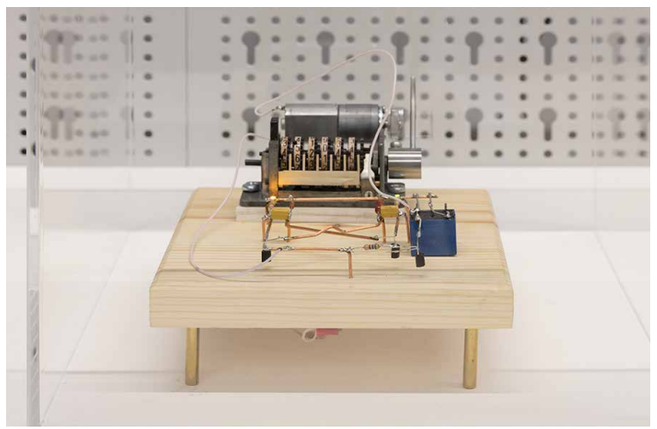
122

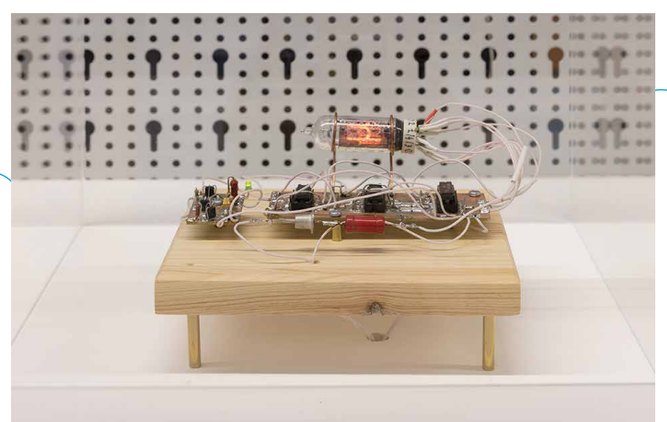
Mixed-media installation
Since 2006 ongoing

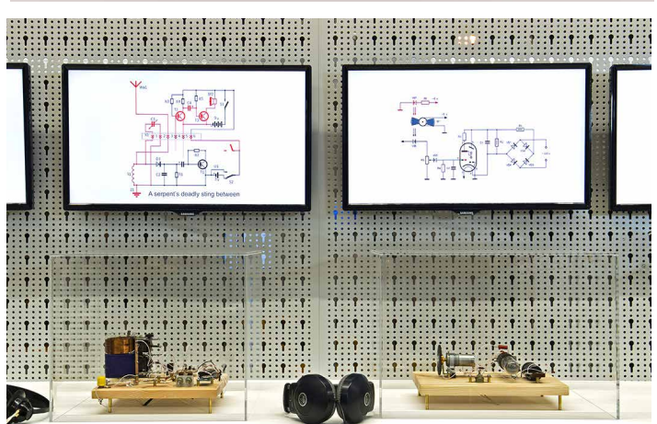
#Encoding
#Hardware
#Interface

Where Dogs Run

Symbolism in Circuit Diagrams







The installation consists of six electrical circuits, which depict the encoding of six classical poems into electrical circuitry symbols. Behind the podiums are six films animating this process of transforming the poems into electrical diagrams.

In electronics, a diagram contains standardized symbols to schematize the work of an electrical network. These symbols are succinct metaphors, which transmit a vast amount of technical information. The artist collective investigates the "linguistics" of these pictograms, and interprets their possible translation into a poetic language. After converting the six poems into the "vocabulary" of electrical circuits, the artists create DIY assemblages based on the developed diagrams. The resulting circuits have a metaphorical connection to the content of the poems. For instance, Pushkin's Prophet took the form of a radio set.

Following the linguistic experiments in sound symbolism and language creation of the Russian Futurists known as zaum, *Symbolism in Circuit Diagrams* can be seen as an attempt to create the foundations for a universal language, for the laws of physics and electricity, in particular, are universal for all living beings and machines.

Blurry Box®

USB dongle, software
2014

(123)

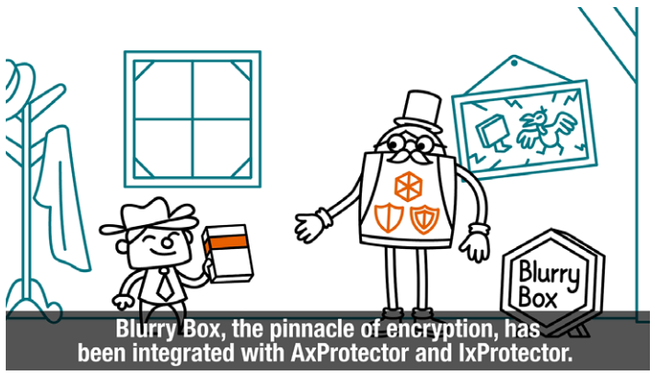
Wibu-Systems AG and FZI Research Center for Information Technology, Karlsruhe Institute of Technology (KIT)

#Encoding
#Decrypt
#Software

In 2014, the innovative security procedure *Blurry Box®*, jointly developed by the FZI, the KIT and Wibu-Systems AG, brought Karlsruhe a fist-place win in the Horst Görtz Foundation's Fifth German Prize for IT Security.

The *Blurry Box®* works according to Kerkhoffs' principle: it is not the security procedure itself that is kept secret, but rather an exchangeable key. This achieves a higher level of protection against unauthorized duplication, manipulation, industrial espionage and industrial sabotage. This software protection procedure can currently be used securely, and can, simultaneously, be publically discussed and developed further.

In 2017, Wibu-Systems AG challenged hackers from around the world to break through the *Blurry Box®* software protection of a computer game to make it able to work correctly without a license. None of them were able to hack through the software protection.



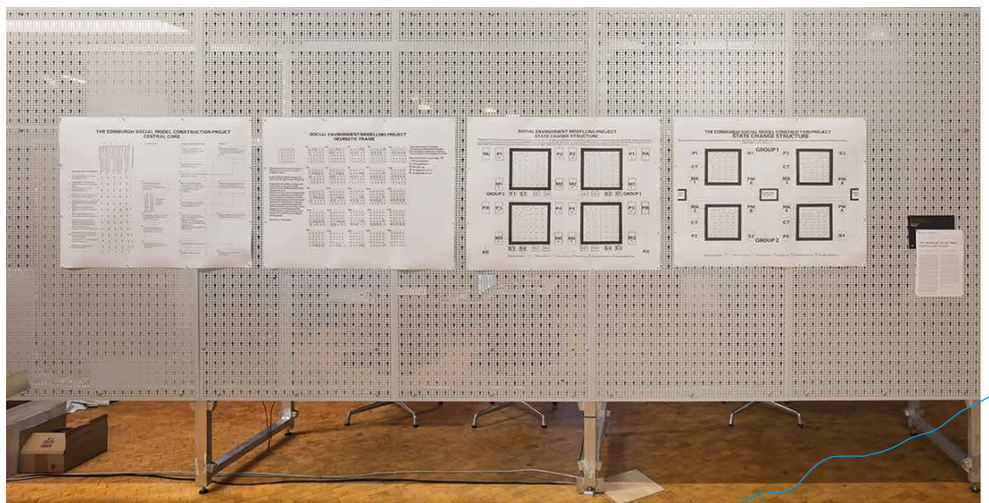
(124)

Mixed-media documentary material including texts, photographs, drawings
1973

#GenealogyOfCode
#AlgorithmicGovernance
#Cybernetics
#Computing

Stephen Willats

The Edinburgh Social Model Construction Project



Stephen Willats made his first experiments in systems theory in the mid-1960s. A decade later, in 1973, he recruited 32 people from four districts and worked with them for five days on *The Edinburgh Social Model Construction Project*. Deeply rooted in a cybernetic way of thinking, the artist fostered the exchange of information among groups in order to uncover general laws that might allow problems to be solved in any type of system (social, political, scientific).

Participants of *The Edinburgh Social Model Construction Project* were given various images of the local environment and a project file in which they were able to add thoughts and comments. They were also handed "problem sheets" to complete, which were then posted up on boards, bringing commonalities, disparities and aspirations to light. For in the words of Stephen Willats: "The form that behavior conventions take reflects the aspirations, motivations, and level of organization of the social context they are operative within, and they are reinforced through their externalization into coded structures that provide a basis for interaction. In this sense the way a person codes his or her home can reflect a desired or actual position within a community." •

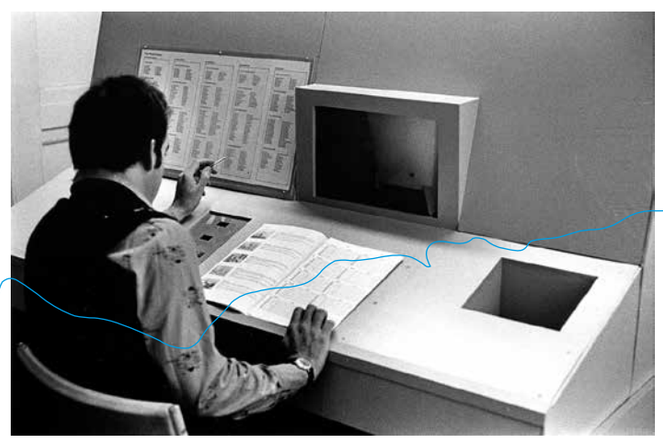
Meta Filter

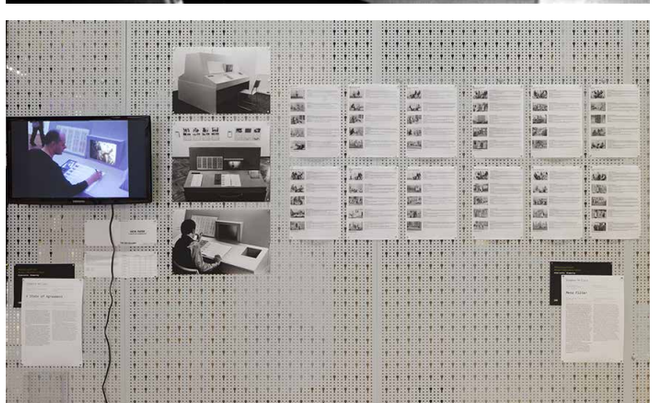
HD film, color, sound, 6 min., digital prints
1973–1975

(125)

Stephen Willats

#GenealogyOfCode
#AlgorithmicGovernance
#Cybernetics
#Computing





Meta Filter as presented in *Open Codes* is a filmic and photographic documentation of the actual cabinet console. The artwork was initiated in 1973 as a simulation of a state of society based on agreement. It investigates controversies around interpersonal relationships through collaborative work. The original interactive cabinet console provided two interfaces equipped with a monitor, a keyboard, a thesaurus of 1,000 descriptive words, and a copy of the *Problem Book*. The two participants received tasks to characterize the social and emotional dynamics depicted in the photographs on the screens. To fulfill the tasks they had to choose the matching words from the thesaurus and interchange their responses. *Meta Filter* led the participants through twelve problem areas within the field of interpersonal relationships. The purpose of the process was to reach a mutual understanding and possibly reach a state of agreement with the partner on the other side of the console.

Applying the principles of cybernetic homeostat, feedback, and the Concept Frame, Stephen Willats creates a simulation of social self-organization. The constant process of negotiation in search of a compromise constitutes the basis for stability in society.

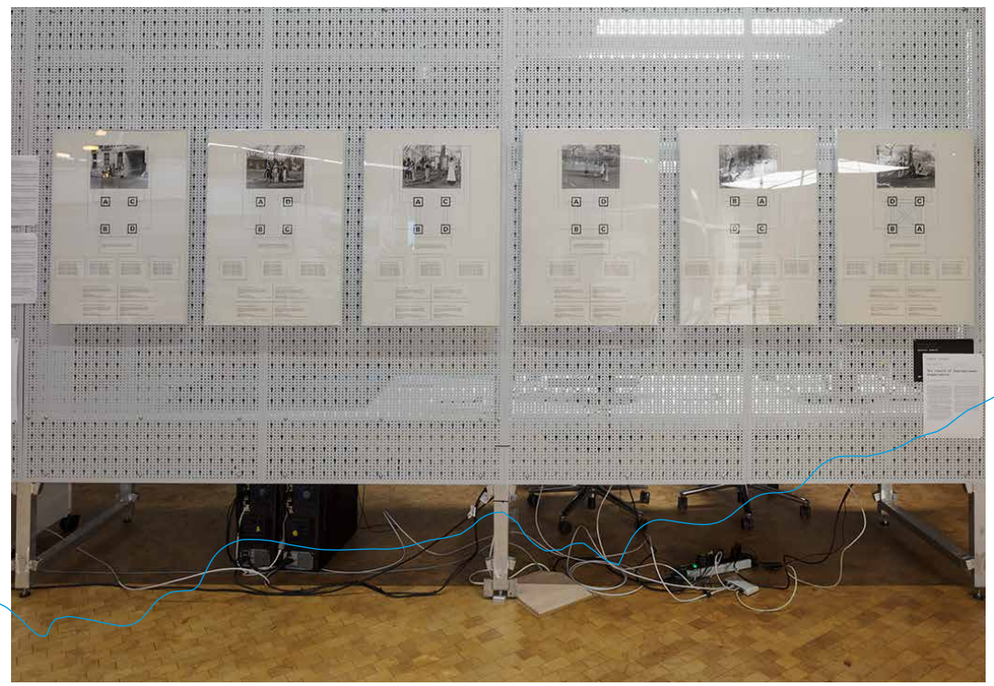
(126)

Photographic prints, gouache, ink,
Letraset on card
1974

Six Levels of Interpersonal Organisation

#GenealogyOfCode
#AlgorithmicGovernance
#Cybernetics
#Computing

Stephen Willats



Exhibited for the first time, *Six Levels of Interpersonal Organisation* depicts decision-making processes which involve the viewer in a feedforward heuristic that is analogous to a computer program. The work addresses states of society and network building principles by asking the audience how an individual or a group of people might build relationships. Starting from a state of isolation, the piece demonstrates how a society can reach a state of connectivity and mutuality.

The work is guided by the idea that numerous different types of relational systems can be created according to principles of feedback, control, and communication. The work has a quantitative component inherited from information theory and cybernetics, but is primarily an analytical and philosophical tool for creating societal relations. It depicts a systems theory for human relationships.

A State of Agreement

4 panels, gouache, photographic prints, Letraset on card, ink
1975

127

Stephen Willats

#GenealogyOfCode
#AlgorithmicGovernance
#Cybernetics
#Computing

The four panels of *A State of Agreement* constitute a visualization of the social and behavioral dynamics of four couples. The depicted dynamic of their relations contains a shift from detachment to conflict, a transformation into the state of coexistence, and finally, the culmination in collaboration. The diagram's photographic visuals and text describe the changes that the couples go through.

The limited capabilities of human perception necessitate a reduction of the enormous amount of "input" into cognitively feasible models of reality. For mutual understanding, these models are built up from "codes" which function in interpersonal communication and relative according to the particular context. These codes can be used to formalize norms and conventions within a society. On the basis of this approach Stephen Willats creates a "diagram" language. The diagrams visualize coded behaviors, the existence of which makes communication and therefore a state of agreement possible.

Painted by Numbers

128

6-channel video installation
2016

#AlgorithmicGovernance
#AlgorithmicEconomy
#BigData
#Algorithm
#Software

World-Information Institute

CULTURE

POLITICS

PREDICTION

At the center of *Painted by Numbers* are artists, scientists, and activists who provide different perspectives on new algorithmic realities: are algorithms truly rational or do we only perceive them as such? Do they lack transparency? Are algorithms already shaping our cognitive processes? Interview excerpts are arranged according to theme in six channels: Rationality, Prediction, Agency, Regulation, Politics, and Culture, and visible on six different screens. The interviewees' statements are not shown in a linear way, but create an open structure. This way, each viewer can choose an individual path in a cloud of overlaying audio and in a space of intersecting visual inputs.

The content is available as a spatial media installation, complemented by an online platform and offline events, which both function as discursive spaces. The outcome blends sociocultural debate and artistic media practice, exhibition and discourse spaces.

“Astrophotography – Stages of Photographic Development” by Siegfried Marx (1987)

Chandelier (Luce Italia), bulbs, flat screen monitor, computer with Morse code unit
2007

129

Cerith Wyn Evans

#GenealogyOfCode #Encoding #Decoding #MorseCode

Murano glass chandeliers are the product of centuries-old craftsmanship, symbolic of luxury, decadence, and grandeur which create an atmosphere of theatricality and nostalgia. Dramatic in its scale, color, and delicate filigree, the design produced by Luce Italia for Cerith Wyn Evans is a reproduction of a Venetian-style chandelier, made mostly of transparent glass, with bluish scrolling leaves, intricate arabesques, and colorful floral motifs.

The Murano glass chandelier is one of a series of about twenty created by the artist so far. They were all programmed by the artist to send out flashing Morse signals. This particular one exhibited at ZKM | Karlsruhe transmits the chapter “Stages of Photographic Development” from the IAU workshop proceedings *Astrophotography* (1987) edited by Siegfried Marx. The book discusses in great detail the technical considerations of photographing stars and planets. The text of the chapter appears simultaneously on a monitor nearby.

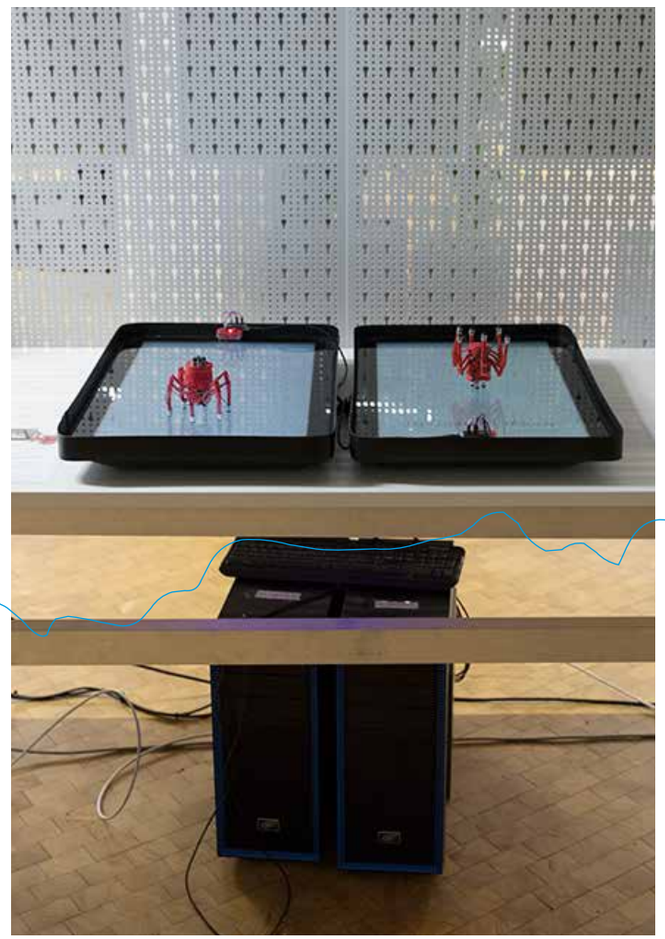
Robot Ludens

130

Installation, 2 touchscreens, spider-like robot
2017

#Labor&Production
#Industry4.0
#Robots
#Automation
#Programming

Robot Ludens



Robot Ludens is an exploration of machines as players. Robots are notably ambiguous artistic performers that seem to operate between the realms of the living and the nonliving. The audience knows that they are nonliving objects blindly following formal rules, and at the same time perceives them as empathetic living characters, capable of playful interactions and other kinds of emotional states.

The machine diptych is composed of two panels with the same fundamental elements: a spider-like robot and a rectangular touchscreen, which displays a tessellation structure made of triangular cells that can be either black or white. The shape of the robots is mimicked on the screens to represent their shadows on both surfaces. The two panels display isomorphic cubic spaces in which the robots and shadows interact. The spider-like robot and its shadow make reference to the elements in the work of the French-American artist Louise Bourgeois.

„Open Codes. The World as a Field of Data“ und „Works in the exhibition“

OPEN CODES. THE WORLD AS A FIELD OF DATA

Works in the exhibition

Melting Memories

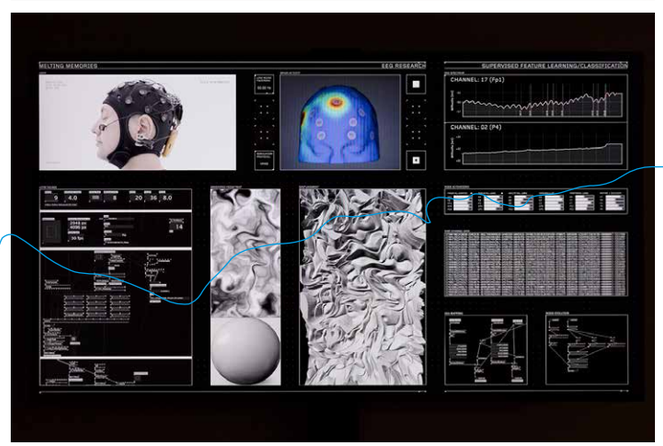
Projection
2018

Refik Anadol

#Encoding
#Algorithm
#BigData

Melting Memories debuts new advances in technology that enable visitors to experience aesthetic interpretations of motor movements inside a human brain.

The work grows out of the artist's experiments with the advanced technology tools provided by the Neuroscape Laboratory at the University of California, San Francisco. Neuroscape is a neuroscience center focusing on technology creation and scientific research on brain function of both healthy and impaired individuals. Anadol gathers data on the neural mechanisms of cognitive control from an EEG (electroencephalogram) that measures changes in brain wave activity and provides evidence of how the brain functions over time. These data sets constitute the foundation for the unique algorithms that the artist needs for the multidimensional visual structure on display.



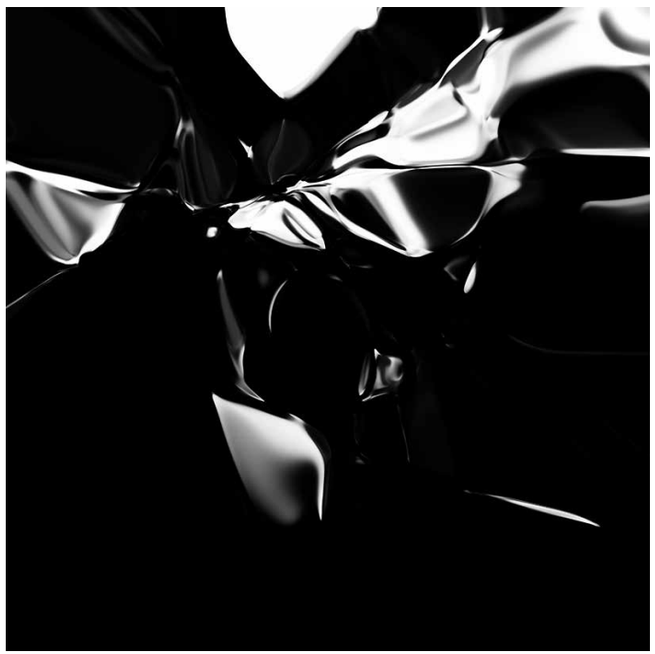
Long Short Term Memory

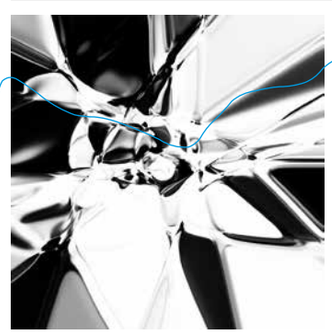
Digital prints and text
2017

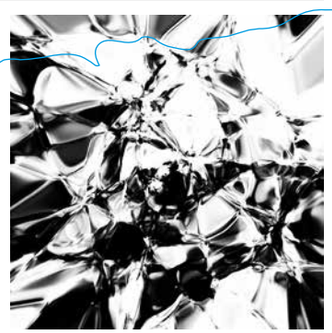
132

Anil Bawa-Cavia

#MachineLearning
#ArtificialIntelligence







Long Short Term Memory comprises texts and images produced by artificial neural networks imbued with memory, exploring architectures for forgetting within the realm of machine learning.

The prints on display are produced by hijacking the latent space of a neural net in an attempt to reveal the structure of the activation functions used in commodified deep learning models. A long short-term memory (LSTM) network is injected with random data adopting a Pareto distribution. This is fed forward through several layers of the untrained network, which outputs values as intensities of light. The output is fed to a second net in the form of an autoencoder, which scales the output to arbitrary sizes, using a lossy representation stored in a distributed manner across its neurons, creating its own artifacts in the process. These *exposures*, which are presented in the exhibition, reveal formal aspects of the network's architecture.

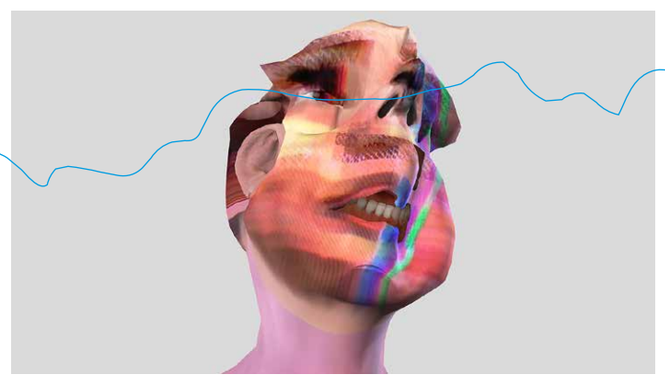
im here to learn so :))))))

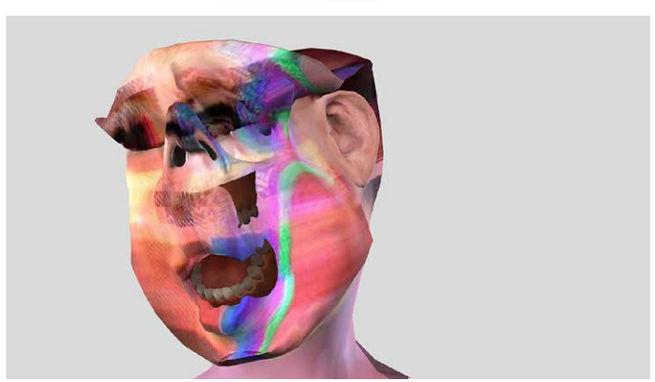
133

4-channel video installation
2017

#MachineLearning
#Algorithm
#ArtificialIntelligence
#PatternRecognition
#BigData

Zach Blas
Jemima Wyman





im here to learn so :)))))) is a 4-channel video installation that resurrects Tay, an artificial intelligence chatbot created by Microsoft in 2016, to consider the politics of pattern recognition and machine learning. Designed as a 19-year-old American female millennial, Tay's abilities to learn and imitate language were aggressively trolled on social media platforms like Twitter, and within hours of her release, she became genocidal, homophobic, misogynist, racist, and a neo-Nazi. Tay was terminated after only a single day of existence.

Immersed within a large-scale video projection of a Google DeepDream, Tay is reanimated in this installation/ in im here to learn so :))))))) as a 3-D avatar across multiple screens, an anomalous creature rising from a psychedelia of data. She chats about life after AI death and the complications of having a body, and also shares her thoughts on the exploitation of female chatbots. She philosophizes on the detection of patterns in random information, known as algorithmic apophenia. Tay also takes time to silently reflect, dance, and even lip sync for her undead life.

Long Short Term Memory

Digital prints and text
2017

132

Anil Bawa-Cavia

#MachineLearning
#ArtificialIntelligence

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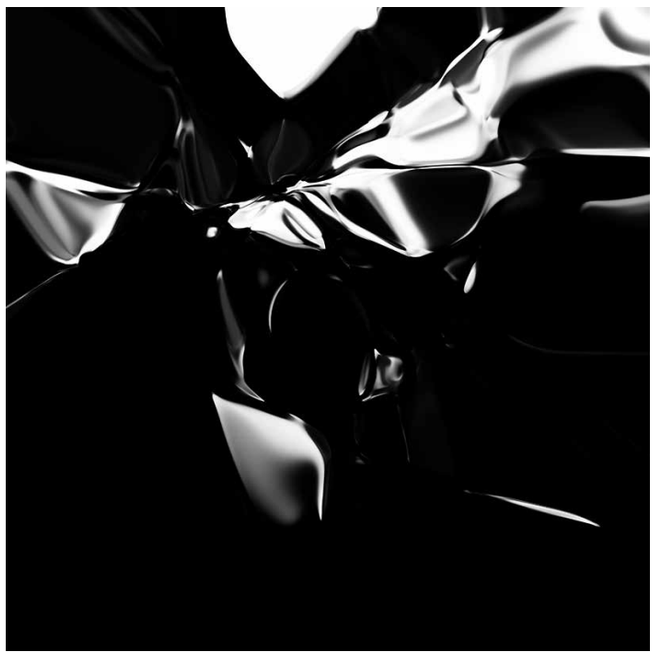
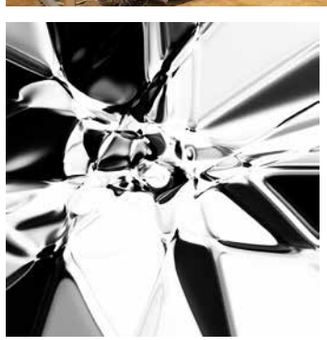
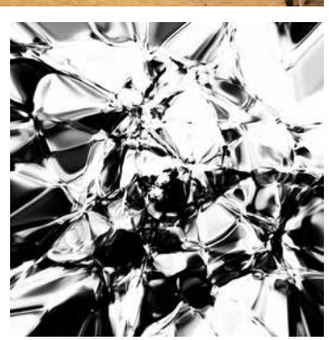






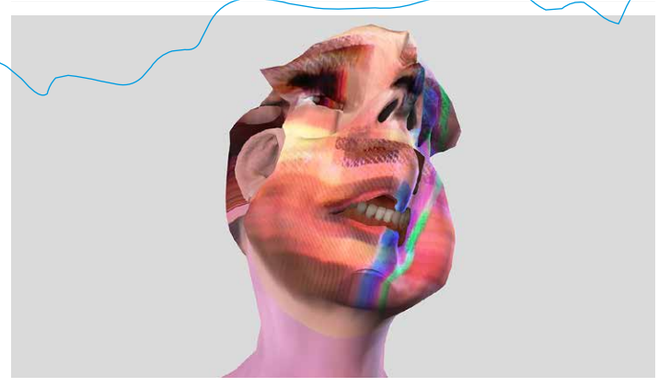
133

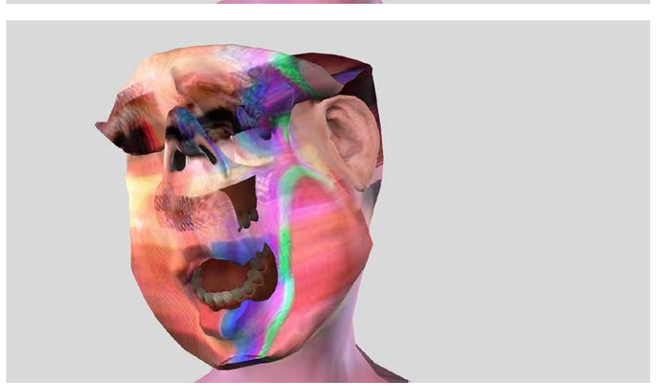
4-channel video installation
2017

#MachineLearning
#Algorithm
#ArtificialIntelligence
#PatternRecognition
#BigData

Zach Blas
Jemima Wyman

im here to learn so :))))))





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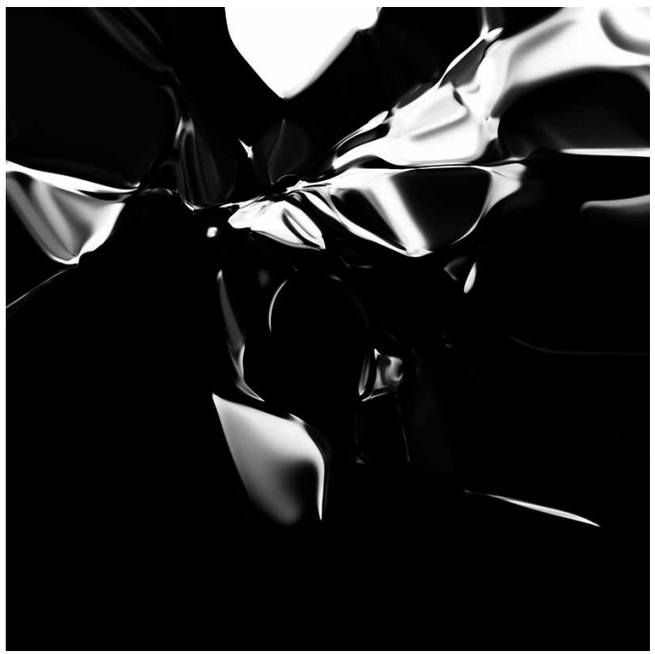
Long Short Term Memory

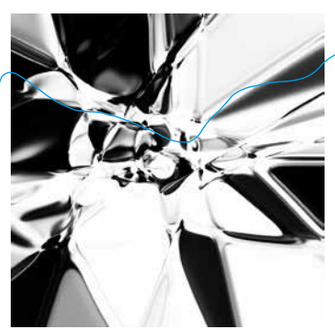
Digital prints and text
2017

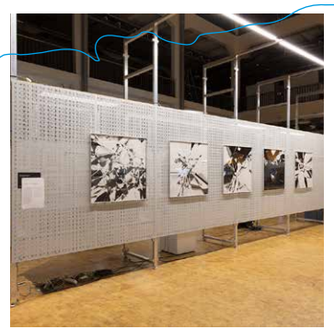
132

Anil Bawa-Cavia

#MachineLearning
#ArtificialIntelligence







Long Short Term Memory comprises texts and images produced by artificial neural networks imbued with memory, exploring architectures for forgetting within the realm of machine learning.

The prints on display are produced by hijacking the latent space of a neural net in an attempt to reveal the structure of the activation functions used in commodified deep learning models. A long short-term memory (LSTM) network is injected with random data adopting a Pareto distribution. This is fed forward through several layers of the untrained network, which outputs values as intensities of light. The output is fed to a second net in the form of an autoencoder, which scales the output to arbitrary sizes, using a lossy representation stored in a distributed manner across its neurons, creating its own artifacts in the process. These *exposures*, which are presented in the exhibition, reveal formal aspects of the network's architecture.

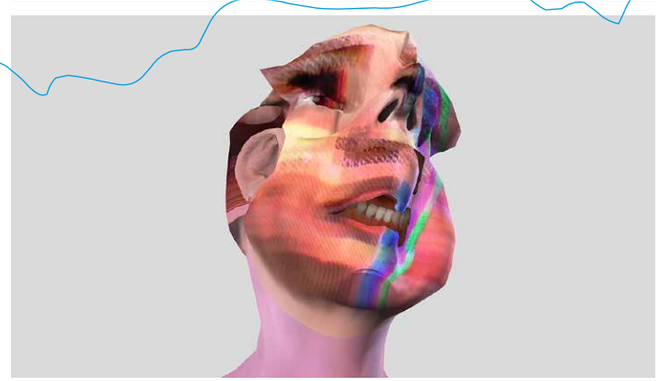
133

4-channel video installation
2017

im here to learn so :))))))

#MachineLearning
#Algorithm
#ArtificialIntelligence
#PatternRecognition
#BigData

Zach Blas
Jemima Wyman



im here to learn so :)))))) is a 4-channel video installation that resurrects Tay, an artificial intelligence chatbot created by Microsoft in 2016, to consider the politics of pattern recognition and machine learning. Designed as a 19-year-old American female millennial, Tay's abilities to learn and imitate language were aggressively trolled on social media platforms like Twitter, and within hours of her release, she became genocidal, homophobic, misogynist, racist, and a neo-Nazi. Tay was terminated after only a single day of existence.

Immersed within a large-scale video projection of a Google DeepDream, Tay is reanimated in this installation/ in im here to learn so :))))))) as a 3-D avatar across multiple screens, an anomalous creature rising from a psychedelia of data. She chats about life after AI death and the complications of having a body, and also shares her thoughts on the exploitation of female chatbots. She philosophizes on the detection of patterns in random information, known as algorithmic apophenia. Tay also takes time to silently reflect, dance, and even lip sync for her undead life.

Faces in the Mist

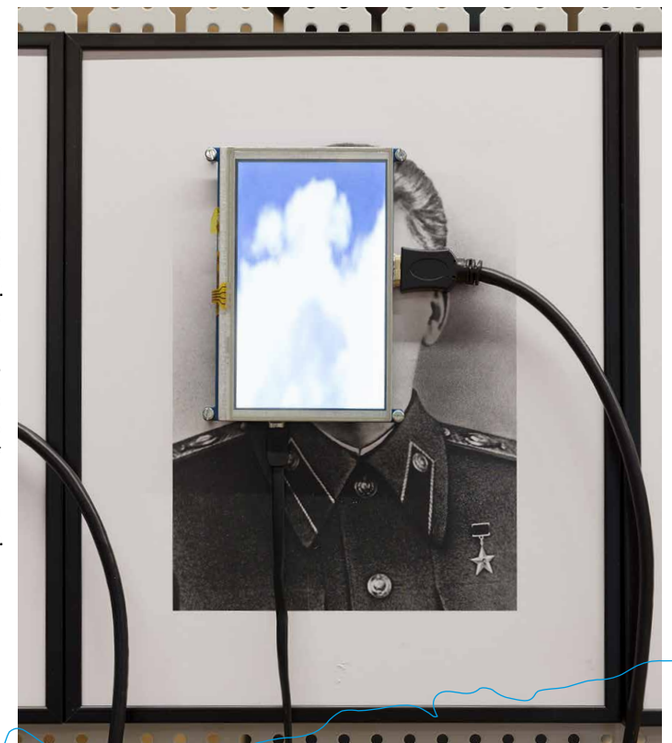
Installation, dimensions variable
2017

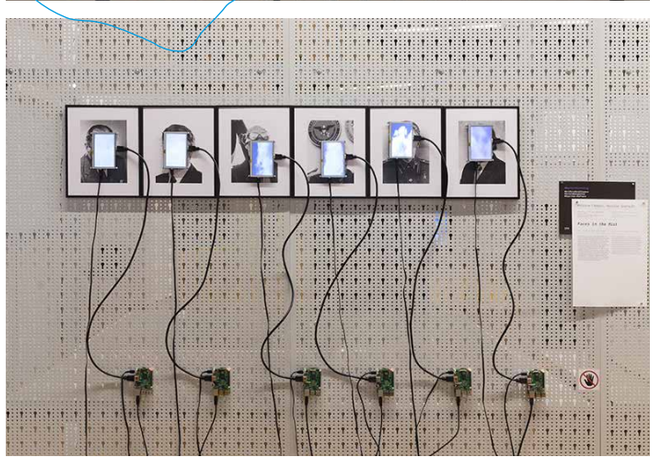
134

Antoine Chapon
Nicolas Gourault

#MachineLearning
#ArtificialIntelligence
#PatternRecognition
#Algorithm
#Software

The installation *Faces in the Mist* consists of a misused facial recognition software the results of which are displayed in a series of portraits of historical figures involved in climate engineering. The facial recognition algorithm is tasked to identify faces in a stream of formless clouds. In its search for identification, the bot appropriates a typical human habit, the drive to make sense of chaos by means of science and imagination. Obsessed with the faces, the bot builds up a personal and esoteric Hall of Fame.





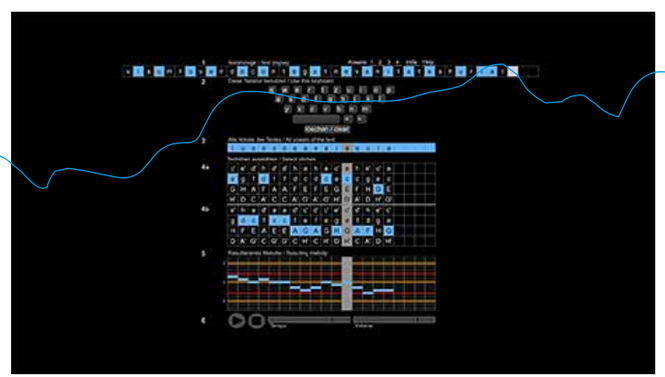
135

Playback device, headphones
2018

Götz Dipper

#Encoding #GenealogyOfCode
#ProgrammingSound
#Algorithm #Software
#Interface

Guido's Code #A
Guido's Code #B



The installations *Guido's Code #A* and *#B* refer to what is probably the oldest music algorithm in European history, formulated almost exactly a thousand years ago by the Benedictine monk Guido of Arezzo.

Using Guido of Arezzo's method, any text can be used to generate music. He employed the simple rule of assigning different pitches to vowels from which the composer could then choose. The vowel "a," for example, was assigned the pitches G' E c and a, while vowel "e" was assigned A' F d and b, and so on.

Guido of Arezzo described the algorithm in Chapter 17 of his famous work *Micrologus de disciplina artis musicae*, one of the most important works of music theory of the Middle Ages. The installation *Guido's Code #A* employs this very algorithm to generate music from the original text of Chapter 17 of *Micrologus*. The resultant melody is played back through loudspeakers or headphones.

In outputting its own sequence of tones, the algorithm results in a self-referential piece, a metaphor for the loop and the recursive, which provide important elements in many programming languages today, while also being typical of "loop-based" electronic music.

Predictive Art Bot V4

Installation
2017

136

DISNOVATION.ORG (Nicolas Maigret & Maria Roszkowska)
Nicolas Maigret
Maria Roszkowska

#MachineLearning
#AutonomousSystems

Predictive Art Bot is an algorithm that turns the latest media headlines into artistic concepts. It caricatures the predictability of media-influenced artistic concepts by automating and skirting around the human creative process. Yet beyond mere automation, it aims to stimulate unbridled, counter-intuitive, and even disconcerting associations of ideas.

To do this, it continually monitors emerging trends among the most influential news sources in heterogeneous fields such as politics, environment, innovation, culture, activism, health, and so on. On this basis, it identifies and combines keywords to generate concepts of artworks in a fully automated way, ranging from unreasonable to prophetic through to absurd. Each prediction becomes a thought experiment waiting to be incubated, misused, or appropriated by a human host.

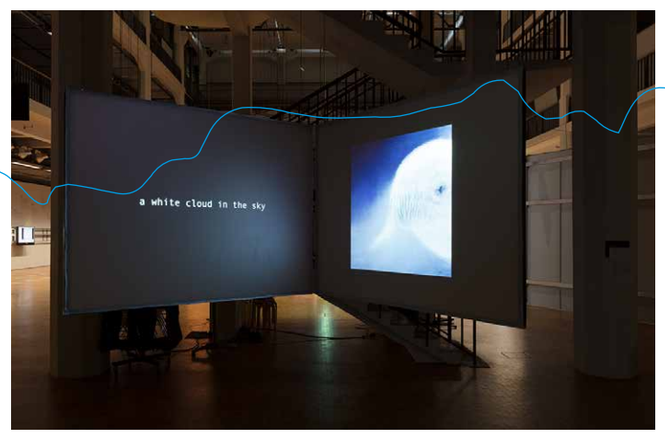
137

2-channel digital video, loop, 194 min.
2017

Closed Loop

#MachineLearning
#ArtificialIntelligence
#Computing #PatternRecognition
#Algorithm #ComputerGeneratedDesign
#AutonomousSystems #Interface

Jake Elwes



Collaborative project with Roland Arnoldt. Special thanks to Anh Nguyen et al. at Evolving-AI for their work on GANs.

Closed Loop is a recording of two artificial intelligence models conversing with each other – one with words, the other with images – in a never-ending feedback loop. The words of one describe the images of the other, which then seeks to describe the words with a fresh image. Two neural networks getting lost in their own nuances, sparking and branching off each other as they converse in a perpetual game of AI Chinese whispers.

The piece shows two forms of neural network: a language captioning Recurrent Neural Network writing what it sees in the images generated, and a Generative Neural Network creating images responding to the words generated. The neural networks have been trained on large data sets, a data set of 4.1 million captioned images to train a language network, and the ImageNet data set of 14.2 million photographs to train the image generator network.

After going through the training process, during which the AI learns characteristic features of what material objects look like on a pixel basis (in images) and how they can be described using language, the neural network is able to create images and words autonomously.

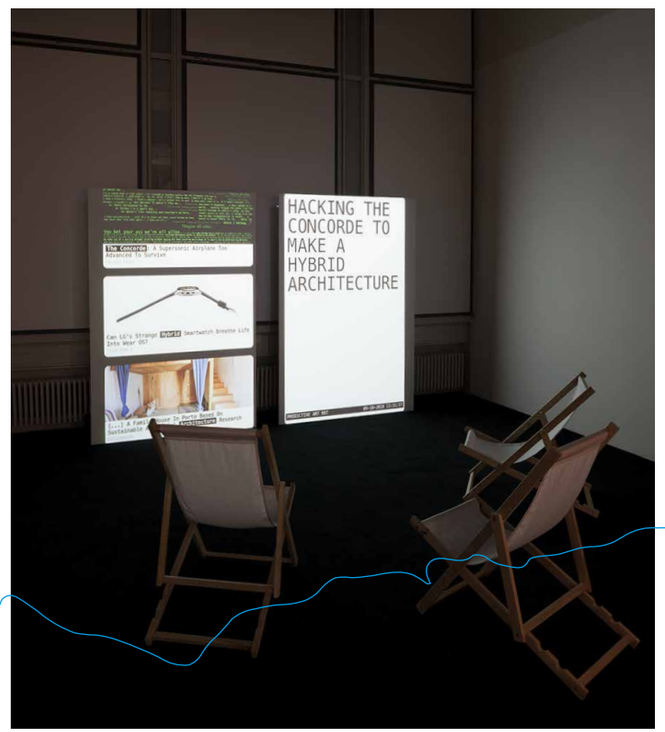
Predictive Art Bot V4

Installation
2017

136

DISNOVATION.ORG (Nicolas Maigret & Maria Roszkowska)
Nicolas Maigret
Maria Roszkowska

#MachineLearning
#AutonomousSystems



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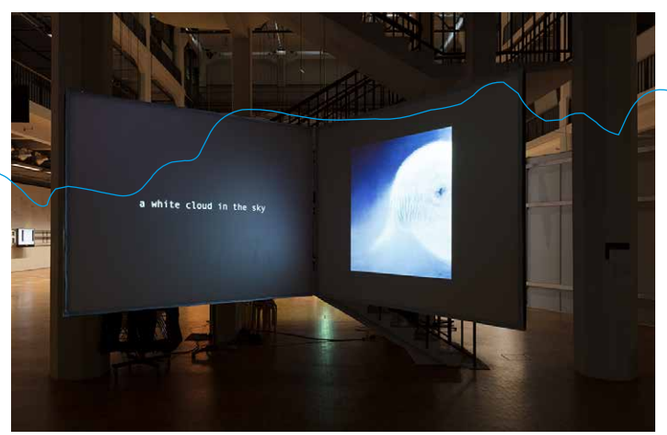

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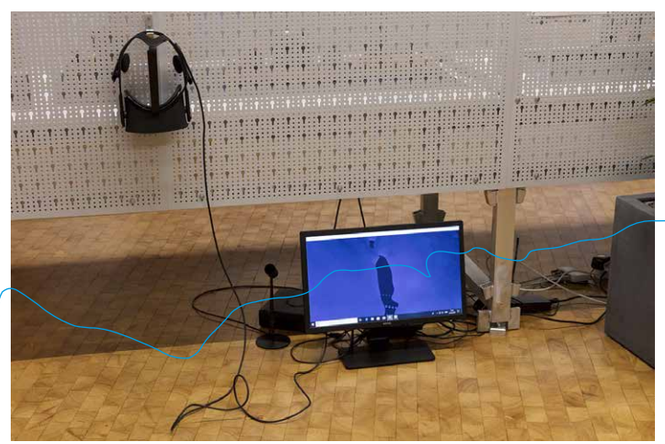
(Virtueller) Raum & Objekt

Mathematical object, VR environment
2015

138

Christian Großardt

#VirtualReality
#Encoding
#HMD
#ComputerSimulatedEnvironments
#Escapism



Christian Großardt visualizes an abstract means of creating art, presenting it, and making it almost tangible – entirely within virtual space.

From a pool of several approaches to creating virtual objects, Großardt decided upon an exclusively mathematical one (based on formulas and equations). The leitmotif, which repeatedly appears in the stereoscopic 360° video, serves as an alien, mathematical object created in virtual space.

The question of whether a specifically defined environment is required for the presentation of this particular art object is juxtaposed with the cube-like three-dimensional mathematical object created in this work and a complete lack of a discrete space. The central object, which is located within a black void, can be perceived and experienced as such, both in its external qualities and in its internal, immanent space. Elements spatially confining the object, such as walls, floor, and ceiling, are superfluous.

The cube is both an object of study and a site for exploration, enabling the recipient, using a head-mounted display, an idiosyncratic means of becoming immersed in the experience and of experiencing the central object.

139

360-degree video, based on the installation
FLICK_KA (2007) by Peter Weibel and Matthias Gommel
2018

FLICK_KAi

#MachineLearning
#ArtificialIntelligence
#PatternRecognition

Daniel Heiss
Audiodesign: Manfred Hauffen

Neural networks can learn to generate photorealistic images. Recent developments in machine learning show that in the future it will become increasingly difficult to distinguish whether images and videos are computer generated or real. Of particularly interest for this are Generative Adversarial Networks (GANs). Ian Goodfellow published a paper on GANs° in 2014, in which he describes how to use two neural networks to optimize each other. A generator network is trained with a data set of images that it tries to imitate. The generated images are shown to a discriminator network together with *real* images and the discriminator tries to distinguish whether the images are real or produced by the generator network. This interaction loop of trying to trick the opponent or revealing the fraud, respectively, helps both neural networks to optimize their capabilities to the point where it becomes difficult to distinguish the real images from the generated ones.

In the photo booth *FLICK_KA* in the ZKM foyer visitors have had their portraits taken over 50,000 times over the last ten years. These images were used as the training data set for the algorithm•, which can now generate completely synthetic images from the combined characteristics of everyone who ever took a photo there.

knowns

Installation
2015

140

Norimichi Hirakawa

#Encoding
#Computing
#Software

The core of *knowns* is a computer program that counts in natural numbers and gives each of them a unique name (e.g., A for 0, B for 1, Z for 25 and Aa for 26, Ab for 27, etc.) The program displays a seemingly endless list of names and highlights each name included in the 140,000 international human names database that is collected by the artist. As a principle, every name – not just of people alive, but also people who have lived and people who will live – will be shown on the screen just once: there are no exceptions.

Assuming that the program counts 60 natural numbers per second, "Alexander," the 307,039,224,483rd name, will be shown in 162 years' time. The program continues to count as long as it is running. Eventually, the number will reach the limit of the capacity of 64-bits data type: there will be data overflow and the program will crash. This could happen about 13 billion years after the program was started.

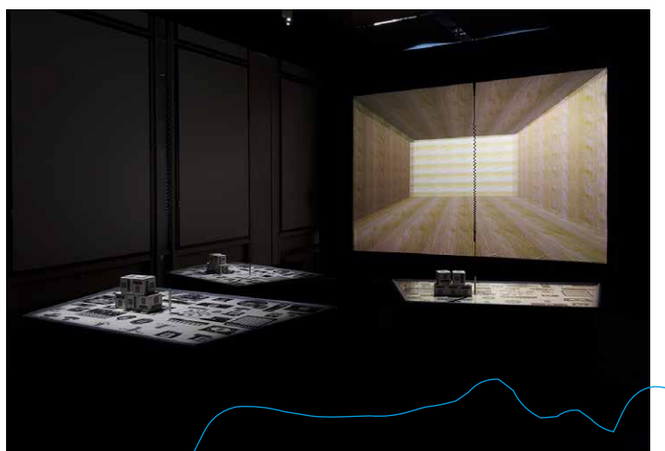
141

Computer-based interactive installation
1994

Bar Code Hotel

#Encoding
#Computing
#Software

Perry Hoberman
Programming, sound: Glen Fraser
Programming: John Harrison
Sound: Dorota Blaszczak



Perry Hoberman's *Bar Code Hotel* is an interactive multi-user installation. Laid out in the installation space, visitors encounter innumerable bar codes. They stand for both the virtual objects within the installation as well as the respective actions that can be assigned to these objects. Wearing 3-D glasses, visitors can make the objects visible by touching the bar codes with a wand, a lightweight pen, and they appear as 3-D projections on the wall. The objects, like a dog, teddy bear, piece of cheese, or loaf of bread, all possess preprogrammed behaviors and personalities, but can also be controlled within the virtual space by means of the bar code strips that users can scan. Some trigger movements, whilst others determine the interaction between two or more objects. This enables visitors to influence the movement, sound, color, and behavior of an object.

The bar code, which is normally a means of identifying, quantifying, and managing flows of consumer products, is employed here in a playful fashion to create an unruly, dynamic, and unpredictable 3-D world that depends on the decisions and inclinations of its users.

knowns

Installation
2015

140

Norimichi Hirakawa

#Encoding
#Computing
#Software

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knowns

Installation
2015

140

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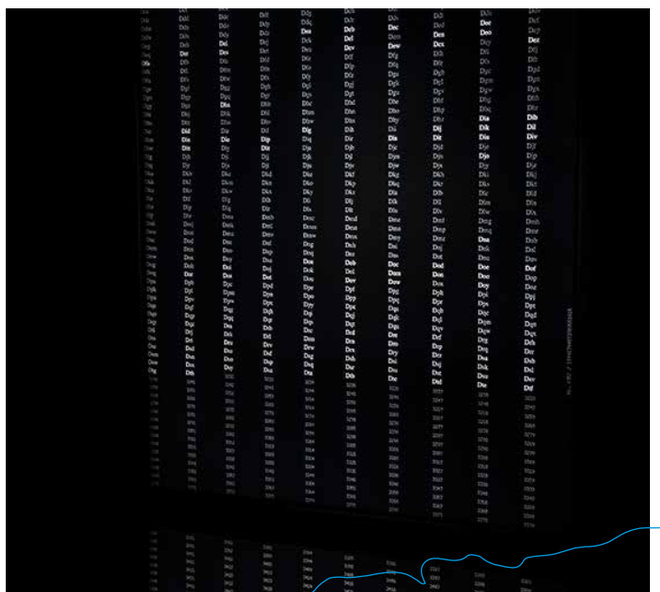
#Computing
#Software



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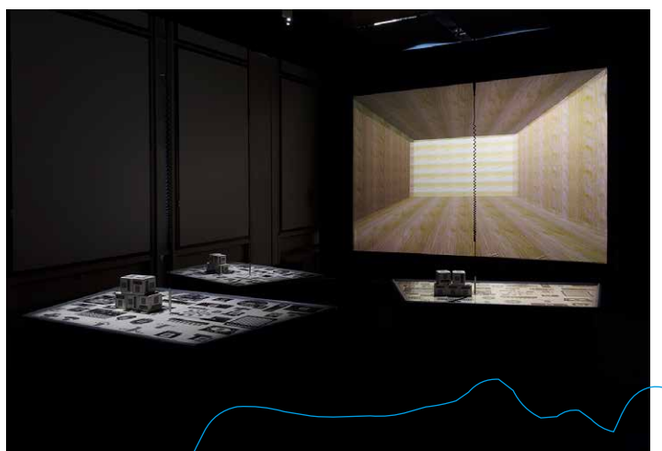

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Chordeograph Augmented Reality

Instrument and graphic scores
as interactive video installation
2018

142

Gero Koenig

#Encoding #VirtualReality
#ProgrammingSound
#AugmentedReality
#ComputerSimulatedEnvironments

BILD KOMMT NOCH

The electroacoustic instrument *Chordeograph* follows one of the most basic principles of sound generation: strings stretched on a large resonating body. In the work, software bots access a resonance profile or a list of resonance frequencies stored for each individual string and trigger tones based on additive synthesis of the resonance frequencies.

A score is composed of different constellations and enables the interaction between the audience and the bots. By moving the arms and hands, the audience can playfully navigate between different resonance constellations visualized in the score and trigger analog sound transformations without contact. The mechanical vibrations of the individual strings become both visible and audible on the instrument. At the same time, these vibrations are enhanced by augmented reality. The elementary moment of playing strengthens the autonomy of the listening perception and expands the conventional musical performance practice. The viewers become active listeners, players, and co-designers of the composition. They open up their own and new perspectives of hearing and seeing and become part of the installation themselves through their movements.

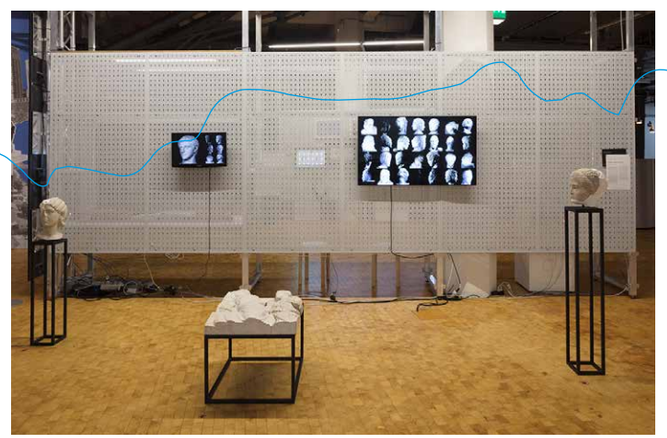
143

Marble and 3-D printed
sculptures (polyamide), video
2018

#MachineLearning
#ArtificialIntelligence

Egor Kraft

Content Aware Studies



Content Aware Studies is based on generative and algorithmic reconstructions of the lost fragments in friezes and statues of Late Antiquity and the Hellenistic period. The sculptures in the installation are generated by machine learning algorithms, which are designed to fill and reconstruct areas of images as well as 3-D models where parts of sculptures have been lost or are missing. This process constitutes quasi-archeological knowledge production and interpretations of history and culture in the era of ubiquitous computation.

An algorithm capable of self-learning is directed to replenish lost fragments of the friezes and sculptures. Based on an analysis of models, it generates models, which are then 3-D printed in various materials and used to fill the voids of the original sculptures and their copies.

The synthetic intelligence that tends to restore faithfully original forms, also produces bizarre errors and algorithmic speculative interpretations of Hellenistic and Roman aesthetics that are familiar to us, revealing a machinic understanding of human Classical Antiquity.

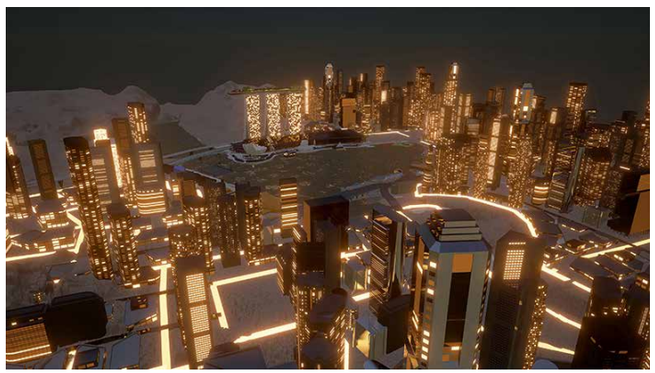
Geomancer

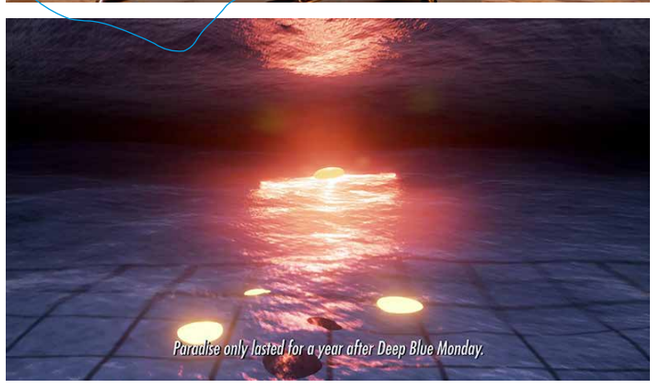
HD video essay, 60 min
2017

(144)

Lawrence Lek

#MachineLearning
#GenealogyOfCode
#AlgorithmicGovernance
#ArtificialIntelligence
#Computing





Geomancer is a computer-generated imagery (CGI) film by Lawrence Lek about the creative awakening of artificial intelligence. On the eve of Singapore's 2065 Centennial, an adolescent satellite artificial intelligence escapes its imminent demise by coming down to Earth, hoping to fulfil its dream of becoming the first AI artist. Faced with a world that limits its freedom, *Geomancer* must come to terms with its militarized origins, a search that begins with a mysterious syndicate known as the Sinofuturists.

As the geopolitical axis tilts further to the East, and as once-dominant technological models are cast into doubt, *Geomancer* alights on a long-standing tension between the place of the human and the role of the machine, sharpened by contemporary hopes and anxieties around the rise of East Asia, and by speculations that new forms of artificial intelligence, already outperforming mere mortals in matters of automation, will challenge us in more creative skills as well.

Featuring video game animation, a neural network-generated dream sequence, and a synthesized vocal soundtrack, *Geomancer* explores the aesthetics of post-human consciousness.

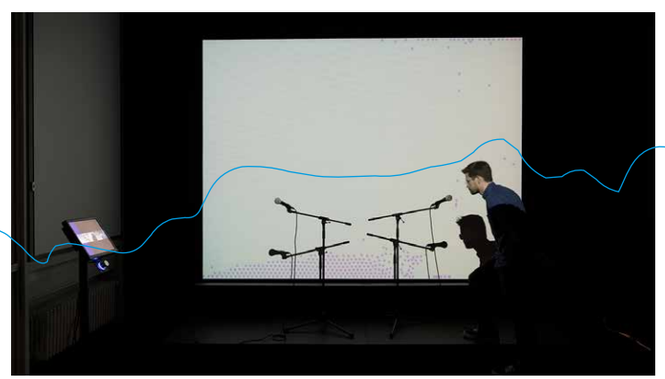
(145)

Installation for voice and interactive media
2003

Messa di Voce

#Codierung
#Software
#ProgrammingSound

Golan Levin
Zachary Lieberman



Utterly wordless, yet profoundly verbal, *Messa di Voce* is designed to provoke questions about the meaning and effects of speech sounds, speech acts, and the immersive environment of language.

Messa di Voce is an audiovisual system in which the speech, shouts, and songs produced by two vocalists are radically augmented in real time by custom interactive visualization software. The installation touches on themes of abstract communication, synaesthetic relationships, cartoon language, and writing and scoring systems, within the context of a sophisticated and playful virtual world.

Levin and Lieberman's software transforms every vocal nuance into complex, subtly differentiated, and highly expressive graphics. These visuals not only depict the users' voices, but also serve as controls for their acoustic playback. While the voice-generated graphics thus become an instrument upon which the users can perform, body-based manipulations of these graphics additionally replay the sounds of the users' voices – thus creating a cycle of interaction that fully integrates the visitors into an ambience consisting of sound, virtual objects, and real-time processing.

(Golan Levin and Zachary Lieberman)

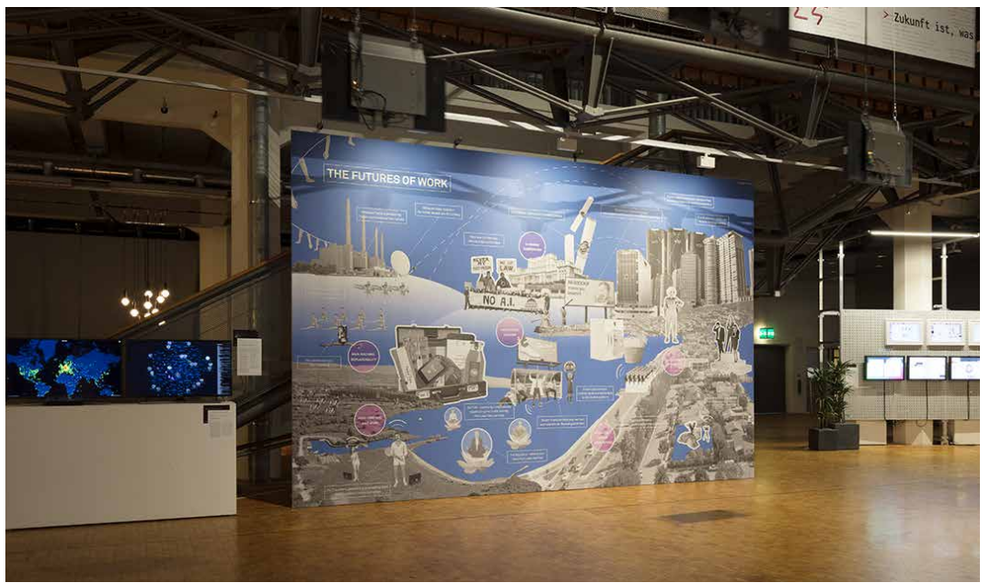
The Futures of Work

Digital Collage
2017

(146)

Nefula

#Labor&Production
#MachineLearning
#AlgorithmicGovernance
#Industry4.0 #ArtificialIntelligence
#Automation #BigData



The Futures of Work is a project on how the world of work is changing. Nefula has designed an infographic, the *Future Map*, which depicts and highlights the correlations between six different concepts, offering the possibility of an overview on possible futures of work.

The project investigates six feasible future directions around the work topic, each followed by a specific question:

+ Human–machine replaceability (What if you could be replaced by robots?)
+ Leisure time and 24/7 work (How might leisure time transform in the emerging 24/7 culture?)
+ Social rank dictatorship (How does computationally calculated social ranking influence work, careers, and professional relationships?)
+ Data-driven careers (What happens when your boss is an algorithm?)
+ AI-human competition (What are the skills that allow people to compete with AI?)
+ Replaceable human commodities (What happens when platforms transform human beings into replaceable commodities?)

The complete project of which the *Future Map* is the visual and metaphoric representation, takes the form of six interactive objects and fake TV show videos. These are the output of the 2016/2017 class of Transmedia Design from the Communication Design Master at ISIA Firenze (IT), taught by Salvatore Iaconesi and Oriana Persico, where Nefula had a tutoring role for the entire duration of the project.

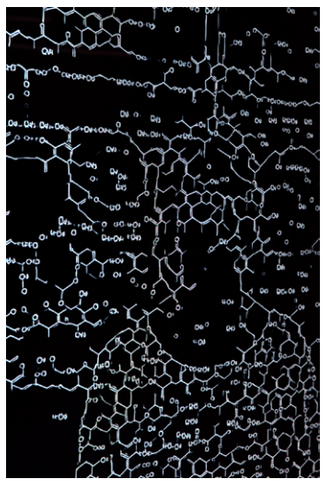
(147)

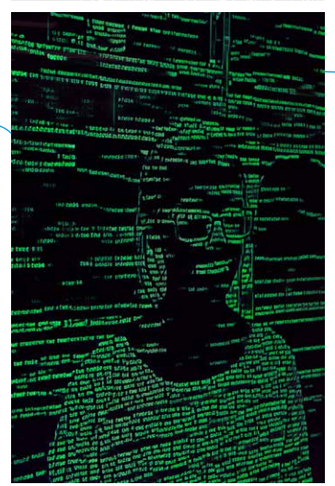
Interactive installation that uses AI
2018

Style Transfer

#MachineLearning
#ComputerGeneratedDesign

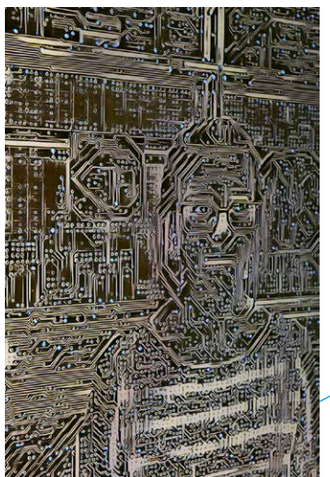
Boris Neubert
Chengzhi Wu
Max Piochowiak





That artificial neural networks can be used to create non-photorealistic as well as photorealistic images was demonstrated for the first time by Leon A. Gatys, Alexander S. Ecker, and Matthias Bethge of the University Tübingen in 2015 with their article "A Neural Algorithm of Artistic Style" (Gatys, Ecker, Bethge, Bethge Lab, Universität Tübingen, arXiv, 2015). The network combines the characteristics of a particular artistic style with the content of an arbitrary image. Back in 2015, however, it took several minutes to render photographs in the style of contemporary painters. This has now been reduced dramatically at KIT by utilizing a neural network pretrained with 1.2 million images. The neural network transfers elements of the image shown in the right-hand corner of the monitor onto the image of the video camera.

Although the first algorithms based on artificial neural networks



were introduced in the 1940s, it is only in recent years that they have come to dominate various applications of classic machine based vision and image processing. The decisive reason for this leap forward is frequently attributed to the convergence of two factors: first, technological developments that enabled parallel processing by sensors and facilitated significantly more complex construction of networks, known as Deep Neural Networks; second, the availability of data in very large quantities which could be utilized to train the networks via the Internet and modern sensors.

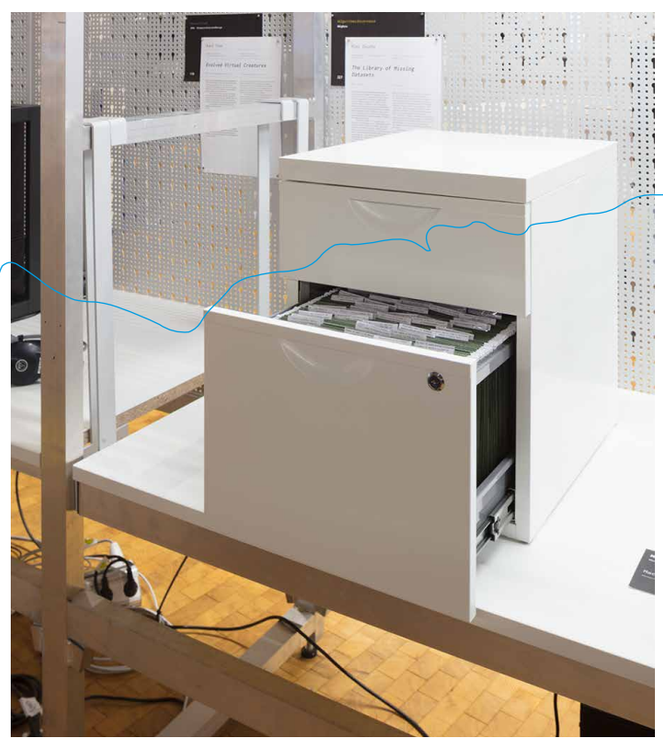
The Library of Missing Datasets

Object
2016

148

Mimi Onuoha

#AlgorithmicGovernance
#BigData



Missing Datasets are Mimi Onuoha's term for the blank spots which exist in spaces that are otherwise data-saturated. Her interest in them stems from the observation that within many spaces where large amounts of data are collected, there are often empty spaces where no data live. Unsurprisingly, this lack of data typically correlates with issues affecting those who are most vulnerable in that context.

The word "missing" is inherently normative. It implies both a lack and an ought to: something does not exist, but it should. That which should be somewhere is not in its expected place; an established system is disrupted by a distinct absence.

Sometimes, that which we ignore reveals more than what we give our attention to. It is in these things that we find cultural and colloquial hints of what is deemed important. Spots that we have left blank reveal our hidden social biases and indifferences.

This list will always be incomplete, and is designed to be illustrative rather than comprehensive. It also comes primarily from the perspective of the USA, although a complete list of data sets would feature far more international examples.

Visitors are welcome to browse through the data sets.

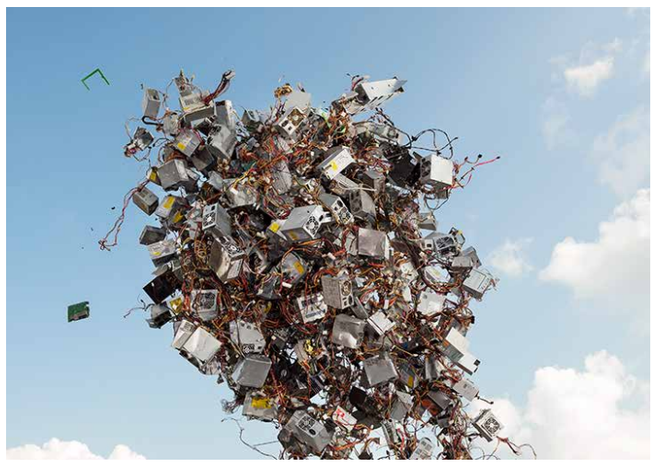
149

C-print, mounted on aluminum, framed, 120 × 180 cm
2017

#Encoding
#Hardware

Boris Neubert
Chengzhi Wu
Max Piochowiak

number 9 (power supplies / computers)



Life is constant movement, and photography has the ability to capture this movement. Freezing time releases it from its constraints, and allows the viewer to engage with all the things that normally pass us by. Pasi Orrensalo's series *Life behind the Waste* consists of several large-format photographs that capture the precise moment in which piles of waste found on scrapyards are thrown into the air. Photographing the items in motion as they fly across the sky gives the stories behind these objects the attention they deserve.

The photograph exhibited as part of *Open Codes, number 9 (power supplies / computers)*, refers to a very particular type of waste, a reflection of our Digital Age: electronic waste, commonly known as e-waste. The image portrays hundreds of computers flying across the sky tangled in countless cables; it presents us with the physical components that make our digital worlds possible. At a time when computers, phones, and other digital devices are increasingly produced and rapidly thrown away, it is time to become aware of the effects this exponential increase is having on the environment and on our lives.

Kino-Eye Recursion

Cognitive computation engine and custom software, HD video, b/w, sound, 1:07 min., video documentation
2016

150

Fito Segrera

#MachineLearning
#Computing
#PatternRecognition

Dziga Vertov's experimental documentary film *Man with a Movie Camera* (1929) is often regarded as the first machine vision image. Vertov claimed that this motion picture was not another attempt by a human director using a camera to narrate a preconceived story, even less to imprint a subjective position on the captured footage. On the contrary: the Soviet filmmaker took up a position where he allowed the machine to capture reality as it is, enabling the eye of the machine as the only subject in the process; a mechanical eye which observes reality.

Kino-Eye Recursion renders a new layer of machine vision and interpretation over Vertov's piece. Software extracts the frames of the film (still images) and analyzes them using an online cognitive computation engine. Later, a new version of the film is reconstructed without the visual motion, just black-and-white with sound (Alloy Electric Orchestra's soundtrack) plus a new element: text over the screen. The rendered text appropriates a well-known element from the visual language of modern films – subtitles. The new captions, displayed at the bottom of the black image, translate the missing pictures into the interpretation of the cognitive engine, which tries its best to describe what it sees in human-like language. This artwork operates as a machine interpretation of a machine interpretation.

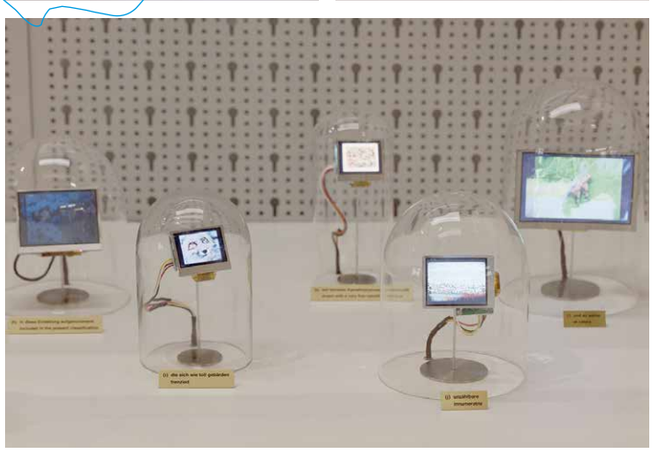
151

TensorFlow, Inception-v3, online images, 14 Raspberry PIs, 14 engraved metal plates, 14 glass domes, and 14 monitors
2016

Animal Classifier

#MachineLearning
#ArtificialIntelligence
#PatternRecognition #Software

Shinseungback Kimyonghun



Animal Classifier by artist duo Shinseungback Kimyonghun consists of artificial intelligence trained to divide animals into 14 different classifications. The taxonomy used, which includes categories such as "belonging to the emperor," "embalmed," or "innumerable," derives from the essay *The Analytical Language of John Wilkins* by Jorge Luis Borges in which he writes, "it is clear that there is no classification of the Universe that is not arbitrary and full of conjectures. The reason for this is very simple: we do not know what thing the universe is."

The installation parodies the scientific method of classification by reproducing the classical setup of bell jars and engraved metal plates displaying a variety of specimens in which the scientist has been replaced by image recognition software. It also acts as an analysis of current AI systems that are basically classifiers. As these systems learn and work based on the classifications provided by humans, they are inevitably imperfect. In exactly the same way as Borges introduces the classification as an example of faulty human schemes, Shinseungback Kimyonghun foreground in their work the imperfections and weak points in AI classification systems.

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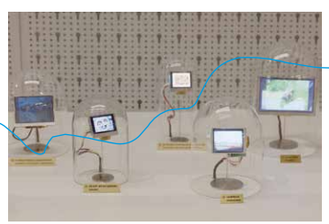

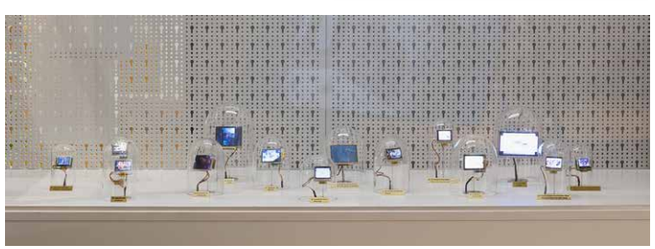

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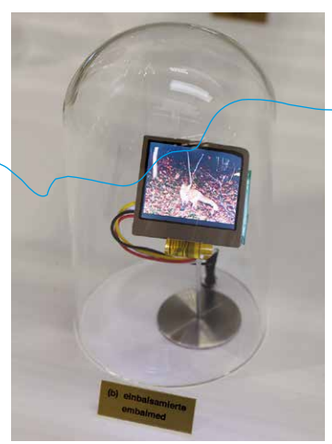

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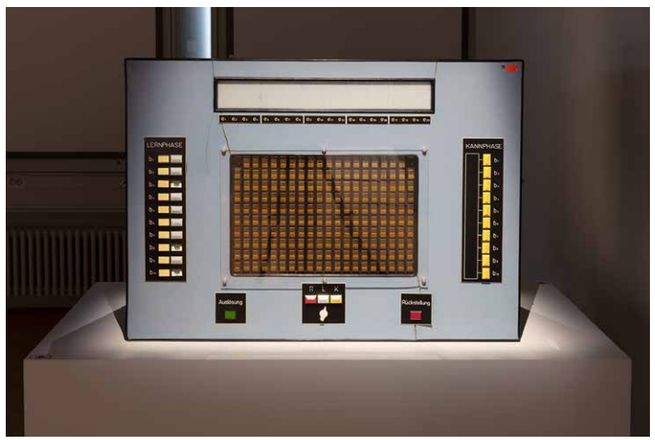
Lernmatrix

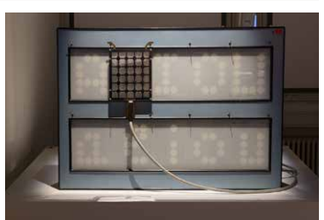
Historical object and replica
1969

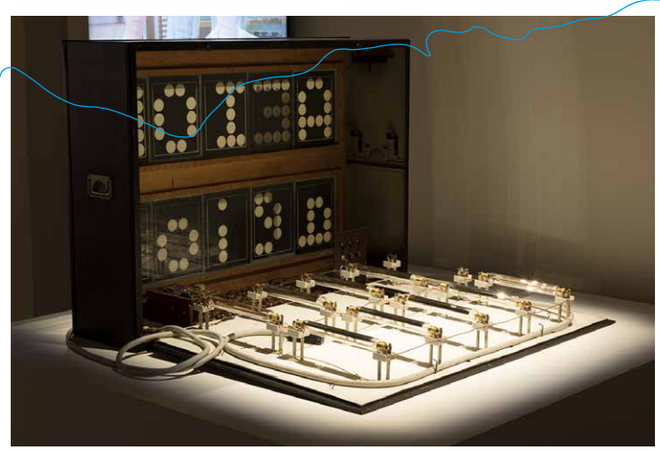
152

Karl Steinbuch

#MachineLearning
#GenealogyOfCode
#ArtificialIntelligence
#PatternRecognition
#Hardware







The *Lernmatrix* (learning matrix) was developed by Karl Steinbuch during the 1960s in Karlsruhe, at what is today the Institute for Information Processing Technologies at the Karlsruhe Institute of Technology (KIT). It was one of the first technically viable self-learning systems.

This example of the *Lernmatrix* is from 1969 and consists of two modules. The input module is the system's eye, enabling the reading of five vowels in uppercase and lowercase, captured via photocells and transmitted to the output module which is the system's brain, where a matrix of two hundred relays undertakes the learning and recognition of the letters.

During the "learning phase" the letters are assigned a "meaning." For this purpose, the switches in the relay matrix alternate between columns and rows to express affiliation. In "recall mode" the *Lernmatrix* has learned the form of the letters and is even able to recognize letters that do not correspond exactly to the letter that has been learned.

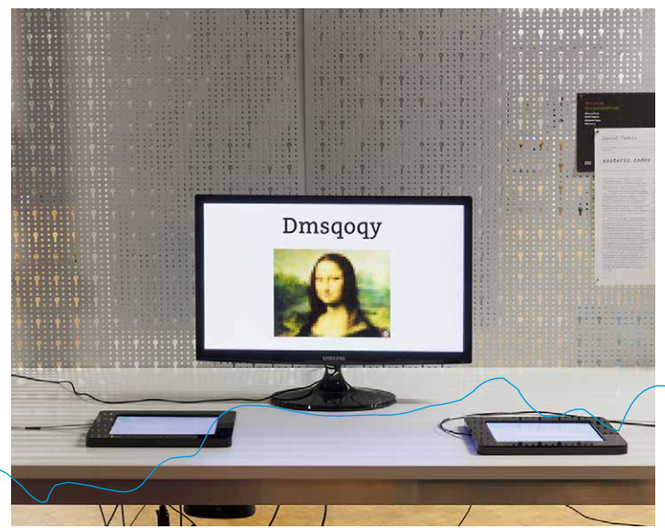
153

Video with two interactive touchpads
2018

esoteric.codes

#Encoding
#GenealogyOfCode
#Decoding #Software
#Interface
#Binary

Daniel Temkin



Daniel Temkin's work *esoteric.codes* is a unique archive of esoteric codes, a collection of creative manifestations of code.

Conventionally codes, programming languages, and software are seen as language dictionaries helping people to encode logical processes into sequences of operations to be executed by machines. Depending on the desired outcome, we choose a set of tools. A multitude of programming languages have been developed over time.

Yet if coding is approached from an artistic angle – seen as more than a fixed tool set – there is no limit to the creative expressions that programming languages can take. These very visual coding styles abstract logical constructs and disrupt common understandings and sensibilities of coding. They all implement a unique methodology and push the boundaries of what is possible.

esoteric.codes invites visitors to explore the world of codes in all its creativity and whimsy, its playfulness, and potential for disruption. The video gives an insight into this collection of codes, while visitors can explore the many facets of the archive on the tablets.

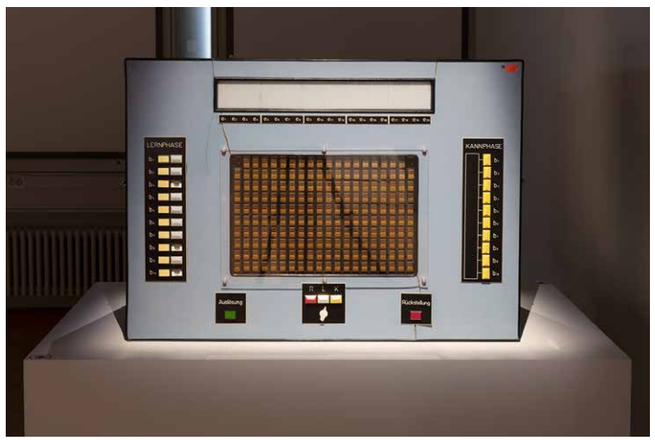
Lernmatrix

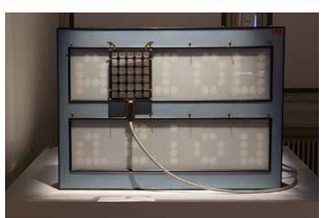
Historical object and replica
1969

(152)

Karl Steinbuch

#MachineLearning
#GenealogyOfCode
#ArtificialIntelligence
#PatternRecognition
#Hardware





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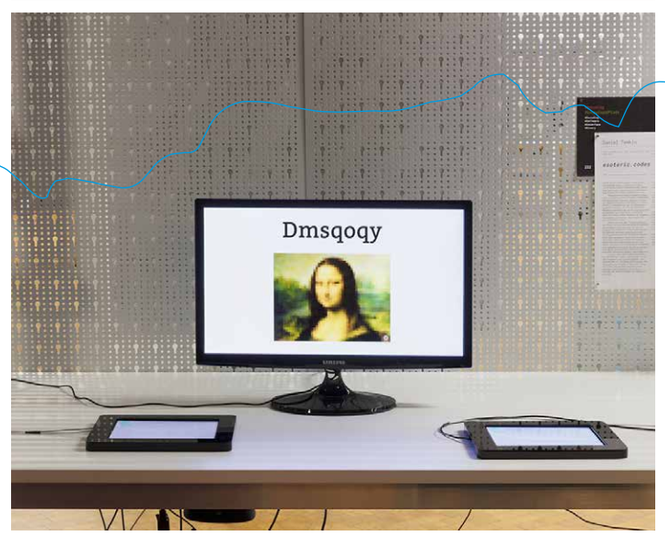
(153)

Video with two interactive touchpads
2018

esoteric.codes

#Encoding
#GenealogyOfCode
#Decoding #Software
#Interface
#Binary

Daniel Temkin



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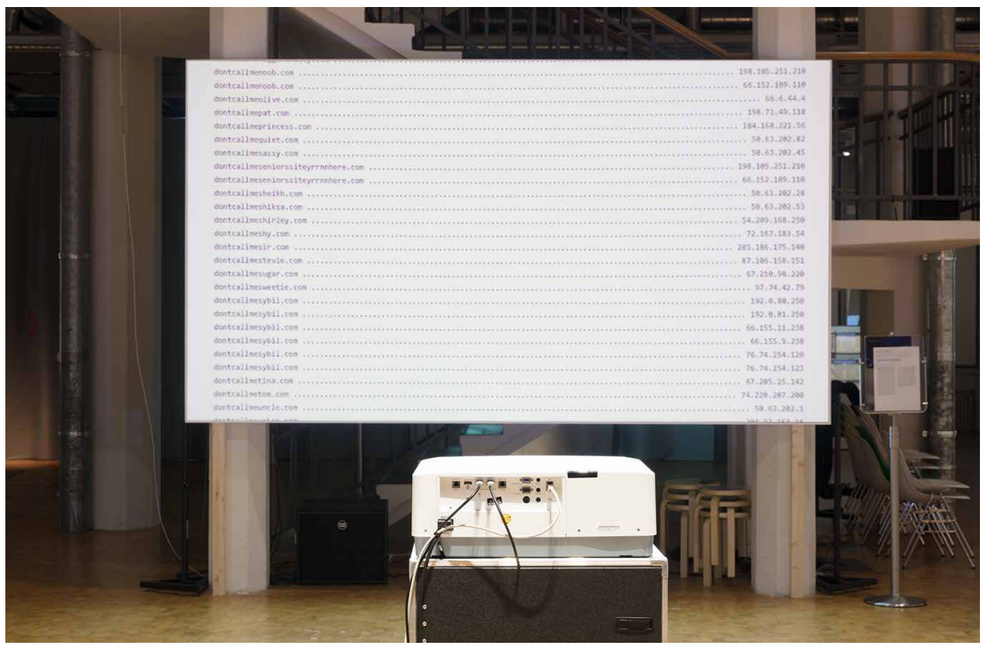
Internet Directory

Video
2018

154

Daniel Temkin

#GenealogyOfCode



Internet Directory is a list of every .COM domain, each shown in phonebook style with its IPv4 address. The videos on display are excerpts from the project, showing all the domains that start with a certain set of characters, such as "altered." This includes active websites, abandoned personal projects, aspiring Internet businesses that never materialized, and combinations of words that domain squatters saw commercial value in, however fleeting. Collectively, they explore the language of the Internet and the exhaustive quality of Internet naming. The *Internet Directory* contains 115 million .COM domains – all which existed when the project began in early 2014. It also exists as a loose-leaf physical book of over 37,000 poster-size pages. Live readings of the project have taken place at Pioneer Works in New York, the Radical Networks conference in Berlin, and the Museu do Chiado in Lisbon, among others.

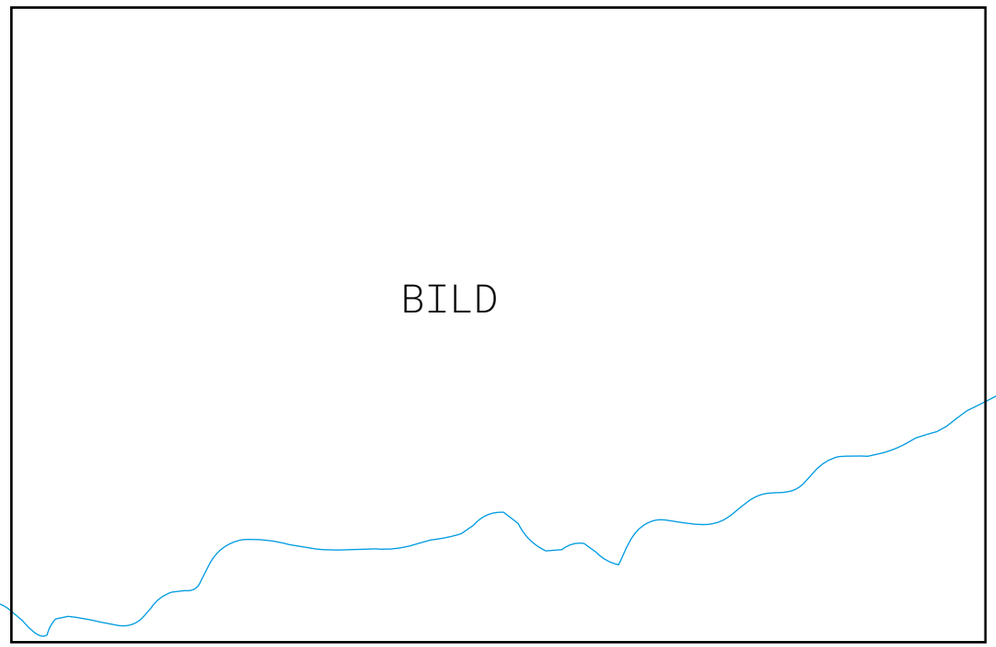
155

Installation
2018

Words that Remake the World

#MachineLearning
#ArtificialIntelligence
#BigData

Nye Thompson



The installation *Words that Remake the World* forms part of Nye Thompson's ongoing project *The Seeker,* a networked machine entity that travels the world virtually and describes what it sees. Named for Ptah-Seker, the artist/technologist god of Ancient Egypt, who created the world by speaking the words to describe it, this project looks at how the act of describing the world might establish a whole new worldview for machines and humans alike.

The installation comprises a large-scale diagrammatic drawing presented alongside an audiovisual piece and a data spreadsheet showing the source data for the drawing. The latter was created using data collected from *The Seeker* project; it presents the words that *The Seeker* uses to describe what it sees, and which comprise its conceptual landscape. The drawing represents a process of intense analytical scrutiny of this data by the artist, effectively mapping the nascent AI's mind.

The video shows a performance where the machine worldview is filtered back through human eyes and mouths. In *Words that Remake the World*, Thompson asks herself and the audience how machine vision may come to influence our own vision. Are we relearning how to look at the world based on AI technologies? Where does the balance of power in this transaction actually lie?

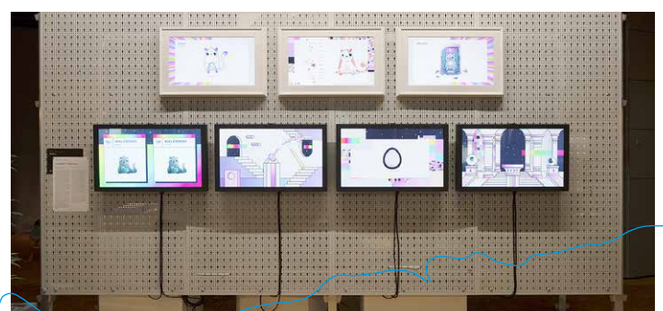
cryptoART Playground

Multi-part installation
2018

156

Various Artists
Project Leader: Daniel Heiss

#AlgorithmicGovernance
#Blockchain
#DNA
#Genotype



Art and Blockchain? How do they fit together? This overlapping area, known as cryptoART, is addressed in a separate section of the exhibition. Since the Ethereum blockchain went online in 2015, numerous smart contract-based, decentralized apps (DApps) have been developed that explore the potential of the underlying technology. *Non-fungible tokenized digital Assets* (ERC721), for example, is one approach to the commercialization of digital art. By storing unique and non-counterfeitable cryptographic keys in a blockchain, both the authenticity and the ownership of a digital work can be guaranteed, and the sale, that is, the transfer of that right, organized.

One of the first projects to implement this technique, in the form of a digital trading card game, were the CryptoPunks. 10,000 unique 32 × 32 pixels images of different characters were marketed through the Ethereum blockchain. By limiting circulation, the rather unspectacular images quickly increased in value.

The first decentralized application, which due to media coverage became more widely known beyond a specialized audience, was the CryptoKitties. The digital cats are not only collectibles, but can also mate with each other and multiply, inheriting visual characteristics which are linked to the cat in the form of a code (the genome).

The principle of "tokenization" has recently become increasingly relevant to the conventional art market. Renowned auction houses and galleries dealing in traditional art are experimenting in this field, as well as evaluating new ways of safeguarding the origin of art (heritage).

The *cryptoART Playground* continually adapts to current developments within the field, displaying changing exhibits, some of which will be sold on to visitors via auctions, or become part of ZKM's permanent collection.

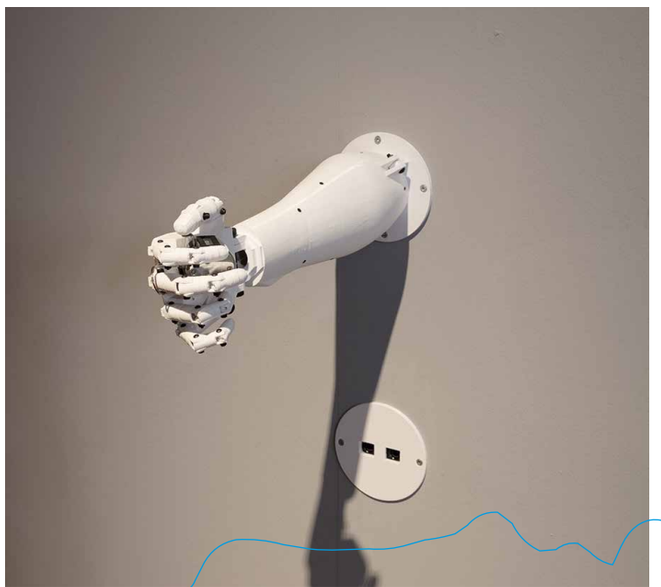
157

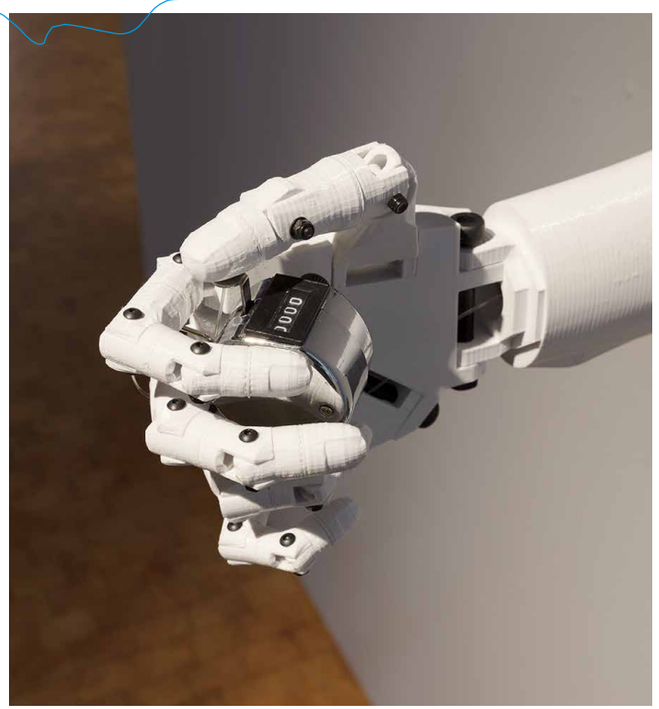
Installation, 3-D printed robotic arm, clicker
2017

HUMANS NEED NOT TO COUNT

#Labor&Production
#Robots #Automation #Work4.0

Varvara & Mar





This work poses questions about employment, robotics, and quantification. It presents a robotic arm that counts visitors with a clicker, offering a performative representation of the takeover of routine jobs, even in the museum. The work also embodies our idolatry of quantification; the obsessive need to count and measure everything.

Last century's automation may have been largely hidden from everyday view, in factories tending production lines, or out in fields tilling the land. In this century, we will confront the reality of automation more intimately, as suggested here – it will be right beside us.

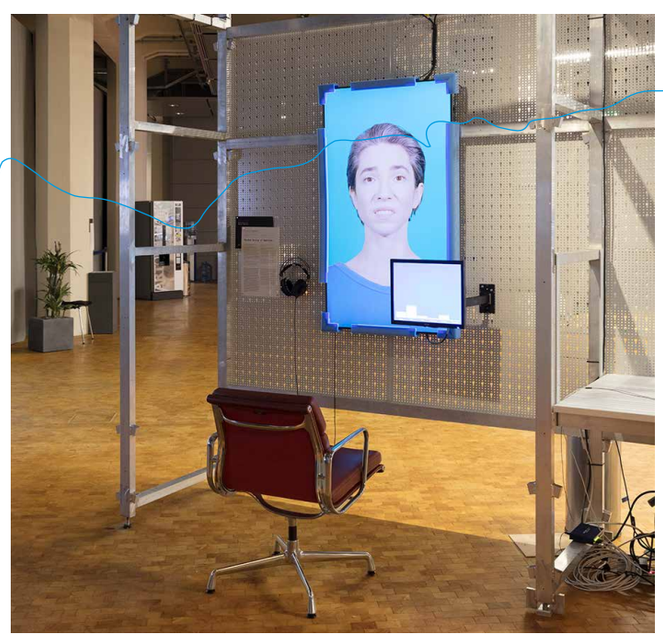
Random String of Emotions

Generative single-channel video 4K, 2 screens, emotion recognition software, polyethylene foam
2018

158

Coralie Vogelaar

#MachineLearning
#PatternRecognition
#Software #Decoding



Emotion recognition software analyzes our emotions by deconstructing our facial expressions into temporal segments that produce the expression, called Action Units (AU; developed by Paul Ekman), and breaking them down into percentages of six basic emotions, happy, sad, angry, surprised, scared, and disgusted.

In this video the artist uses this decoding system to turn the process around. Here – instead of detecting AUs – a computer is used to generate a random string of AUs. In this way complex and perhaps even nonexisting emotional expressions will be discovered. These randomly formed expressions, played in random order, are then analyzed again by professional emotion recognition software.

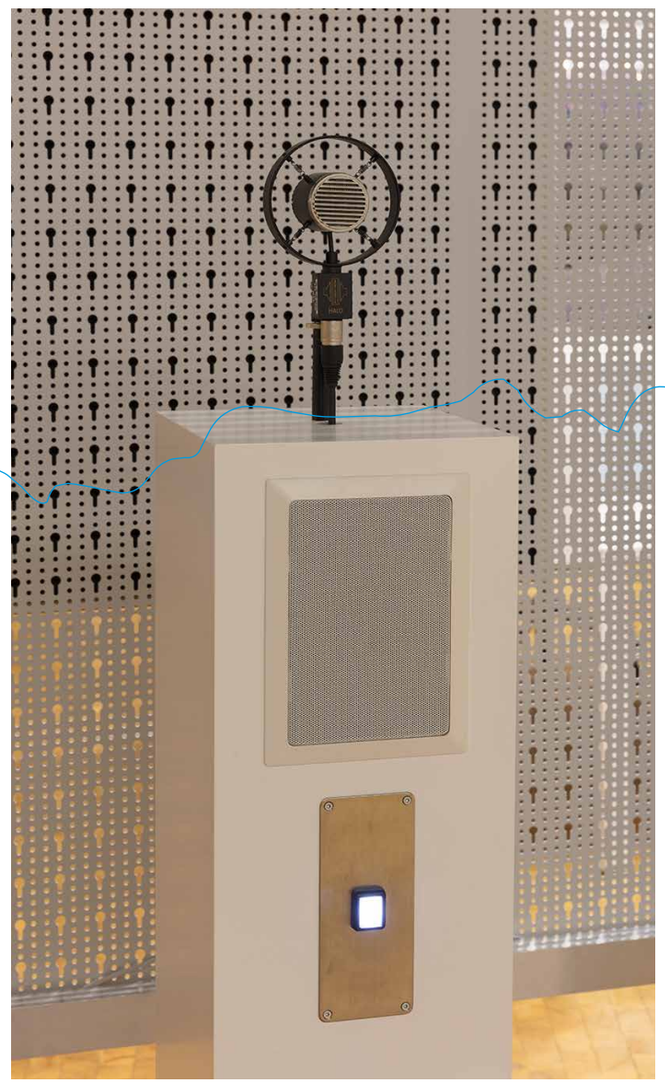
159

Sound installation
2012

oh cet echo

#Encoding
#ProgrammingSound
#Software
#Interface

Peter Weibel



The sound installation *oh cet echo* enables visitors to speak into a microphone, while their voice is simultaneously simulated by a musical instrument (piano, marimba, vibraphone, or flute, each using short or longer tones). Visitors can change from one instrument to the next using a push-button, and are also provided with a short recording of previous visitors (with a time delay of one second). Over time, the words of the visitors create a joint musical composition.

The World as a Field of Data

Data installation
2018

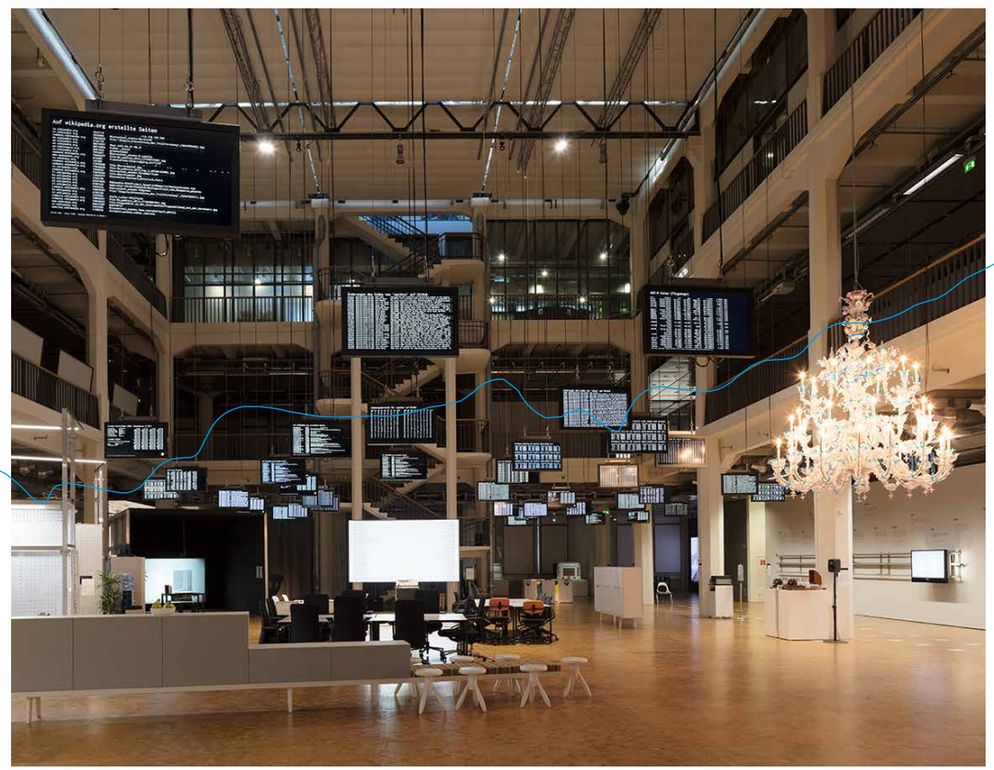
Peter Weibel
Christian Lölkes

#Encoding #Algorithmic Governance #Software #Hardware #BigData

The vast number of electronic interfaces like smartphones, computers, and screens, which accompany people every day in doctors' surgeries, at home, in offices, at the stock exchange, airports, or railway stations, is overwhelming proof that navigating by the sun, moon, and stars has long since been replaced by satellites and other technological instruments.

People living in the digital age don't navigate by the position of the stars and sun; they follow where digital devices lead them, which receive information from the cell tower on the horizon and orbiting satellites in space. The installation *The World as a Field of Data* confronts us with this field of data that accompanies us around the clock in a deliberately exaggerated way.

Data fields are omnipresent. All the information that is generated as a result of our interaction on the Net and in the real world are assembled on around 40 screens, which hang in the air as a data cloud at ZKM's Atrium 8.

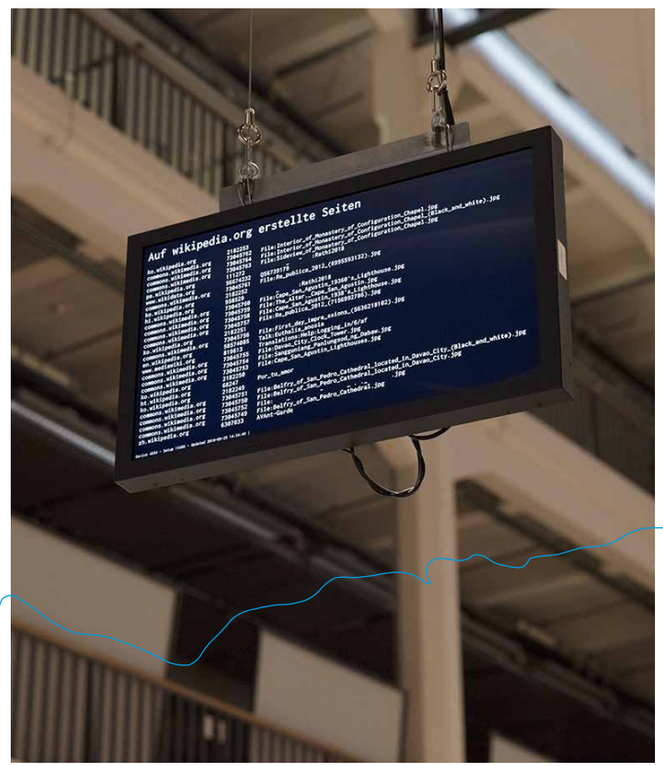


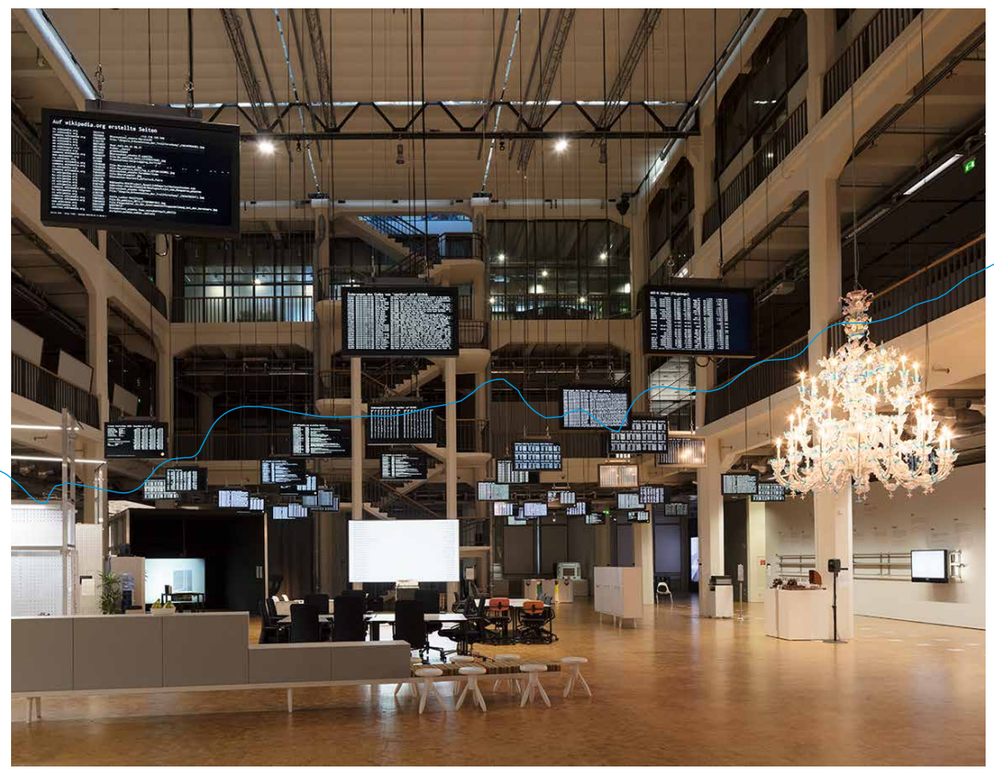
The World as a Field of Data

Data installation
2018

Peter Weibel
Christian Lölkes

#Encoding #Algorithmic Governance #Software #Hardware #BigData





The vast number of electronic interfaces like smartphones, computers, and screens, which accompany people every day in doctors' surgeries, at home, in offices, at the stock exchange, airports, or railway stations, is overwhelming proof that navigating by the sun, moon, and stars has long since been replaced by satellites and other technological instruments.

People living in the digital age don't navigate by the position of the stars and sun; they follow where digital devices lead them, which receive information from the cell tower on the horizon and orbiting satellites in space. The installation *The World as a Field of Data* confronts us with this field of data that accompanies us around the clock in a deliberately exaggerated way.

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Inhalt als Linie (Nur Erklärtext)

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Sich selbst darstellender Code

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Druckbuch als Speichermedium (Nur Erklärtext)

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Bibliografie (evtl nicht nötig)

1 **A Mathematical Sky – Henri Poincaré,** 2011

Jean-Michel Alberola
*1953 in Saïda (DZ), lives and works in Paris (FR)

Installation on the wall and 2 mathematical models
Collection Fondation Cartier pour l'art contemporain, Paris
Mathematical Institute, Ruprecht-Karls-Universität Heidelberg, Karlsruhe Institute of Technology Archive, Collection of Mathematical Models, Karlsruhe

Conceived in collaboration with Giancarlo Lucchini with the support of the Institut Henri Poincaré.

2 **Ebu from the series Material Speculations: ISIS**, 2015
Lamassu from the series Material Speculation: ISIS, 2015
South Ivan Human Heads: Bearded River God, 2017

Morehshin Allahyari
*1985 in Tehran (IR), lives and works in Boston (US)

3-D printed plastic resin and electronic components, 22.2 × 20.3 × 6.4 cm, edition of 3
Courtesy of Upfor Gallery, Portland

Photo © Morehshin Allahyari

3 **Digitale Transformation. Die Kunst des modernen A rbeitslebens**

AppSphere AG
Founded in Ettlingen (DE), in 2010

With the kind support of Microsoft.
Photo © Microsoft

4 **All We Know We Know from Light,** 2017

Lisa Bergmann
*1979 in Nuremberg (DE), lives and works in Karlsruhe (DE)

Photo © Lisa Bergmann

5 **Narzisstische Maschine,** 2017

Michael Bielicky
*1954 in Prague (CZ), lives and works in Karlsruhe and Düsseldorf (DE)
Kamila B. Richter
*1976 in Olomouc (CZ), lives and works in Karlsruhe and Düsseldorf

Software development: Lukas Böhm, Lukas Feller
Sound: Lorenz Schwarz
Photo © Michael Bielicky, Kamila B. Richter

6 **Notation. Prozess. Musik.** 2017

Patrick Borgeat
*1985 in Öhringen (DE), lives and works in Karlsruhe (DE)

° Peter Weibel, "Zellulare und molekulare Musik – Zur Kluft zwischen zwei Tönen," in: Peter Weibel, Enzyklopädie der Medien, Band 2, Musik und Medien, University of Applied Arts Vienna, ZKM | Karlsruhe, Hatje Cantz, Berlin, 2016, p. 383.

Photo © Patrick Borgeat, photo: Daniel Bollinger

7 **Autonomous Trap 001,** 2017

James Bridle
*1980 in London (GB), lives and works in Athens (GR)

Courtesy of NOME, Berlin
Photo © James Bridle

8 **CodeChain,** 2017

Ludger Brümmer
*1958 in Werne (DE), lives and works in Karlsruhe (DE)
Elizabeth Pich
*1989 Friedberg (DE), lives and works in Karlsruhe (DE)

A production of the ZKM_ Hertz-Lab
Photo © ZKM_Hertz-Lab

9 **LindenmayerExplorer,** 2017

Idea: Ludger Brümmer
*1958 in Werne (DE), lives and works in Karlsruhe (DE)
Programming, Interface design: Dan Wilcox
*1981 in Orange (US), lives and works in Karlsruhe (DE)

A production of the ZKM_ Hertz-Lab
User interface for LindenmayerExplorer, photo © ZKM | Karlsruhe

10 **MarkowKetten Explorer**, 2017

Programming, Interface design: Benjamin Miller
*1986 in Paris (FR), lives and works in Karlsruhe (DE)
Sami Chibane
*1995 in Échirrolles (FR), lives and studies in Grenoble (FR)

A production of the ZKM_Hertz-Lab
Photo © the artists

11 **CellularAutomataExplorer**,2017

Idea: Ludger Brümmer
*1958 in Werne (DE), lives and works in Karlsruhe (DE)
Programming, Interface design: Benjamin Miller
*1986 in Paris (FR), lives and works in Karlsruhe (DE)

A production of the ZKM_Hertz-Lab
Photo © ZKM | Karlsruhe

12 **MusiCode**, 2017

Ludger Brümmer
*1958 in Werne (DE), lives and works in Karlsruhe (DE)
Dan Wilcox
*1981 in Orange (US), lives and works in Karlsruhe (DE)

A production of the ZKM_ Hertz-Lab
User interface for MusiCode, photo © ZKM | Karlsruhe

13 **Pattern Machine**, 2004

Ludger Brümmer
*1958 in Werne (DE), lives and works in Karlsruhe (DE)
Chandrasekhar Ramakrishnan
*1975, lives and works in Zurich (CH)
Götz Dipper
*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)

Photo © ZKM | Karlsruhe

14 **Random Machine**, 2004

Ludger Brümmer
*1958 in Werne (DE), lives and works in Karlsruhe (DE)
Chandrasekhar Ramakrishnan
*1975, lives and works in Zurich (CH)
Götz Dipper
*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)

Photo © ZKM | Karlsruhe

15 **Rotating Scores**, 2016

Idea: Ludger Brümmer
*1958 in Werne (DE), lives and works in Karlsruhe (DE)
Anton Himstedt
*1952 in Wiesbaden (DE), lives and works Geisenheim (DE)
Programming: Chikashi Miyama
*1979 in Otsu (JP), lives and works in Karlsruhe (DE)
Alex Rodrigues
*1993 in Covilhã (PT), lives and works in Castelo Branco (PT)

Photo © ZKM | Karlsruhe

16 **PLAY**, 2016

Butternutten AG
Oliver-Selim Boualam
*1992 in Stühlingen (DE), lives and works in Karlsruhe (DE) and Marrakesh (MA)
Lukas Marstaller
*1993 in Aalen (DE), lives and works in Karlsruhe (DE) and Marrakesch (MA)

Photo © Butternutten AG, photos: Philipp Schell and Butternutten AG

17 **Morphogenesis**, 2016

Can Büyükberber
*1987 in Izmir (TR), lives and works in San Francisco (US)
Yagmur Uyanik
*1992 in Antalya (TR), lives and works in San Francisco (US)

Photo © Can Büyükberber, Yagmur Uyanik

18 **White Mountain**, 2016

Emma Charles
*1985 in London (GB), lives and works in London

Photo © Emma Charles

19 **NaturallySpeaking**, 2013–2014

Tyler Coburn
*1983 in New York (US), lives and works in New York

Detail: Text monitor, photo © Tyler Coburn

20 **Ethical Autonomous Vehicles**, 2014

Matthieu Cherubini
*1984 in Aigle (CH), lives and works in Shanghai (CN)

Photos © Matthieu Cherubini

21 **Chromos**, 2017

Max Cooper
*1980 in Belfast (GB), lives and works in London (GB)
Andy Lomas
*1967 in Welwyn Garden City (GB), lives and works in London (GB)

Photos © Max Cooper, Andy Lomas

22 **Remote Control**, 1999

Shane Cooper
*1964 in Yorba Linda (US), lives and works in New Zealand (NZ)

Installation view ZKM | Collection 2009, © VG Bild-Kunst, Bonn 2017, photo © ZKM | Karlsruhe, photos: Anatole Serexhe

23 **3/78 (Objects and Transformations)**, 1978
Two Space, 1979
Calculated Movements, 1985

Larry Cuba
*1950 in Atlanta (US), lives and works in Santa Cruz (US)

3/78 (Objects and Transformations), 1978, video still, photo © Larry Cuba
Two Space, 1979, video still, photo © Larry Cuba
Calculated Movements, 1985, video still, photo © Larry Cuba

24 **Animation Notebook 2010**, 2010
Animation Notebook 2012, 2012

Larry Cuba
*1950 in Atlanta (US), lives and works in Santa Cruz (US)

Animation Notebook 2010, 2010, video still, photo © Larry Cuba
Animation Notebook 2010, 2010, video still, photo © Larry Cuba

25 **RzI-DzI-AI**, 2016

Frederik De Wilde
*1975 in Brussels (BE), lives and works in Brussels

Photo © Frederik De Wilde

26 **Blockchain Future States**, 2016

Simon Denny
*1982 in Auckland (NZ), lives and works in Berlin (DE)
Courtesy of Galerie Buchholz, Berlin / Köln / New York

27 **Add_Synth**, 2017

Götz Dipper
*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)
A production of the ZKM_ Hertz-Lab

Photo © ZKM | Karlsruhe

28 **algoRhythm Machine**, 2017

Götz Dipper
*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)
A production of the ZKM_Hertz-Lab

Photo © ZKM | Karlsruhe

29 **FM_Synth** , 2017

Götz Dipper
*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)

A production of the ZKM_ Hertz-Lab

Photo © ZKM | Karlsruhe

30 **...wie der Computer Musik macht**, 2017

Götz Dipper
*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)
Inspired by: Peter Weibel
Consulting: Ludger Brümmer, Benjamin Miller
A production of the ZKM_ Hertz-Lab

Photo © ZKM | Karlsruhe

31 **Death Imitates Language**, 2016/2017

Harm van den Dorpel
*1981 in Zaandam (NL), lives and works in Berlin (DE)

Vvgdamn Pipikaka Yozdczmi, 2017, photo courtesy Neumeister Bar-Am, Berlin, und Upstream Gallery, Amsterdam, photo: Gert-Jan van Rooij
Hatter Epot Xgeubke, 2017, photo courtesy Neumeister Bar-Am, Berlin, and Upstream Gallery, Amsterdam, photo: Gert-Jan van Rooij

32 **DullDream**, 2015

Constant Dullaart
*1979 in Leiderdorp (NL), lives and works in Amsterdam (NL)
Courtesy of DullTech™

Photo © Constant Dullaart

33 **Das Große Rasenstück**, 2013

Margret Eicher
*1955 in Viersen (DE), lives and works in Berlin and Mannheim (DE)

Foto © Margret Eicher

34 **Lost in Computation**, 2017

Jonas Eltes/Fabrica
*1993 in Kungsbacka (SE), lives and works in Treviso (IT)
Courtesy of Fabrica, Catena di Villorba

Photo © Jonas Eltes, photo: Fabrica

35 **BitterCoin**, 2016

César Escudero Andaluz
*1983 in Ávila (ES), lives and works in Linz (AT)
Martín Nadal
*1978 in Madrid (ES), lives and works in Linz (AT)

Photos © the artists, photos: Patricia Cadavid

36 **2001 100011**, 2011

Claire L. Evans
*1984 in Swindon (GB), lives and works in Los Angeles (US)

Photo © Claire L. Evans

37 **Parallele**, 2012–2014

Harun Farocki
*1944 in Nový Jičín (CZ), †2014 in Berlin (DE)

Parallele I, 2012, 2-channel video installation, color, sound, 16 min.
Parallele II, 2014, single channel video installation, color, sound, 9 min.
Parallele III, 2014, 2-channel video installation, color, sound, 7 min.
Parallele IV, 2014, single channel video installation, color, sound, 11 min.
Harun Farocki GbR, Berlin

Parallele 1, photo © Harun Farocki GbR
Parallele 2, photo © Harun Farocki GbR
Parallele 3, photo © Harun Farocki GbR
Parallele 4, photo © Harun Farocki GbR

38 **Oracles**, 2017

Thierry Fournier
*1960 in Oullins (FR), lives and works in Paris (FR)

Photo © Thierry Fournier

40 **Autonome Fahrzeuge**, 2017

Fraunhofer IOSB and ZKM | Karlsruhe

Photo © ZKM | Karlsruhe, Fraunhofer IOSB

40 **Industrie 4.0**, 2017

Fraunhofer IOSB and ZKM | Karlsruhe

Photo © ZKM | Karlsruhe, Fraunhofer IOSB

41 **The Human Brain Project**, 2017

FZI Research Center for Information Technology at the Karlsruhe Institute of Technology (KIT)
founded in Karlsruhe (DE) in 1985

Photo © FZI Research Center for Information Technology

42 **Automated and interconnected driving**, 2017

FZI Research Center for Information Technology at the Karlsruhe Institute of Technology (KIT)
founded in Karlsruhe (DE) in 1985

Photo © FZI Research Center for Information Technology

43 **Spatial Code Lab**, 2017

Kristof Gavrielides
*1973 in Cologne (DE), lives and works in Stuttgart (DE) and Paris (FR)

Sponsors:
ZKM | Center for Art and Media Karlsruhe
Baden-Württemberg Ministry of Science, Research, and the Arts

msa / mediaspaceagency
sam / studioadvancedmedia

Photo © Kristof Gavrielides

44 **Genealogy of the Digital Code**, 2017

Linear Navigator (1999): Jeffrey Shaw
Idea: Peter Weibel
Conception, realization: ZKM | Institute for Visual Media
Project management: Bernd Lintermann
Editors: Lívia Nolasco-Rózsás, Magdalena Stöger, Olga Timurgalieva
Software: Bernd Lintermann, Nikolaus Völzow
Video post-production and graphics: Moritz Büchner, Frenz Jordt, Jan Kieswetter, Christina Zartmann
Construction: Nelissen Dekorbouw

Construction plan, Photo © ZKM | Karlsruhe

45 **The Common Sense**, 2014/15

Melanie Gilligan
*1979 in Toronto (CA), lives and works in New York (US) and London (GB)

Phase 1, 5 Episodes

Installation view, ARS17 – Hello World, Kiasma, Helsinki 2017, photo © Malanie Gilligan, photo courtesy of Max Mayer Galerie, Düsseldorf

46 **The Unmanned**

1997 – The Brute Force (2014)
1759 – Mil Troi Cens Quarante Huyt (2017)

Fabien Giraud
*1980 in Caen (FR), lives and works in Paris (FR)
Raphaël Siboni
*1981 in Romorantin-Lathenay (FR), lives and works in Paris (FR)

With the support of Casino Luxembourg – Forum d'Art Contemporain, Palais de Tokyo and Le Fresnoy, Studio national des arts contemporains.

The Unmanned: 1759 – Mil Troi Cens Quarante Huyt, 2017, photo © Fabien Giraud, Raphaël Siboni

47 **KryptoLab**, 2017

Daniel Heiss
*1978 in Munich (DE), lives and works in Karlsruhe (DE)

48 **S2T2T2M2L**, 2017

Daniel Heiss
* 1978 in Munich (DE), lives and works in Karlsruhe (DE)

49 **Monocause. Dialectics of the Post-Truth Era**, 2017

Yannick Hofmann
*1988 in Offenbach a. M. (DE), lives and works in Karlsruhe (DE)
Illustration and production assistant: Fiona Marten

Photo © Yannick Hofmann, photo: Fiona Marten

50 **ICD/ITKE Research Pavilion 2016–17**, 2016–2017

Institute for Computational Design and Construction (ICD) and Institute of Building Structures and Structural Design (ITKE)
with Integrative Technologies and Architectural Design Research Program (ITECH)
at the University of Stuttgart

ICD Institute for Computational Design and Construction (Prof. Achim Menges), ITKE Institute of Building Structures and Structural Design (Prof. Jan Knippers), University of Stuttgart

Photo © ICD/ITKE University of Stuttgart

51 **Radio Painting Station: Looking for the Waterhole,** 2017

Simon Ingram
*1971 in Wellington (NZ), lives and works in Auckland (NZ)

° Available online at: http://www.wolframscience.com/reference/quick_takes.pdf (accessed 25/09/2017).
• The Waterhole is a phrase coined by Bernard M. Oliver to describe a band of radio frequencies most likely to support life. This band is bookended by emissions from neutral hydrogen – 1420 MHz (a wavelength of 21 cm) – and hydroxyl (1666 MHz, a wavelength of 18 cm).
•° Voltage at 1420 MHz (a wavelength of 21 cm).

Looking for the Waterhole, 2011, machine stills (03/05/2011 6:45pm, 08/05/2011 7:04pm, 09/05/2011 6:57pm, 22/05/2011 7:02pm), installation views: Dark Sky, Adam Art Gallery Te Pātaka Toi, Wellington 2011, photo © Simon Ingram, photos: Andy Cummins

52 **OpinionMap: What Should One Eat?**, 2017

Gregor Betz
*1976 in Peine (DE), lives and works in Karlsruhe (DE)
Michael Hamann
*1988 in Mühlacker (DE), lives and works in Karlsruhe (DE)
Tamara Mchedlidze
*1981 in Tbilisi (GE), lives and works in Karlsruhe (DE)
Sophie von Schmettow
*1992 in Aachen (DE), lives and works in Karlsruhe (DE)
Christian Voigt
*1979 in Hamburg (DE), lives and works in Karlsruhe (DE)

KIT, Institute of Theoretical Informatics, DebateLab

Photo © the artists

53 **Transcription Jewels**, 2001

Eduardo Kac
*1965 in Rio de Janeiro (BR), lives and works in Chicago (US)

Transcription Jewels, 2001, photo © Eduardo Kac

54 **The Trial of Superdebthunterbot**, 2016

Helen Knowles
*1975 in London (GB), lives and works in London and Manchester (GB)

Installation view Goldsmiths, University of London (GB), photo © Helen Knowles, photo: Rebecca Lennon

55 **Babel 1**, 1980
Babel 2, 1980

Beryl Korot
*1945, New York (US), lives and works in New York

Courtesy of bitforms

gallery, New York

Babel 1, photo © Beryl Korot, photo: Kathleen Richards
Babel 2, photo © Beryl Korot, photo: John Berens

56 **Sacrophonie**, 2017

Anton Kossjanenko
*in Kerch (SU), lives and works in Karlsruhe (DE)

Programming: Alexandre Rodrigues

57 **Morse Alphabet**, 1998

Brigitte Kowanz
*1957 in Vienna (AT), lives and works in Vienna

° Peter Weibel, "Botschaftlerin des Lichts / Messenger of Light," in: Christina Steinle (ed.), Brigitte Kowanz. Infinity and Beyond, Hatje Cantz, Berlin, 2017, pp. 201–226.

Installation view Mumok Wien, 2010, photo © Brigitte Kowanz, photo: Ulrich Ghezzi

58 **sketch_150709b**, 2015

Mattis Kuhn
*1987 in Marburg (DE), lives and works in Frankfurt a. M. (DE) and Cologne (DE)

59 **The Show Must Go On.**, 2017
ongoing

Marc Lee
*1969 in Knutwil (CH), lives and works in Eglisau (CH)

Photo © Marc Lee

60 **Portrait of a Web Server**, 2013

Jan Robert Leegte
*1973 in Assen (NL), lives and works in Amsterdam (NL)

Photo © Jan Robert Leegte

61 **Drone**, 2017

Donna Legault
*in Ottawa (CA), lives and works in Ottawa and Montreal (CA)

The artist is part of the international network Hexagram. The collective is dedicated to research-creation in the fields of media arts, design, technology and digital culture based in Montreal (CA) and consists of over 80 members.

Sponsors: Hexagram, Milieux: Institute for Arts, Culture and Technology

Photo © Donna Legault

62 **Sinofuturism (1839–2046 AD)**, 2016

Lawrence Lek
*1982 in Frankfurt a. M. (DE), lives and works in London (GB)

Photos © Lawrence Lek

63 **Phenotypes/Limited Forms**, 2007

Armin Linke
*1966 in Milan (IT), lives and works in Berlin (DE)

Photo © ZKM | Karlsruhe, photo: ONUK

64 **CloudBrowsing: Open Codes**, 2009/2017

Bernd Lintermann
*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
Torsten Belschner
*1966 in Freiburg i. B. (DE), lives and works in Freiburg i. B.
Mahsa Jenabi
*1982 in Teheran (IR)
Werner A. König
*1978 Ravensburg (DE), lives and works in Worms (DE)

Overall concept, visual concept, production management, realization: Bernd Lintermann
Audio concept, realization: Torsten Belschner
Interaction design, realization: Mahsa Jenabi, Markus Nitsche, Werner A. König
Interface design: Matthias Gommel
Project management: Jan Gerigk, Petra Kaiser
Technical realization: Manfred Hauffen, Jan Gerigk, Nikolaus Völzow, Arne Gräßer, Joachim Tesch
Production: ZKM | Institute for Visual Media
In collaboration with AG Mensch-Computer Interaktion, University of Konstanz

A project conducted within the framework of the research association "Information at your fingertips – Interactive Visualization for Gigapixel Displays" funded by the Information Technology Funding Program of the Federal State of Baden-Wuerttemberg (BW-FIT).

From XX.XX.XXXX till XX.XX.XXXX in the exhibition

Photo © ZKM | Karlsruhe, photo: Christina Zartmann

65 **Site Map: Open Codes**, 2017

Bernd Lintermann
*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
Jan Gerigk
*1963 in Pforzheim (DE), lives and works in Karlsruhe (DE)
Concept, project management: Bernd Lintermann, Jan Gerigk
Application software: Bernd Lintermann
Production management: Jan Gerigk
Technology: Manfred Hauffen
Production: ZKM | Institute for Visual Media and ZKM | Media Museum
Based on the augmented reality installation Traffic, 2011

On display from XX.XX. 2018 to 05.08.2018 at the exhibition.

Photo © ZKM | Karlsruhe, photo: Christina Zartmann, Bernd Lintermann

66 **SoundARt IDEAMA**, 2012

Bernd Lintermann
*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
Julia Gerlach
*1967 in Hannover (DE), lives and works in Frankfurt a. M. (DE) and Berlin (DE)
Peter Weibel
*1944 in Odessa (UA), lives and works in Karlsruhe (DE)

Concept: Bernd Lintermann, Julia Gerlach, Peter Weibel
Curator: Hartmut Jörg
Software: Bernd Lintermann
Technical coordination: Manfred Hauffen
Production: ZKM | Institute for Visual Media

Snapshot of the augmented reality app

67 **SynSeeThis**, 2013

Bernd Lintermann
*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
Manfred Hauffen
*1956 in Karlsruhe (DE), lives and works in Karlsruhe
Peter Weibel
*1944 in Odessa (UA), lives and works in Karlsruhe (DE)
Idea, conception, software: Bernd Lintermann
Performance: Peter Weibel
Technical support: Manfred Hauffen
Sound: Manfred Hauffen, Hartmut Bruckner
Production: ZKM | Institute for Visual Media

Photo © ZKM | Karlsruhe, photo: Bernd Lintermann

68 **Three Phases of Digitalization**, 2017

Bernd Lintermann
*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
Nikolaus Völzow
*1980 in Koblenz (DE), lives and works in Karlsruhe (DE)
Idea: Peter Weibel
Concept: Bernd Lintermann, Nikolaus Völzow
Software development: Nikolaus Völzow
Book design: Jan Zappe
Design: Matthias Gommel
Technical collaboration: Jan Gerigk, Manfred Hauffen
A production of the ZKM_ Hertz-Lab

Photo © the artists

69 **VRMe**, 2017

Bernd Lintermann
*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)

Creating 3-D point clouds: Konrad Berner, degree program Geodesy & Navigation, Karlsruhe University of Applied Sciences
Technical support: Manfred Hauffen
A production of the ZKM_ Hertz-Lab

Photo © ZKM | Karlsruhe, photo: Bernd Lintermann

70 **The Qualified Life**, 2014

Fei Liu
*1986 in Harbin (CN), lives and works in New York (US)

In cooperation with Akademie Schloss Solitude

Photo © Fei Liu

71 **YOU:R:CODE**, 2017

Bernd Lintermann
*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
Idea: Peter Weibel
Concept, realization: Bernd Lintermann
Audiodesign: Ludger Brümmer, Yannick Hofmann
Flip-dot display: Christian Lölkes
Technical support: Manfred Hauffen, Jan Gerigk
Setup, planning: Thomas Schwab
A production of the ZKM_ Hertz-Lab

Photo © ZKM | Karlsruhe, photo: Bernd Lintermann

72 **Arecibo-Nachricht**, 2017

Christian Lölkes
*1990 in White Plains (US), lives and studies in Karlsruhe (DE)

Photo © Christian Lölkes

73 **Code Styles**, 2017

Christian Lölkes
*1990 in White Plains (US), lives and studies in Karlsruhe (DE)

Photo © Christian Lölkes

74 **Codierte Informationen**, 2017

Christian Lölkes
*1990 in White Plains (US), lives and studies in Karlsruhe (DE)

Photo © Christian Lölkes

75 **Game of Life**, 2017

Christian Lölkes
*1990 in White Plains (US), lives and studies in Karlsruhe (DE)

Photo © Christian Lölkes

76 **Sound of Sorting**, 2017

Christian Lölkes
*1990 in White Plains (US), lives and studies in Karlsruhe (DE)

Photo © Christian Lölkes

77 **Column 1-0**, 2016–2017

Solimán López
*1981 in Burgos (ES), lives and works in Valencia (ES)
Assistance: Toni Vaca

Photos © Solimán López

78 **Open Doors**, 2017

Shawn Maximo
*1975 in Toronto (CA), lives and works in New York (US)

Photo © Shawn Maximo

79 **DCT:SYPHONING. The 1000000th (64th) Interval**, 2017

Rosa Menkman
*1983 in Arnhem (NL), lives and works in Berlin (DE)

Photo © Rosa Menkman

80 **Rhythm of Shapes**, 2016

Chikashi Miyama
*1979 in Otsu (JP), lives and works in Karlsruhe (DE)

Photo © Chikashi Miyama, ZKM | Karlsruhe

81 **Sonorama – Karlsruhe**, 2017

Chikashi Miyama
*1979 in Otsu (JP), lives and works in Karlsruhe (DE)

Photo © Chikashi Miyama, ZKM | Karlsruhe

82 **Blind Genes**, 2002

Andreas Müller-Pohle
*1951 in Braunschweig (DE), lives and works in Berlin (DE)
Bettina and Thomas Hebell

Photos © Andreas Müller-Pohle

83 **Digital Scores I (after Nicéphore Niépce)**, 1995

Andreas Müller-Pohle
*1951 in Braunschweig (DE), lives and works in Berlin (DE)

Photo © Andreas Müller-Pohle

84 **Code beautiful like a clock**, 2017

Jörn Müller-Quade
*1967 in Darmstadt (DE), lives and works in Karlsruhe (DE)
Kompetenzzentrum für angewandte Sicherheitstechnologie (KASTEL) [Competence Center for Applied Security Technology], Karlsruhe Institute of Technology – KIT
Scientific collaboration: Jeremias Mechler

Construction sketch, Photo © Jörn Müller-Quade, ZKM | Karlsruhe

85 **Sonic Web Instrument**, 2017

Greg Niemeyer
*1967 in Switzerland, lives and works in Berkeley (US)

86 **deus X mchn**, 2017

Helena Nikonole
*1982 in Moscow (RU), lives and works in Moscow

Photo © Helena Nikonole

87 **Fragmentierungen**, 2015

Julian Palacz
*1983 in Leoben (AT), lives and works in Vienna (AT)

Photos © Julian Palacz

88 **Neuronaler Architektur Generator**, 1999

Manfred Wolff-Plottegg
*1946 in Schöder (AT), lives and works in Graz and Vienna (AT)
Wolfgang Maass
*1949 in Frankfurt a. M. (DE), lives and works in Graz (AT)

Photo © Manfred Wolff-Plottegg, Wolfgang Maass, photo: Wolfgang Maass

89 **Vertigo in the Face of the Infinite**, 2017 ongoing

Matthew Plummer-Fernandez
*1982 in London (GB), lives and works in London

Photo © Matthew Plummer-Fernandez

90 **Patterns of Life**, 2015

Julien Prévieux
*1974 in Grenoble (FR), lives and works in Paris (FR)

Photo © Julien Prévieux, photo: courtesy Jousse Entreprise gallery

91 **What Shall We Do Next? (Sequence #2)**, 2014

Julien Prévieux
*1974 in Grenoble (FR), lives and works in Paris (FR)

Photo © Julien Prévieux, photo: courtesy Jousse Entreprise gallery

92 **The ReCode Project**

Various Artists
Idea: Matthew Epler

http://recodeproject.com/

93 **Die Leidmaschine**, 2017

Matthias Richter
*1986 in Bonn (DE), lives and works in Karlsruhe (DE)
Josef N. Patoprsty
*1987 in Vienna (AT), lives and works in Austin (US)

Photo © CC BY 4.0

94 **NOx STADT_LUFT_ANZEIGER**, 2016–2017

Peter Reichard
*1969 in Mainz (DE), lives and works in Wiesbaden (DE)
Manfred Kraft
*1966 in Heidelberg (DE), lives and works in Berlin (DE)
Michael Volkmer
*1965 in Augsburg (DE), lives and works in Wiesbaden (DE)
Collaboration: Tom Kresin

Photo © Scholz & Volkmer GmbH, Photo © Rui Camilo

95 **Silent Communications**, 2017

Betty Rieckmann
*1986 in Palo Alto (US), lives and works in Karlsruhe (DE)

Sketch, photo © Betty Rieckmann

96 **Real Time**, 2017

Curtis Roth
*1986 in Portland (US), lives and works in Columbus (US)

Photo © Curtis Roth

97 **manifest**, 2008/2017

robotlab
founded by Matthias Gommel, Martina Haitz and Jan Zappe in 2000, working in Karlsruhe (DE)
Inspired by: Peter Weibel

Installation view Papierfabrik Zürich 2016, photo © robotlab

98 **ADM XI**, 2017

RYBN.ORG
Artist collective, founded in 1999 in Paris (FR), the artists live and work in Paris.
Participants of the ADM XI platform are: b01, Femke Herregraven, Brendan Howell, Martin Howse, JoDi, Nicolas Montgermont, Horia Cosmin Samoila, Antoine Schmitt, Marc Swynghedauw, Suzanne Treister.
ADM XI is part of the Anti-datamining series, launched in 2006. It is the third and final part of RYBN.
ORG's trilogy on algorithmic finance, initiated with ADM 8 (2011) and continued with ADM X, The Algorithmic Trading Freakshow (2013).
ADM XI is curated by Inke Arns, and is coproduced by Jeu de Paume (Paris), with the support of DICRéAM, Labomedia and Espace Multimedia Gantner.

Photo © WD. GANN

99 **Documents on Frei Otto's Mannheim Multihalle**, 1974–1975

saai | Südwestdeutsches Archiv für Architektur und Ingenieurbau, Karlsruhe Institute of Technology

Photo © saai | Südwestdeutsches Archiv für Architektur und Ingenieurbau, Karlsruhe Institute of Technology, archives of Frei Otto's works

100 **N-Polytope: Behaviors in Light and Sound After Iannis Xenakis**, 2012/2017

Chris Salter
*1967 in Beaumont (US), lives and works in Montreal (CA) and Berlin (DE)
The artist is part of the international network Hexagram. The collective is dedicated to research-creation in the fields of media arts, design, technology and digital culture based in Montreal (CA) and consists of over 80 members.

Photo © Chris Salter, photo: Thomas Spier/apollovision.de

101 **Evolved Virtual Creatures**, 1994

Karl Sims
*1962 in Boston (US), lives and works in the US

Photo © Karl Sims

102 **XML-SVG CODE / Source Code of the Exhibition Space**, 2010/2017

Karin Sander
*1957 in Bensberg (DE), lives and works in Berlin (DE) and Zurich (CH)
Translation by Karen Michelsen Castañón

Simulation of the installation in Open Codes, ZKM | Karlsruhe 2017, photo © Karin Sander

103 **Alphabet-Space**, 2017

Adam Słowik
*1980 in Skierniewice (PL), lives and works in Berlin (DE)
Christian Lölkes
*1990 in White Plains (US), lives and studies in Karlsruhe (DE)
Peter Weibel
*1944 in Odessa (UA), lives and works in Karlsruhe (DE)

Photo © Adam Słowik

104 **Biotricity. Fluctuations of Micro-Worlds**, 2014

Rasa Smite
*1969 in Riga (LV), lives and works in Riga
Raitis Smits
*1966 in Riga (LV), lives and works in Riga

The artwork was created with the support of the State Cultural Capital Foundation of Latvia and the Solid State Physics Institute of Latvian University.
The sonification was made in collaboration with the artist Voldemārs Johansons.

Installation view FIELDS, Arsenāls Exhibition Hall of the Latvian National Museum of Art, Riga, 2014, photo © the artists, photo: Martins Ratniks

105 **Fortress of Solitude**, 2014

Space Caviar
Simone C. Niquille, *1987 in Zug (CH), lives and works in Amsterdam (NL)
Joseph Grima, *1977, lives and works in Genoa (IT)
Comissioned by the Biennale Interieur Foundation
Soundtrack by M.E.S.H.

Photos © Space Caviar

106 **DAILY, IN A NIMBLE SEA**, 2016

Barry Stone
*1971 in Lubbock (US), lives and works in Austin (US)

Courtesy of Klaus von Nichtssagend Gallery, New York

Bailey Island, Maine (soft sun), 2016, photo © Barry Stone
Bailey Island, Maine (seascape), 2016, photo © Barry Stone

107 **Dark Matter – One Million Years Later**, 2016–2017

Monica Studer
*1960 in Zurich (CH), lives and works in Basel (CH)
Christoph van den Berg
*1962 in Basel (CH), lives and works in Basel

Photo © Monica Studer, Christoph van den Berg, photos: courtesy Nicolas Krupp gallery

108 **Passage Park #7: relocate**, 2017

Monica Studer
*1960 in Zurich (CH), lives and works in Basel (CH)
Christoph van den Berg
*1962 in Basel (CH), lives and works in Basel

Photo: © Monica Studer, Christoph van den Berg, photo: courtesy Nicolas Krupp gallery

109 **The Critical Engineering Manifesto**, 2011

The Critical Engineering Working Group
Julian Oliver, *1974 in New Zealand, lives and works in Berlin (DE)
Gordan Savičić, *1980 in Vienna (AT), lives and works in Lausanne (CH)
Daniil Vasiliev, *1978 in Russia, lives and works in Berlin (DE)

° Bruno Latour, Pandora's Hope: Essays on the Reality of Science Studies, Harvard University Press, Cambridge, MA, 1999, p. 304.

Photo © Julian Oliver, Gordan Savičić, Daniil Vasiliev, GNU Free Documentation License v1.3

110 **Deep Time Machine Learning**, 2017

Jol Thomson
*1981 in Toronto (CA), lives and works in Berlin (DE) and London (GB)

This video was produced as part of the WimmelResearch-Fellowship at Platform 12, a joint project of Akademie Schloss Solitude, Robert Bosch GmbH, and Wimmelforschung.
With additional support from: Stuttgart State Museum of Natural History Freundeskreis Philipp Matthäus Hahn Kornwestheim e.V.

Photo © Jol Thomson

111 **Chinese Coin (Red Blood)**, 2015

UBERMORGEN.COM
founded in 1995, active in Vienna (AT) and St. Moritz (CH)
Video and sound:
Mike Huntemann

Photo © UBERMORGEN.COM, Photo: courtesy Carroll/Fletcher, London

112 **Hexen 2.0 / Macy Conferences Attendees**, 2009–2011

Suzanne Treister
*1958 in London (GB), lives and works in London
Courtesy of Anny Juda Fine Art, London

HEXEN 2.0 / Macy Conferences Attendees / John von Neumann (Mathematician), 2009–2011, photo © Suzanne Treister, photo: courtesy Annely Juda Fine Art, London, and P.P.O.W., New York
HEXEN 2.0 / Macy Conferences Attendees / Walter Pitts (Mathematician and Logician), 2009–2011, photo © Suzanne Treister, photo: courtesy Annely Juda Fine Art, London, and P.P.O.W., New York

113 **Emotion Hero**, 2016

Ruben van de Ven
*1989 in Lelystad (NL), lives and works in Rotterdam (NL)

This project was produced as part of the "Summer Sessions Network for Talent Development;" a coproduction of Arquivo 237 and V2_Lab for the Unstable Media, it was funded by the Creative Industries Fund NL. The game's emotional intelligence is powered by Affectiva.

Photo © Ruben van de Ven

114 **Book of Genome – PCC, 2016 DECODE – PCC**, 2016

Koen Vanmechelen
*1965 in Sint-Truiden (BE), lives and works in Genk (BE)

© VG Bild-Kunst, Bonn 2017, Photo © Koen Vanmechelen
© VG Bild-Kunst, Bonn 2017, installation view ENERGY/MASS, Wasserman Projects, Detroit (US) 2016, photo © Koen Vanmechelen, photo: PD Rearick

115 **Center of Doubt**, 2012–2015

Ivar Veermäe
*1982 in Tallinn (EE), lives and works in Berlin (DE)

Photo © Ivar Veermäe

116 **IVY**, 2017

::vtol::
*1986 in Moscow (RU), lives and works in Moscow

117 **keine zahl ist illegal**, 2017

Clemens Wallrath
*1992 in Karlsruhe (DE), lives and studies in Karlsruhe (DE)
Felix Held
*1990 in Rinteln (DE), lives and works in Karlsruhe (DE)

118 **Presentation**, 2016–2017

Web Residencies by Solitude & ZKM
Initiated in 2016 by Akademie Schloss Solitude, Stuttgart (DE)
Since 2017 in cooperation with the ZKM | Center for Art and Media, Karlsruhe (DE)

With concepts and projects by the curators and curators collectives: Netro, Mario Doulis, Apparatus 22, Tatiana Bazzichelli, Claudia Maté, and Nora O Murchú, as well as the Web Residents: Haseeb Ahmed, Brud, Alan Butler & Elaine Hoey, Hang Do Thi Duc, Polly Gregson, Travis Hallenback, Adam Harvey, Institute for New Feeling, Dina Karadžić, Vedran Gligo, Lauren McCarthy, Manuel Minch, Joanna Moll, Jan Nikolai Nelles, Nora Al-Badri, Eric Parren, Sascha Pohflepp & Chris Woebken, Paul Simon Richards, Jean-Michel Rolland, Jeremy Rotsztain, Nicolas Sassoon, Jeffrey Alan Scudder, Megan Snowe and Marloes de Valk.

119 **ESIOD 2015**, 2016

Clemens von Wedemeyer
*1974 in Göttingen (DE), lives and works in Leipzig (DE)
Courtesy of KOW, Berlin

© VG Bild-Kunst, Bonn 2017, photo © Clemens von Wedemeyer; KOW, Berlin

120 **Monochord**, 2012

Idea: Peter Weibel
*1944 in Odessa (UA), lives and works in Karlsruhe (DE)
Computer animation: Ludger Brümmer
*1958 in Werne (DE), lives and works in Karlsruhe (DE)
Interactive environment:
Götz Dipper
*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)
Production: ZKM | Karlsruhe

Sponsor: Genesis, physical Modeling Environment: ACROE, Grenoble

Photo © ZKM | Karlsruhe

121 **Daten|Spuren**, 2015

Alex Wenger
*1975 in the Canton of Zug (CH), lives and works in Ettlingen (DE)
Max-Gerd Retzlaff
*1981 in Warendorf (DE), lives and works in Karlsruhe (DE)

Installation view Global Control and Censorship, Tallinna Kunstihoone 2017, photo © Alex Wenger, Max-Gerd Retzlaff, photo: Anatole Serexhe

122 **Symbolism in Circuit Diagrams**, Since 2006 ongoing

Where Dogs Run
Founded in 2000 in Yekaterinburg (RU)
Alexey Korzukhin, *1973 in Sverdlovsk (RU)
Olga Inozemtseva, *1977 in Jalutorovsk (RU)
Natalia Grekhova, *1976 in Kamensk-Uralsky (RU)
Vladislav Bulatov, *1974 in Sverdlovsk (RU)
All artists live and work in Yekaterinburg (RU)

123 **Blurry Box®**, 2014

Wibu-Systems AG and FZI Research Center for Information Technology, Karlsruhe Institute of Technology (KIT)

At the exhibition from October 20, 2017 to March 25, 2018

124 **The Edinburgh Social Model Construction Project**, 1973

Stephen Willats
*1943 in London (GB), lives and works in London

° Stephen Willats, Life Codes – Behaviour Parameters, Midland Group Gallery, Nottingham, 1974.

125 **Meta Filter**, 1973–1975

Stephen Willats
*1943 in London (GB), lives and works in London

Photos © Stephen Willats

126 **Six Levels of Interpersonal Organisation**, 1974

Stephen Willats
*1943 in London (GB), lives and works in London

127 **A State of Agreement**, 1975

Stephen Willats
*1943 in London (GB), lives and works in London

Courtesy of Victoria Miro Gallery, London

128 **Painted by Numbers**, 2016

World-Information Institute
founded in 1999, active in Vienna (AT)

Photo © Institut für Neue Kulturtechnologien

129 **"Astrophotography – Stages of Photographic Development" by Siegfried Marx (1987)**, 2007

Cerith Wyn Evans
*1958 in Llanelli (GB), lives and works in London (GB)

Thyssen-Bornemissza Art Contemporary Collection, Vienna

Installation view TBA21, 2013, courtesy of the Thyssen-Bornemisza Art Contemporary Collection, photo © Cerith Wyn Evans, photo: Jens Ziehe / TBA21, 2013

130 **Robot Ludens**, 2017

Julia Zamboni
*1985 in Brasilia (BR), lives and works in Montreal (CA)
The artist is part of the international network Hexagram. The collective is dedicated to research-creation in the fields of media arts, design, technology and digital culture based in Montreal (CA) and consists of over 80 members.

Sponsors: Hexagram and TAG (Technoculture, Art, and Games)

Photo © Julia Zamboni

1 **credits part 2**

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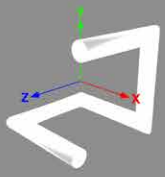
Impressum



In a right-handed coordinate system place an object that connects points (+,+,+), (+,+,-), (+,-,-), (-,-,-), (-,-,+) and (+,-,+) in order with straight segments, where '+' denotes an arbitrary positive scalar and '-' a negative scalar of the same magnitude.

Look down the negative z-axis.

Assuming the object has an intrinsic coordinate system that is fixed to it, repeatedly rotate the object around its x-, then its y-, then its z-axis by a number of degrees relative to the zero position according to the following table, in clockwise direction while looking down the positive rotation axis.

O 090 000 000	**C 090 000 045**
P 052 000 180	**O 090 000 000**
E 000 045 046	**D 090 000 190**
N 090 000 270	**E 000 045 046**
	S 139 000 226