
OPEN CODES
LIVING IN DIGITAL WORLDS
20/10/2017 - 05/08/2018

This exhibition is an extraordinary experiment in educational policy! Join us and let’s launch it together!

Editorial

To understand the world
we inhabit.
To understand the world
we live in.
To understand the world
that sustains us.

Today we live significant portions of our lives in an artificial, human-made world of data. Digital codes provide access to this world. When we turn on a mobile phone, for example, we are immediately confronted with the prompt "enter passcode." In Paris it is also commonplace to get into a house or room by entering a numerical code at the door. Codes are crucial keys for access to our contemporary world, both analogue and digital.

The oldest codes in our culture include alphabets and numeral systems. In communication studies, a language is designated as a code in the broadest sense. All communication rests on the exchange of information generated by the sender using a given code and interpreted by the recipient according to the same code. More generally speaking, then, a code is based on a character set; it forms the instructions for depiction so that the characters of one character set can be clearly assigned to those of another. For example, the stream of sounds of the spoken English language can be assigned to the 26 letters of the Latin alphabet in order to represent the spoken vowels and consonants in writing. This visual alphabetical code of 26 letters can, in turn, through the use of short and long sound signals, be translated into Morse code. The essential characteristic of a code, then, is its translatability from one code to another. But what is most astonishing is that a virtually unlimited number of sentences can be produced from either the 26 letters of the Latin alphabet or the three signs of Morse code (short signal, long signal, pause), that is to say, a potentially infinite amount of information can be coded.

Morse Code

The signals of Morse code are transmitted via an electromagnetic telegraph. These characters can be sent as sound or radio signals, as an electrical impulse via a telephone line through the interruption of a constant signal with a button, or optically by switching a light on and off. Morse code fundamentally consists of two states, the signal and the pause, and a temporally variable signal length. This transmission method is called Morse telegraphy. It was named after the painter and inventor Samuel Morse, who constructed the first model of a functional electromagnetic telegraph in 1833. Initially it was only able to transmit ten digits, which were translated into letters and numbers according to a coding chart (a = · –). In a later, more developed form, standardized Morse code provided the vital radio technology for seafarers.

Numerical Code

While the alphabetical code predominated as the primary code for human culture and communication for thousands of years, today numerical code dominates our world, as the examples cited above show. This code essentially consists of the ten numerals 1 to 9 and 0, through which an almost infinite number of numbers can be formed. In 1697, Gottfried Wilhelm Leibniz achieved for numerical code something similar to what Morse would later achieve for alphabetical code.[1] Leibniz proved that all numbers can be represented by just two digits, 0 and 1. He did not take words, images or numbers as counterparts for objects as was usual, but rather allocated digits to numbers for the first time: "Numbers can be used to express all kinds of true sentences and deductions" (Leibniz, *De progressione dyadica*, 1679) Leibniz's binary number system, his binary code, with which he began to translate words and sentences into numbers, was a prerequisite for the digital code of today.

As all information in the digital world is processed as numbers, letters of the alphabet and numerals are depicted as bit sequences in the computer. The combinations of 0 and 1 (bits) can be stated as numbers, signs or letters (e.g., a = 1100 0001, b = 1100 0010). In coding theory, the elements that make up the code are called "code words," and the symbols that make up the code words are called the "alphabet." Whereas until recently, the code systems of language and writing served the purposes of communication between people, today many code systems are available which also enable people to communicate with machines and things. These include the bar codes and QR codes of merchandise management, as well as the important ASCII (American Standard Code for Information Interchange), which is used for coding character sets.

In computer science, the text of a computer program that is written in a programming language in a way that is legible to people is called source code, source text, or program code. It is created according to the rules of the respective programming language. Source code is often written in ASCII code. In order for the computer to execute the source code, it has to be converted into machine language, that is, into commands that can be executed by a processor.

On the History of Digitization

Important twentieth-century philosophical books bear titles such as *Word and Object* (Willard Van Orman Quine, 1960) and *Les Mots et les choses* (Michel Foucault, 1966)[2]. These books tell of an analogue world that consists primarily of things and of the relationship between things and words. Thus in these texts, language is the instrument that orders the world. Hence Ludwig Wittgenstein's famous dictum, "The limits of my language mean the limits of my world."[3]

Indeed, language was the first tool which enabled people to explain and shape the world. People gave names to things, and these relations between words and things were decisive for culture and civilization for thousands of years. Just as people gave names to things, they also assigned pictures to things, which gave rise to a second cultural technology; the art of imagery, from painting to photography. The things also generated sounds; moreover, people even created new things especially to produce sounds.

The world of images, words, and sounds was soon joined by the world of numbers. Mathematics is the world of numbers. The evolution of digitization proceeded in three stages. The first stage of digitization, or rather the mathematization of the world, began with the mathematization of physics. In 1623, Galileo Galilei wrote, "Nature is a book written in the language of mathematics."[4] Depicting things in words and images in itself represents a considerable level of human abstraction. Expressing the world in numbers which took on a life of its own as mathematics, was the as yet highest stage of a cultural technology that distinguished people from all other living creatures. This increased abstraction through mathematics and the development of the natural sciences as mathematical disciplines digitization began in the proper sense 400 years ago. Mathematics became a universal language.

To put it simply and schematically: in the seventeenth and eighteenth centuries the mathematization of physics took place (1st stage), and in the nineteenth and first half of the twentieth century the mathematization of thought (2nd stage). In the latter half of the twentieth century both tendencies converged in the development of electronics (3rd stage). In his monumental

Philosophiae Naturalis Principia Mathematica of 1686, Isaac Newton laid the foundations for describing nature in mathematical terms. Joseph-Louis de Lagrange's 1788 masterpiece *Méchanique analytique* was the first work to offer a full description of the universe on the basis of pure algebraic operations. He carried physics over into analytical mathematics. Lagrange algebraized mathematics and mathematized physics. This algebraization of physics led to the second stage of digitization: the algebraization of logic (of formal thought). Logical forms were captured with the aid of mathematical methods and terms. As a response to Newton's *Principia*, Bertrand Russell and Alfred North Whitehead published their three-volume work *Principia Mathematica*, 1910–1913. Like Gottlob Frege, who used his 1879 work *Begriffsschrift. Eine der arithmetischen nachgebildete Formelsprache des reinen Denkens* to translate thought into mathematical formulas, Russell and Whitehead portrayed thinking and logic in mathematical terms.

A milestone was set by George Boole who defined the laws of thinking as laws of formal logic and these in turn, building on Lagrange, as algebraic mathematics. In *The Mathematical Analysis of Logic* (1847) and *An Investigation of the Laws of Thought* (1854), Boole proved that logic and algebra are identical by expressing logical statements as algebraic equations. Alan Turing, ultimately, brought these tendencies to mathematize the world, language, and thought to their culmination in his famous 1936 essay "On Computable Numbers." Turing's depiction of the calculability of numbers and number processes is considered the foundational paper for the development of the digital computer, for what is known as the Turing machine. Henceforth one no longer just calculated with numbers but rather numbers became calculable. With calculable numbers, nature becomes computable.

With the further development of the computer from a pure calculating machine to a machine of images, sound, and language, a new world of data emerged. Images and texts can be computed and visual and acoustic worlds can be simulated. In a word, everything that was previously made up of objects, words, sounds, and images can be represented in numbers and constructed from numbers. The crucial aspect of this digital cultural technology is a hitherto unimaginable reversibility. In the analogue world the principle of irreversibility prevails in the relationship between things and words or images. Things can be transformed into words, but not words can be retransformed into things, because the word "chair" is not actually a chair. Things can be transformed into images, but not images into thing, because the picture of a pipe is not a pipe, to cite René Magritte's 1929 painting *La trahison des images*, which displays the image of a pipe and below it the words *Ceci n'est pas une pipe* – this is not a pipe. In the era of digitization, words, images and sounds are transformed into data, and – for the first time in human history – this data can be transformed back into sounds, images, and words. And with 3-D printing data can even be transformed into things. The relation between data and things, words, images are reversible. The language of data, algorithms, and programming languages has become a universal language out of which the world of sounds, images, texts, and things emerges. Thus mathematics has long since ceased to be just the language of nature; it has become the language of culture. The book that describes the contemporary world must be titled *The Things and the Data*. The relationship between things, words, and images used to be irreversible. However, now the relationships between data and words, images and sounds are reversible in the digital world.

Digital Codes

Digital cultural technology, however, has also provided the foundations for another revolution, which will possibly usher in a new era. Culture to date has been based on two-dimensional notation: notes, numbers, and signs on paper are notated and fixed just like writing. The computer, however, enables the simulation of moving three-dimensional spaces, and in this way enables a future, three-dimensional notation which is already being used today by architects and designers. 3-D cinema was the first attempt along these lines, but it is with 3-D printing that this future begins to become a reality through the aforementioned possibilities of reversible transformations. Thanks to the development of this cultural technology, which renders the relationship between the worlds of things and signs reversible, we will live in an environment that is underpinned by sensors and intelligent agents, managed by codes and algorithms, and equipped with artificial intelligence.

The fact that this has become possible goes back to "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," which was ascertained by Nobel Laureate Eugene Wigner in 1960. Reality is what can be expressed mathematically and electronically controlled. The best example of this is Claude E. Shannon's 1937 master's thesis, *A Symbolic Analysis of Relay and Switching Circuits*. In this work, Shannon proved that Boolean propositional logic can be used with the logical values 0 and 1 to control a remote-controlled switch with two switch positions that acts electromagnetically and is operated by an electric current. As the title of his work conveys, relay and switching circuits, arrangements of relays and switches, are mapped onto Boolean propositional logic in a symbolic analysis. Boolean logic thus becomes switching algebra. The linking together of the rules of logic with the controlling of switching circuits, that is, the use of the binary qualities of electrical switching circuits (on – off, 1 – 0, electricity – no electricity) to execute logical operations, henceforth became definitive for the construction of all electronic digital computers. Shannon showed that the mental formulas of Boolean algebra could be transformed into material switching algebra. Formal thought was carried over into electronic switching circuits according to the rules of Boolean algebra. Electronics became the physics of mathematics.

In connection with the discovery of electromagnetic waves by Heinrich Hertz (1886–1888), that is, the invention of telecommunications (the telegraph, the telephone, television, radar, radio, satellites, the internet) and the development of transistors (1947), integrated circuits, and microchips, over the last century the mathematization of the world became transferable to the material world of electronics. Thus the equation of "Machinery, materials, and men" (Frank Lloyd Wright, 1930), which applied to the nineteenth and twentieth centuries, had to be expanded to "Media, data and men" (Peter Weibel, 2011) for the twenty-first. After alphabetical code was supplemented by numerical code, algorithms now represent a fundamental element of our social order.

The Concept of the Exhibition – An Experiment in Education

By means of some 200 artistic and scientific works, the exhibition displays the world of digital codes and the future forms of life influenced by them in eight areas: #GenealogyOfCode, #Encoding, #MachineLearning, #AlgorithmicGovernance, #Algorithmic-Economy, #VirtualReality, #Labor&Production, and #Genetic-Code. The works presented offer you the chance of trying out an unusual way of engaging with art and defining your own exhibition visit a bit. Unlike with the conventional reception of analogue paintings, sculptures, and installations, the horizon of meaning in *Open Codes* is only revealed in the process of observers physical interacting with the works. The participation of the audience is the moment when the works come into being materially. Participatory and analytical engagement with the works therefore includes new forms of concentration and meditation as well as divertissement. The *discours* of the exhibition is arranged as an architectural *parcours* so that you have the opportunity to stroll around autonomously among islands of art and knowledge or to be active and creative at the places called "work stations," that is, to converse with other people or to take a break and rest. Because the works unfold in a particularly fascinating way when observed for a longer period of time and we want you to explore the works intensively, we are providing drinks and snacks free of charge. Admission to the exhibition is free – and you will experience a combination of a laboratory and a lounge, a learning environment and park oasis.

It is clear that in this exhibition architectonic concept and scenography depart radically from the usual museum set-up of the White Cube. Elements of a studio, a laboratory, and the home alternate, from a glowing cloud to programmable music machines. The museum as the Commons: the museum becomes an open source community in which people collaborate and become more competent, creative, and knowledgeable together. On the one hand, the architecture is designed to evoke the atmosphere of a space for making, doing, and co-working. On the other hand, the walls are positioned so that they create organic forms. Here the museum becomes a place of community education where the acquisition of knowledge is not only rewarding, but is also rewarded. For the real message of digital transformation is: The society of tomorrow will (have to) change from a work-based society to a knowledge-based society. Thus we demand access to free civic education in the twenty-first century! It is imperative we have culturally competent citizens in order to defend democracy.

The ZKM | Museum Communication team has therefore developed innovative learning concepts with the goal of opening up the intriguing world of digital coding for people of all ages. The wide-ranging communications program offers suitable formats for everyone: small children and (grand)parents, hackers and artists, computer scientists and coding amateurs. You can explore digital coding in theory and in practice directly in the exhibition spaces together with active participants from Karlsruhe and ZKM employees – at workshops, parties, camps, algoraves, science slams, experimental tours, or programming courses.

Peter Weibel

1 G. W. Leibniz in a letter to Rudolph August, Duke of Brunswick-Lüneburg, known as the New Year’s Letter, January 12, 1697.

2 English edition: *The Order of Things* [1966], Pantheon, New York, 1970.

3 Ludwig Wittgenstein, *Tractatus logico-philosophicus*, 1921, proposition 5.6.

4 Galileo Galilei, *Il Saggiatore* (1623), Edition Nazionale, vol. 6, Florence 1896, p. 232.

Open Codes 101

Exhibition Manual

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. Of central importance in these debates is the position and purpose of a museum in this day and age. When you hear the word “museum,” you probably think of its institutional remit to collect, preserve, and exhibit historical artifacts and/or artworks. With the exhibition *Open Codes* we are proposing a new definition of the museum for the twenty-first century which breaks with rigid structures and outdated attitudes: Our goal is to address present-day challenges and needs and integrate them into the museum. It is an attempt to engage with today’s realities and point up 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 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 as collaborative processes to create synergies between different professions and various forms of knowledge and expertise. You, the visitors, are invited to work, produce, and learn together with others. The design of the exhibition, which is interspersed by park-like oases for relaxing, spaces for focused working, office spaces, and play areas, aspires to promote competence, creativity, and acquisition of knowledge. *Open Codes* is a platform that facilitates collaboration and co-creation; which invites you to participate in open exchange within an environment that undergoes constant change. In the exhibition various approaches are tried out to test new forms of encounter and critical debate. You will get to know a very new kind of environment where knowledge can be accessed; it is a place that continuously changes, re-configures, develops, and evolves.

A part of this concept are various tools that you can use to address the exhibition:

Hashtags

The many topics dealt with in the exhibition are grouped in eight key areas:
#GenealogyOfCode
#Encoding
#MachineLearning
#AlgorithmicGovernance
#Labor&Production
#AlgorithmicEconomy
#VirtualReality
#GeneticCode

A distinguishing feature of the exhibition is that the artworks are not physically grouped according to themes. The overarching topics are presented as title hashtags together with other hashtags associated with these topics. This allows you to draw connections among the different themes. Each artwork is assigned several hashtags.

This hashtag system is similar to how hashtags are used in the media, and thus represents for the open, flowing, and dynamic connections between themes that is so characteristic of our networked world.

The # character was used to denote a number – e.g., # 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. Through hashtags being combined with content, images, videos, etc., a non-hierarchical system results that resembles a cloud: all kinds of content can be associated with very different keywords, and do not fall under just one specific and exclusive category.

The hashtag 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 Brochure

The brochure you are holding in your hands is one of the main tools for navigating the exhibition. In addition to this text about the exhibition and its components, it contains an introduction by the exhibition's curator, Peter Weibel, texts describing the eight thematic areas, a text on the subject of signal codes and machine codes by Franz Pichler, and a list of the artworks on show.

Descriptions of the artworks are displayed next to them in the exhibition and are also available on the exhibition website.

If you wish to focus on a particular key theme (title hashtag) of the exhibition in more detail, you can refer to the accompanying leaflet with the floorplans of the exhibition. There you will find a map of each thematic complex as well as an overview of the entire exhibition. This is the quickest way to see where specific works can be found in the exhibition.

The App

You can also navigate the exhibition by using the *experience_zkm* app, which is available for Android and Apple devices. With this app you can start a keyword search for one of the title hashtags and you can hear the particular text as an audio file while the artworks flagged that are associated with that particular theme will be highlighted on the exhibition map.

The app also has a few special features: Throughout the exhibition you will see markers on the floor. When you approach one, the app will send you a notification, and if you approach an interactive artwork, your smartphone will supply instructions of how you can interact with the work. This feature can be turned off.

Info Points and Website

In addition to the Brochure and the App we have put together an extensive online resource of information which includes descriptions of the artworks, images, as well as a great deal of background material – journal and newspaper articles, videos, further reading –, and other artworks that are only available online. You can access this information via the main ZKM website (https://open-codes.zkm.de) from your own devices or at the Info Points in the gallery space.

Work Stations

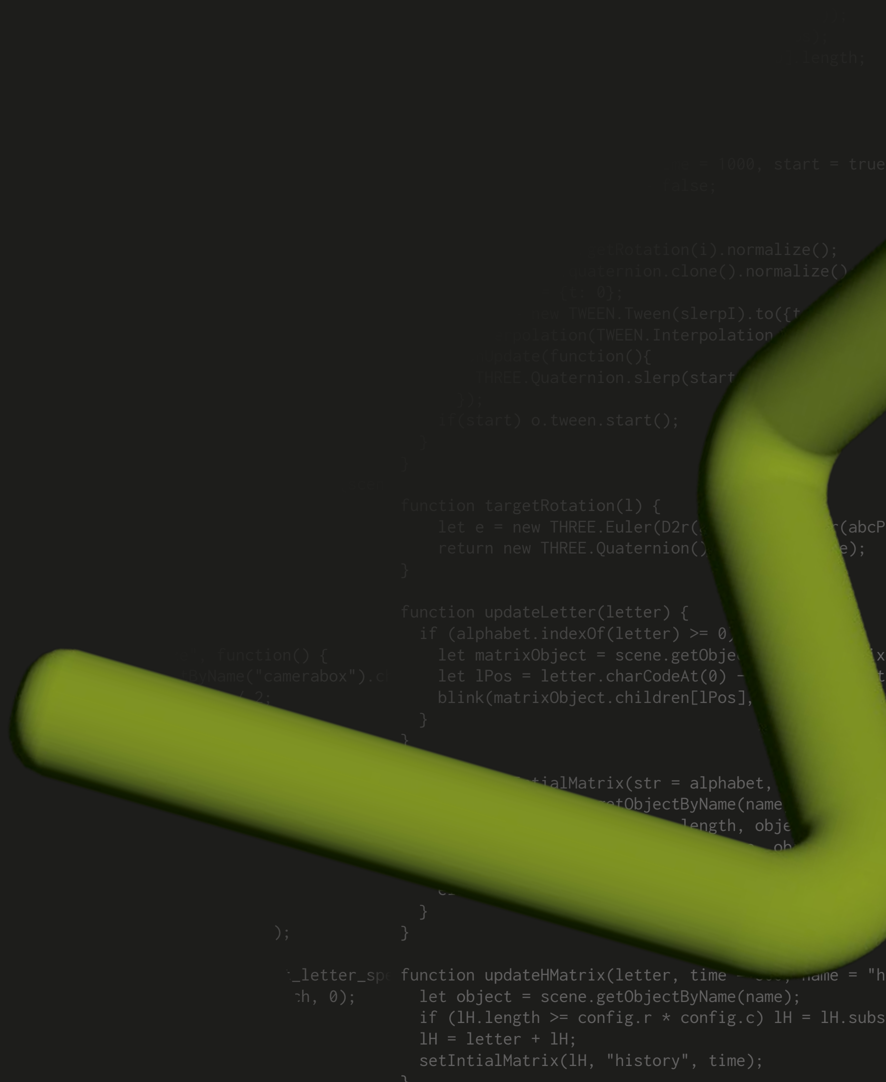
All over the exhibition you will find tables and work stations where you can sit down at any time to read, write something down, code, or do anything else you feel inspired to do. The work stations are there to let you give free rein to your imagination so that you don't have a long search for somewhere to put down your ideas. In these areas you can work by yourself or in a group. Some of the work stations are designed as co-working spaces and facilitate exchanges between very different people and interests.

Other work stations are more quiet environments conducive to concentration and focused work. To whet your appetite for learning, to reward your educational competence, non-vending machines provide drinks and snacks, fruit, etc. absolutely free of charge.

The working area in Atrium 8 is of a different kind; it is designed so that various public events can take place there. Workshops, lectures, and roundtable discussions will be held and everyone is invited to participate and get involved. The important thing about this space is that *you* can shape its content. We provide the infrastructure; you fill it with ideas. If you would like to hold or organize an event here, just visit our website to book the spaces at the desired date.

#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 [Great Art], is explained most extensively in his notable work *Ars magna* (1274–1308).[1] 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.[2]

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 endless 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.[3]

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 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'"[4], 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.[5] Boole's binary system is based on the three most basic operations used as logical operations: AND, OR, and NOT.[6]

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."[7]

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].[8] 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",[9] 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 languages whose extension is that very assembler."[10] (`#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 of transistors binary systems became ubiquitous in computing.

In addition to algorithms (see `#Algorithm` in key area `#Encoding`) and calculations anything decodable can be described by binary code. Perhaps the best-known example is ASCII (American Standard Code for Information Interchange), the characters displayed on a computer screen, which was developed from telegraph code beginning in 1960.

The capacities of current computers may not be sufficient for the amount and complexity of computing in the future. The development of modern computers has been very fast, which is even more striking when compared to the improved performance of cars. If cars made in 1971 had improved at the same rate as computer chips, then by 2015 new models would have had top speeds of about 680 million kilometers per hour.[11]

Quantum computing could be the answer to the recent and seemingly inevitable expansion.

In a quantum computer logical operations are performed on an atomic level. Atoms register more than bits, they are able to register 0 and 1 at the same time, and thus quantum bits or qubits are more efficient than classical bits because they can perform two computations simultaneously.[12]

"How long can computation continue in the universe? Current observational evidence suggests that the universe will expand forever. As it expands, the number of ops performed and the number of bits available within the horizon will continue to grow."[13]]

1 Raimundus Llullus, *Opera*, 2 vols., Frommann-Holzboog, Stuttgart-Bad Cannstatt, 1996, S. 228–663. See also Anthony Bonner, *The Art and Logic of Ramon Llull: A User's Guide*, Brill, Leiden, Boston, 2007.

2 See Ana H. Maróstica, "*Ars Combinatoria* and Time: Llull, Leibniz and Peirce," in: *Studia Lulliana*, vol. 32, 1992, pp. 105–134, here p. 111.

3 See Hermann J. Greve, "Entdeckung der binären Welt," in: *Herrn von Leibniz' Rechnung mit Null und Eins*, Siemens Aktiengesellschaft, Berlin, Munich, 1966, pp. 21–31.

4 L. F. Menabrea, *Sketch of the Analytical Engine Invented by Charles Babbage*, translated from the French and supplemented with notes upon the memoir by Ada Lovelace, printed by Richard and John E. Taylor, London, 1843, p. 696f.

5 See George Boole, *The Mathematical Analysis of Logic: Being an Essay Towards a Calculus of Deductive Reasoning*, Macmillan, Cambridge, 1847.

6 See Paul J. Nahin, *The Logician and the Engineer: How George Boole and Claude Shannon Created the Information Age*, Princeton University Press, Princeton (NJ), Oxford, 2013.

7 Friedrich Kittler, "There Is No Software," in: *Stanford Literature Review*, vol. 9, no. 1 Spring 1992, pp. 81–90, here p. 88.

8 See Alan Turing, "On Computable Numbers, with an Application to the Entscheidungsproblem," in: *Proceedings of the London Mathematical Society*, ser. 2, vol. 42, no. 1, January 1937, pp. 230–265.

9 Andrew Hodges, *Alan Turing: The Enigma*, Princeton University Press, Princeton (NJ), Oxford, 2014, p. 177.

10 Kittler 1992, p. 82.

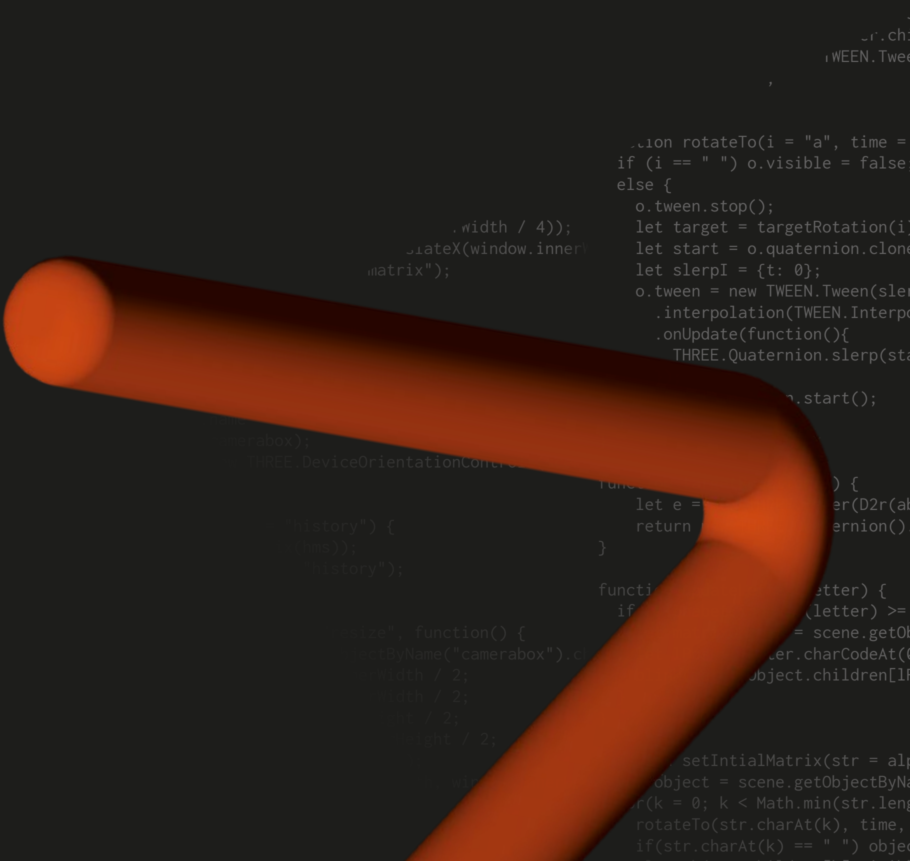
11 See Tim Cross: "Vanishing point: The rise of the invisible computer," in: *The Guardian*, 01/26/2017, available online at: https://www.theguardian.com/technology/2017/jan/26/vanishing-point-rise-invisible-computer, accessed 09/13/2017.

12 Seth Lloyd, *Programming the Universe: A Quantum Computer Scientist Takes on the Cosmos*, Vintage Books, New York, 2007, pp. 136–139.

13 Ibid., p. 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)."[1] 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."[2] 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."[3]

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."[4] 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.

1 Andrew Butterfield and Gerard Ekembe Ngondi, *A Dictionary of Computer Science*, 7 ed., Oxford University Press, Oxford, 2016, p. 93.

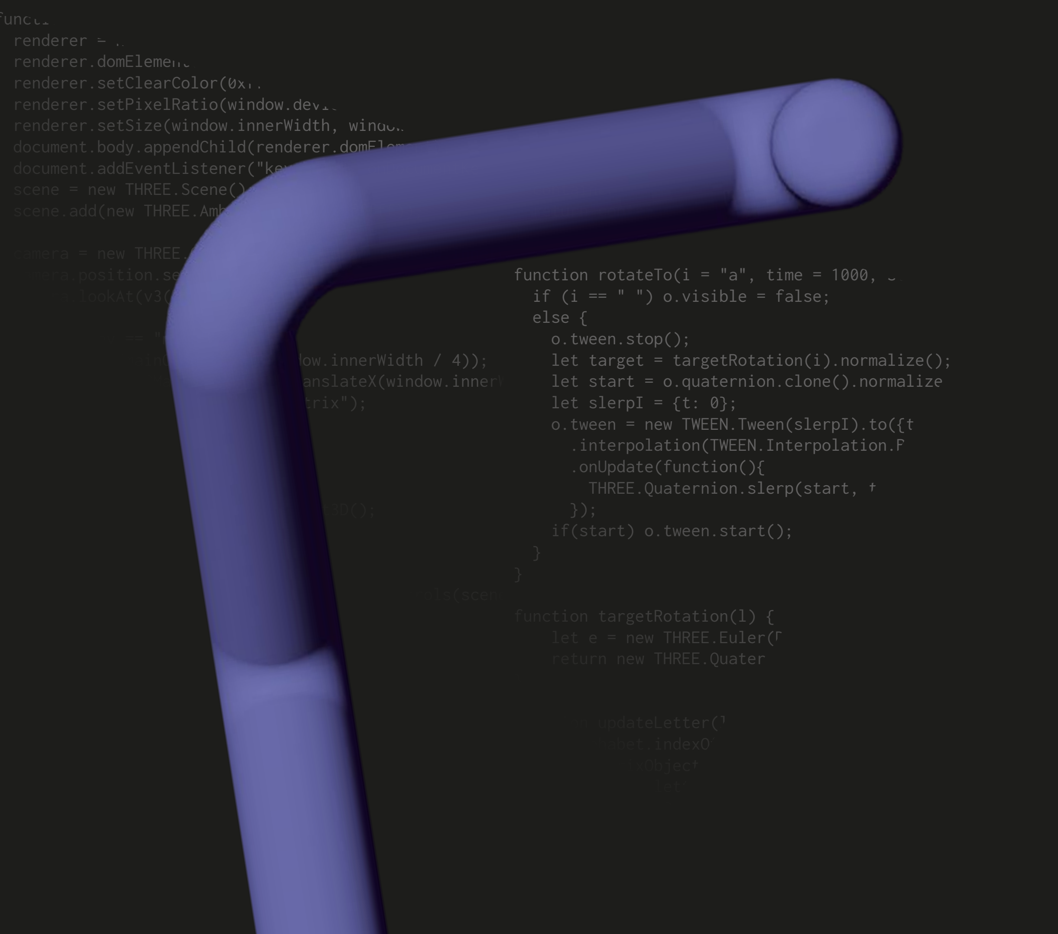
2 Rob Kitchin and Martin Dodge, *Code/Space: Software and Everyday Life*, The MIT Press, Cambridge (MA), London, 2011, p. 25.

3 Alexander R. Galloway, *Protocol: How Control Exists after Decentralization*, The MIT Press, Cambridge (MA), London, 2004, p.166.

4 Susan M. Hockey, *A Dictionary of Computing*, 2 ed., Oxford University Press, Oxford, 1986, p. 352.

#MachineLearning

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



In computer science #ArtificialIntelligence (AI) determines the operations of intelligent agents using forms of mechanical or "formal" reasoning. AI was founded on the idea that a machine can simulate human intelligence. Alan Turing's theory of computation suggested that it was possible to represent logical opera tions by modifying simple symbols such as 0 and 1. Turing assumed that reasoning can be formalized 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 (#Algorithm, see key area #Encoding).[1] 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 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.[2] 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.[3]

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.[4] Together with Donald O. Hebb's work on associative learning deriving from the firing of nodes that produce synaptic interrelations,[5] Frank Rosenblatt developed the foundation for machine learning.[6] #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.[7] 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.[8] 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.**

1 See Alan Turing, "On Computable Numbers, with an Application to the Entscheidungsproblem," in: *Proceedings of the London Mathematical Society*, ser. 2, vol. 42, no. 1, January 1937, pp. 230–265.

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

3 See John R. Searle, "Minds, Brains, and Programs," in: *Behavioral and Brain Sciences*, vol. 3, no. 3, September 1980, pp. 417–424.

4 Warren S. McCulloch and Walter Pitts, "A Logical Calculus of the Ideas Immanent in Nervous Activity," in: *Bulletin of Mathematical Biophysics*, vol. 5, no. 4, December 1943, pp. 115–133.

5 Donald O. Hebb, *The Organization of Behavior: A Neuropsychological Theory*, Wiley, New York, Chapman and Hall, London, 1949.

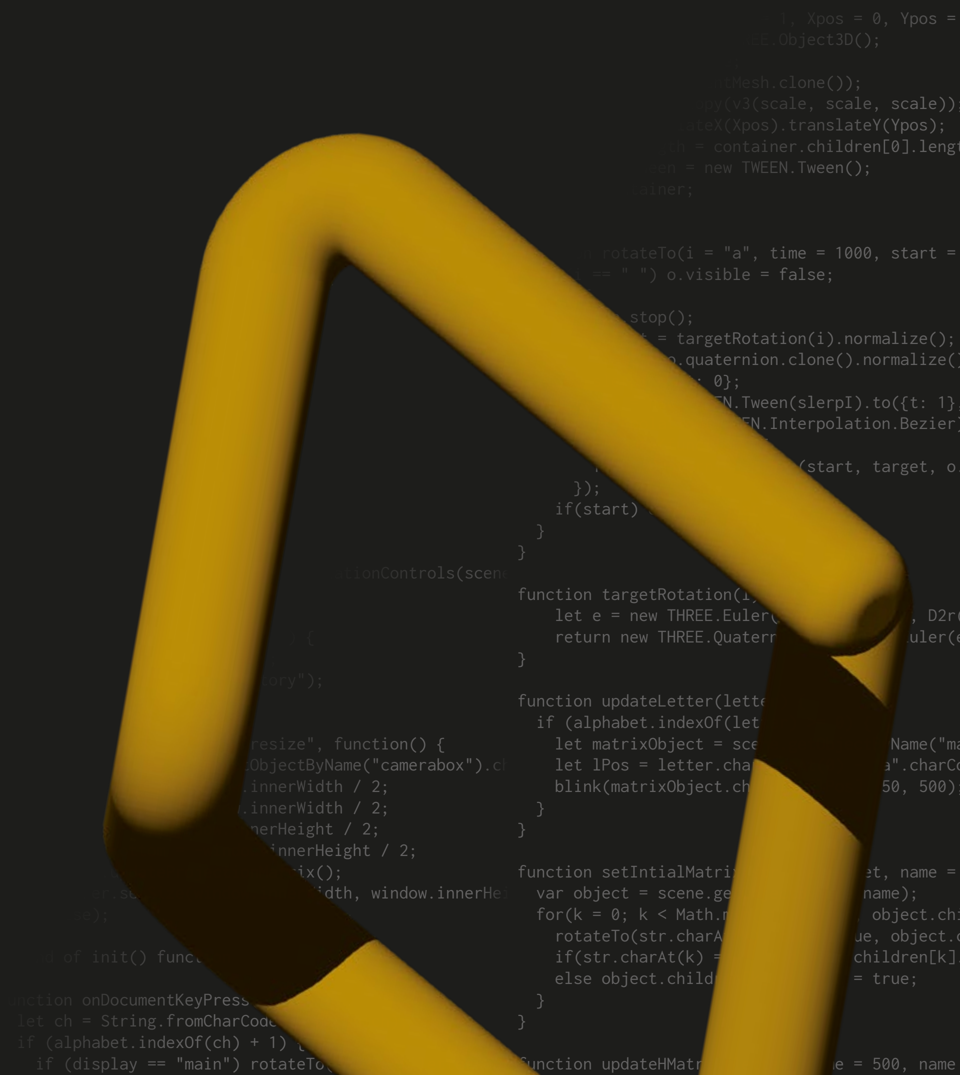
6 Frank Rosenblatt, "The Perceptron: A Probabilistic Model for Information Storage and Organization in the Brain," in: *Psychological Review*, vol. 65, no. 6, 1958, pp. 386–408.

7 See Yann LeCun, Yoshua Bengio, and Geoffrey Hinton, "Deep Learning," in: *Nature*, vol. 521, May 2015, pp. 436–444.

8 See Geoffrey E. Hinton, Simon Osindero, and Yee-Whye Teh, "A Fast Learning Algorithm for Deep Belief Nets," in: *Neural Computation*, vol. 18, no. 7, July 2006, pp. 1527–1554.

#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.[1] #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.[2] 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.[3] 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 – which detect patterns and connections between pieces of data. Correlations of data become sources of knowledge and/or information.

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.[4] 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 consumer behavior through micromarketing of products. On the other side stands the state which uses new technology to gather information that is supposed to prevent crime but at the same time can attempt to influence how the electorate votes through microtargeting. 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.

1 See Isabell Lorey, *States of Insecurity: Government of the Precarious*, Verso, London, New York, 2015, pp. 23ff.

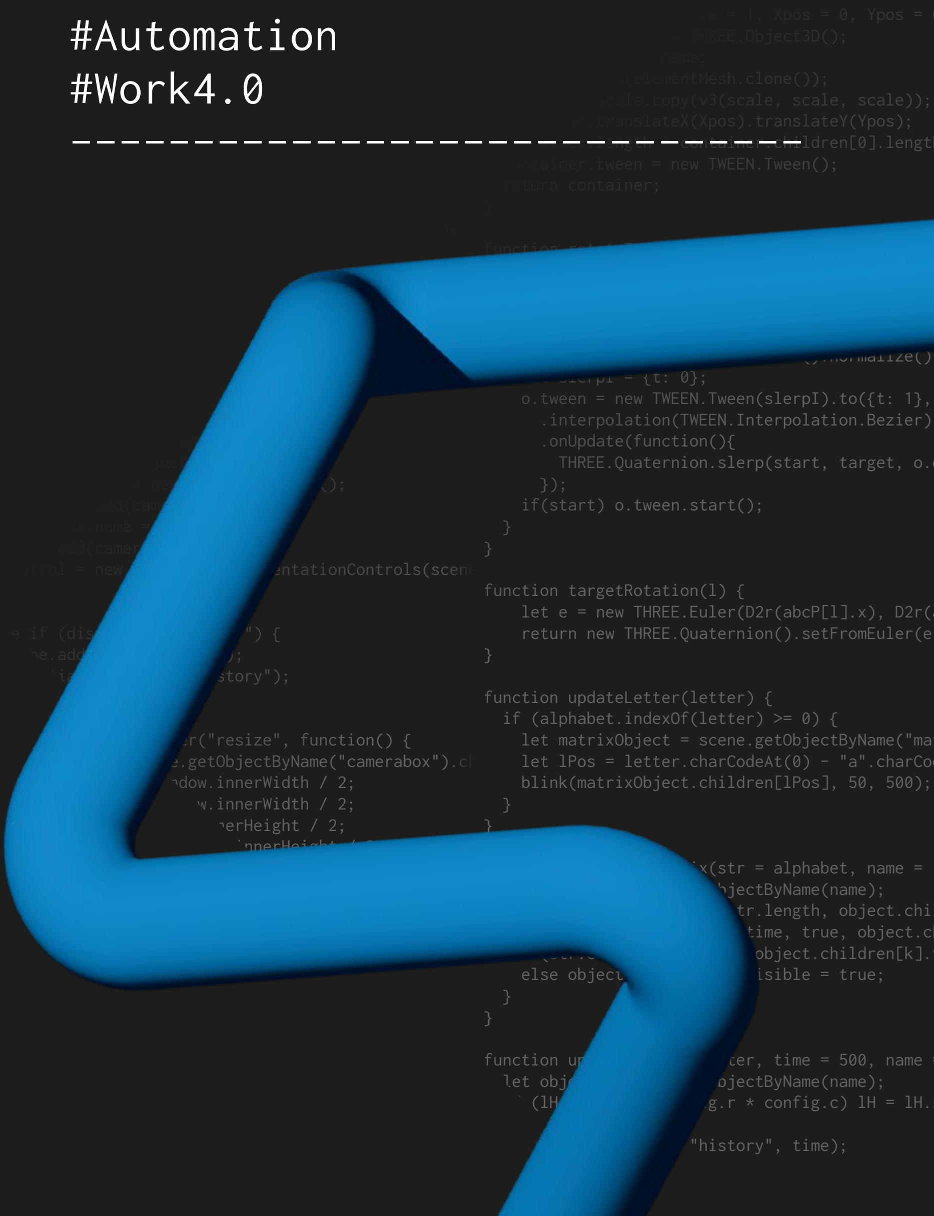
2 See Luciana Parisi, *Contagious Architecture: Computation, Aesthetics, and Space*, The MIT Press, Cambridge (MA), London, 2013, pp. 169ff.

3 See Rob Kitchin, *The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences*, Sage Publications, Los Angeles, London, 2014, pp. 67ff.

4 Gilles Deleuze, "Postscript on the Societies of Control," in: *October*, vol. 59, Winter 1992, pp. 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.[1] 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.[2]

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.[3]

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`**.[4]**
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.

1 See Nick Srnicek, *Platform Capitalism*, Theory Redux series, Polity Press, Cambridge (UK), 2017, pp. 4–5.

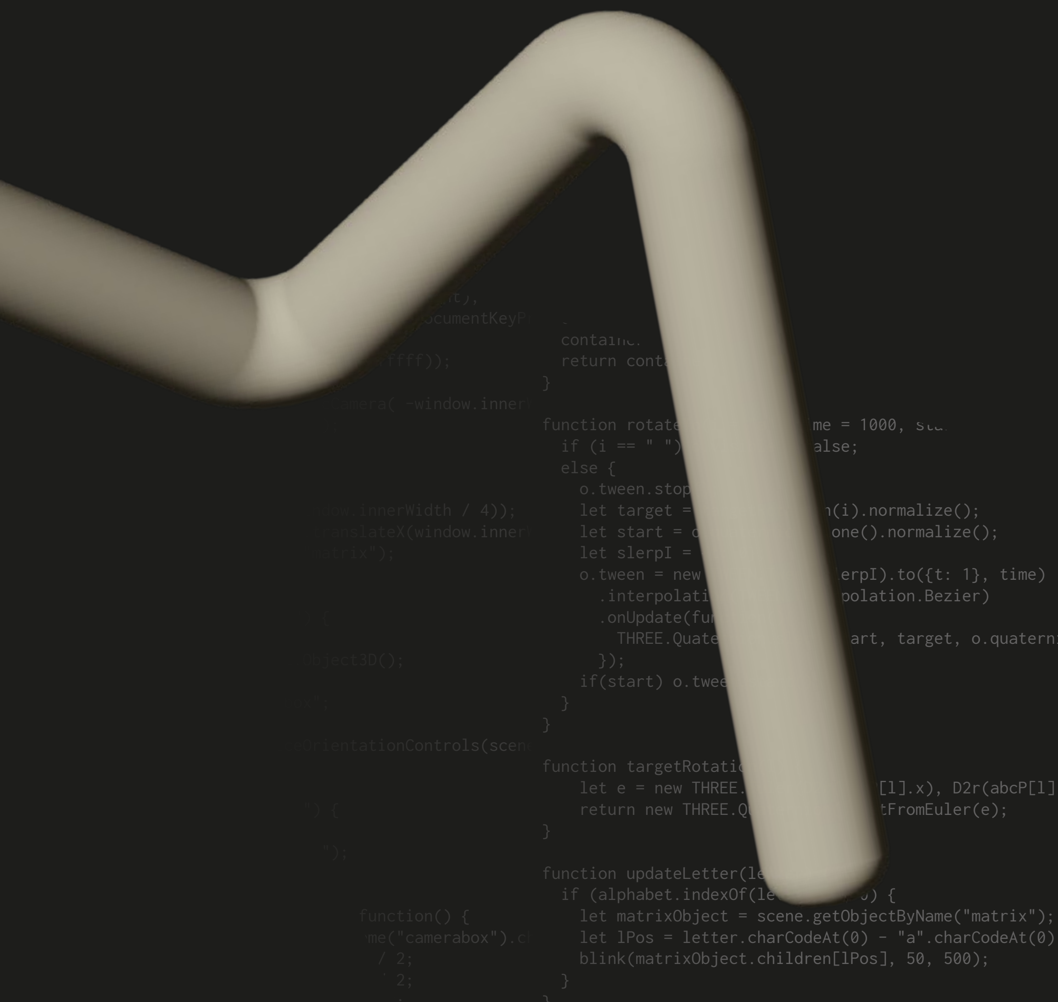
2 See Bundesministerium für Wirtschaft und Energie, *Industrie 4.0 und Digitale Wirtschaft: Impulse für Wachstum, Beschäftigung und Innovation*, Bundesministerium für Wirtschaft und Energie, Berlin, 2015.

3 See Bundesministerium für Bildung und Forschung, *Zukunftsbild Industrie 4.0*, Bundesministerium für Bildung und Forschung, Berlin, 2015.

4 See Ned Rossiter, *Software, Infrastructure, Labor: A Media Theory of Logistical Nightmares*, Routledge, New York, 2016, p. 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,[1] 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.

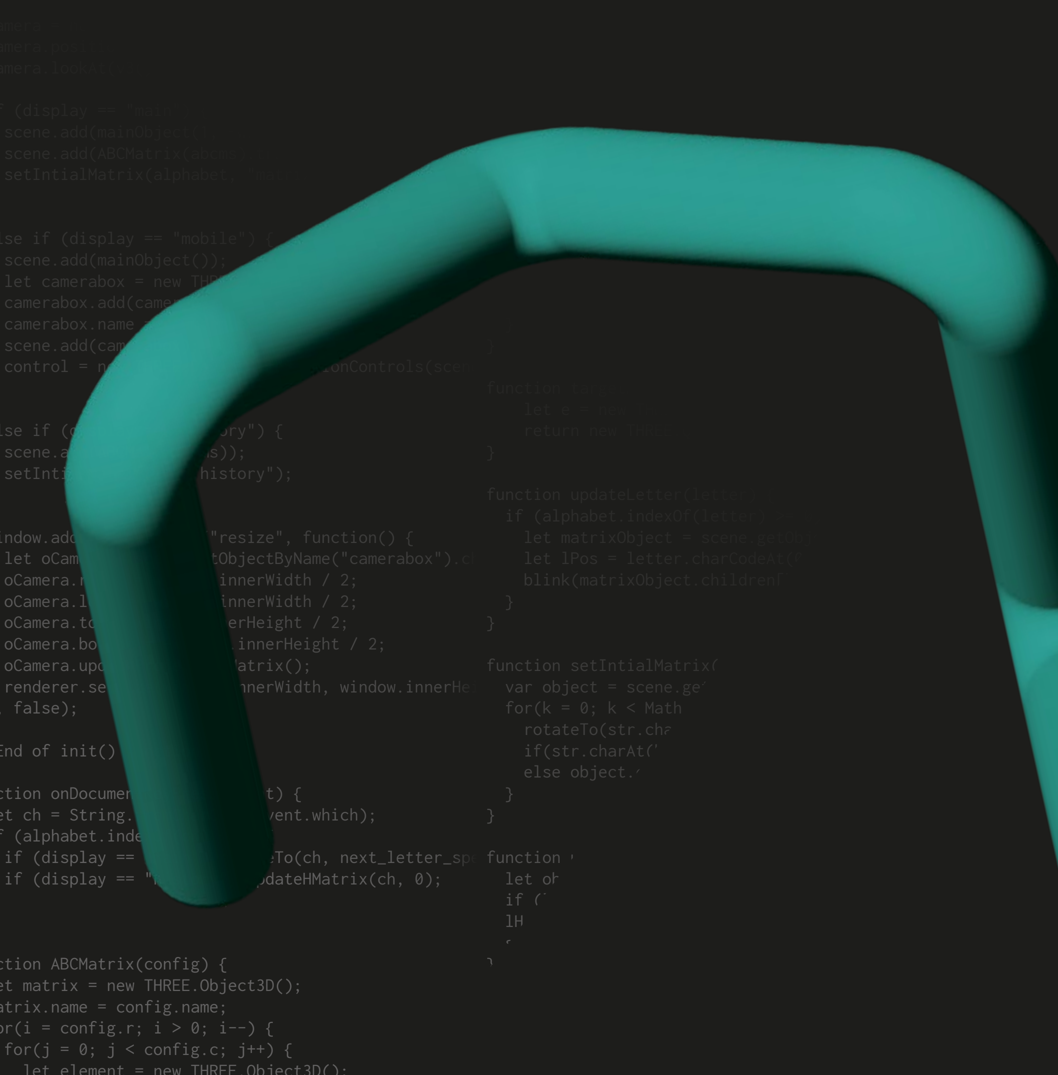
Like other disruptive technologies born in the digital age, cryptocurrencies are challenging the way things have been done in economics so far, foreseeing a future in which middlemen would become obsolete. In a world run by blockchain technologies, new tools for business strategies and managing transfers would be developed, shifting "the control of money and information away from the powerful elites [...] to the people to whom it belongs."[2] 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.

1 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.

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

#VirtualReality

#HMD
#ComputerSimulatedEnvironments
#AugmentedReality
#ComputerGeneratedDesign
#Escapism



To understand the significance of *virtual* and #VirtualReality in the present context let us take a closer look at the rise of current usages of these terms. Virtual reality (VR) is understood as a technical term, as a medium that reproduces spatial experiences for its viewers – experiences of and in spaces that do not physically exist and cannot be explored by touch, for example, especially when other visual stimuli are blocked out (for example, by head-mounted displays, #HMD). In art, since ca. 1920, bodies that only appear to exist are referred to as virtual (e.g., Naum Gabo, *Konstruktion*, 1921). A rotating wire driven by an electric motor, for example, produces what looks like a three-dimensional figure on a disk. In the 1920s, experimental psychology and gestalt theory investigated this phenomenon in depth, for example, the stereo-kinetic effect. Kinetics and Op Art are its products. 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.[1]

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."[2]

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.[3] For Deleuze virtual is not opposed to real, but to actual – in this understanding virtual is a mode of reality.[4] Guattari describes virtual as one of "four ontological functors"[5] – 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.[6] 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 in the 1980s (Myron W. Krueger, *Artificial Reality*, 1983) 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). The Art of Immersion, however, actually pulls the observer into the image and not only opens a window as painting and framed art works do. VR is a gateway through which viewers in the real world enter and leave the virtual world. VR literally opens a door into another reality.

In the gaming industry and 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.

1 See *Webster's Third New International Dictionary*, unabridged edition, Merriam Webster, 1993.

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

3 See Henri Bergson, *Materie und Gedächtnis. Eine Abhandlung über die Beziehung zwischen Körper und Geist*, introduction by Erik Oger, trans. Julius Frankenberger, Verlag Felix Meiner, Hamburg, 1991, p. 127.

4 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*, Continuum, London, 2002.

5 Felix Guattari, *Chaosmosis: An Ethico-aesthetic Paradigm*, trans. Paul Bains and Julian Pefanis, Indiana University Press, Bloomington, 1995.

6 See Antonin Artaud, *The Theater and Its Double*, trans. Mary C. Richards, Grove Press, New York, 1958, p. 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 1953 it was clear that the genetic information in DNA, a macromolecule forming a double helix (James Watson, Francis Crick), 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.[1]

The metaphors and phrasing used in molecular biology were strongly influenced by #Cybernetics (see key area #Machine-Learning) and information theory that became influential in the late 1940s and 1950s, exactly when genetics started to spread its wings.[2]

DNA and RNA were called "informational molecules" or "tapes" governed by the rules of information processing.[3] Genetic code was also compared to a computer program, for example, "organs, cells and molecules are united by a communication network."[4]

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[5], the sequence of nucleotide base pairs that make up human DNA. The private research project of Craig Venter (Celera Corporation) has worked with automated DNA sequencing since 1998.

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)."[6] 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.[7] 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[8], 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.

1 Adrian Mackenzie and Theo Vurdubakis, "Codes and Codings in Crisis: Signification, Performativity and Excess," in: *Theory, Culture & Society*, vol. 28, no. 6, 2011, pp. 3–23, here p. 7.

2 See Lily E. Kay, *Who Wrote the Book of Life: A History of Genetic Code*, Stanford University Press, Stanford, 2000, esp. pp. 73–127.

3 See Carl R. Woese, *The Genetic Code: The Molecular Basis for Genetic Expression*, Harper & Row, New York, 1967, pp. 253–254.

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

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

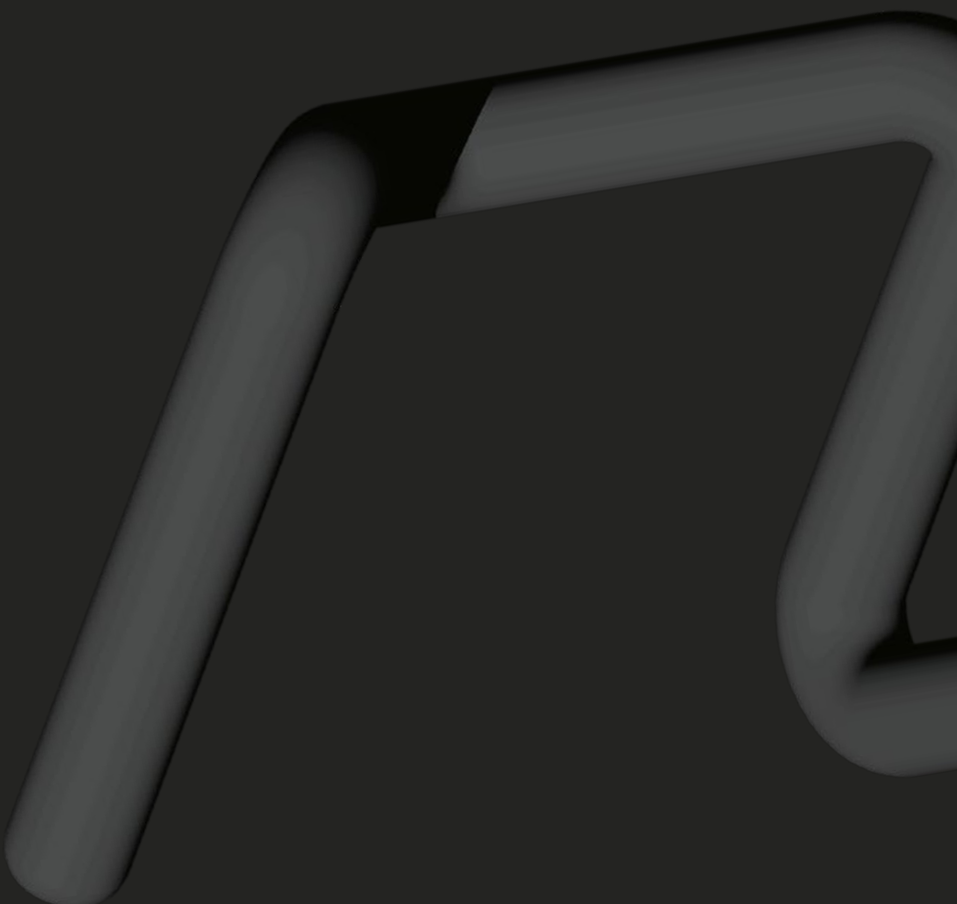
6 Brandon Adkins, *A Future Guide to Bioengineering*, Kindle e-book, Amazon Distribution, Leipzig, 2016, p. 5.

7 See Alex Reis, "CRISPR/Cas9 and Targeted Genome Editing: A New Era in Molecular Biology," in: *NEB* expressions, no. 1, 2014, available online at: https://www.neb.com/tools-and-resources/feature-articles/crispr-cas9-and-targeted-genome-editing-a-new-era-in-molecular-biology, accessed 09/13/2017.

8 See Andy Extance, "How DNA Could Store All the World's Data?," in: *Nature*, vol. 537, no. 7618, September 1, 2016, pp. 22–24.

Signal Codes and Machine Codes

Franz Pichler



#GenealogyOfCode
#Binary
#Computing
#NumeralSystem

Codes:
Mathematical Objects for Transmitting Messages

Signal codes

Signals enable communication between people via machines. They make it possible to exchange messages, thereby conveying information. Every signal has technical, material, and mathematical abstract components. For example, each Morse signal that is transmitted from a sender to a recipient is comprised of a series of states of electrical energy that can also be expressed mathematically as the dots and dashes of the Morse alphabet. The Morse code is the essential part of the exchange of messages. The electrically generated signal executes and transmits the Morse code via the technological apparatus available. Certain technical, physical devices are necessary in order to generate signals and to transmit, save, and receive them. The technical means used for optical, acoustic, mechanical, magnetic, and electrical signals can be generated by means of physics, optics, acoustics, mechanics, magnetism, electricity, and electromagnetic waves. In principle, all of these types of signals can be used to display one and the same signal code.

The assignment of code symbols belonging to a signal is called encoding. The transformation of one signal into another is known as signal conversion. Analogue signals are those for which the associated mathematical description requires the use of a system of real numbers. Analogue signals are found predominantly in the measurement of physical states. The signals that are generated by musical instruments or by human voices are also examples of analogue signals. Digital signals are those that can be expressed mathematically through a system of whole numbers. Together with their associated digital codes, digital signals currently make the effective exchange of messages possible by means of microelectronics, computer technology, and information technology. They also provide the basis for data to be processed by computers.

Codes: Mathematical Objects to Generate Dynamic Processes

Machine codes

In everyday life and the workplace, we are constantly confronted with dynamic processes. We designate processes as dynamic that take on different states over the course of time. For example, consider the dynamic process that takes place in connection with the purchase of a ticket from a ticket machine. This begins with the initial state; the ticket machine is directed toward an end state in temporal succession through incremental signals that are sent by clicking, which culminates in the issue of a ticket after payment has been made. Another example of a dynamic process is the weather forecast shown on television, in which the weather conditions in geographic areas are shown in chronological order for successive days of the week. The implementation of work plans, in which the state of the work at given times is shown, can also be considered an example of a dynamic process. We live in a world in which we are surrounded by a multitude of dynamic processes. Ultimately, one can even see oneself as a dynamic process – albeit a highly complex one.

Generally speaking, every dynamic process is a conglomerate of parts: material, energy, and information. Dynamic processes that primarily relate to information, however, are the focus of the *Open Codes* exhibition. This is a matter of dealing with the mathematical foundations, the mathematical system that is essential for the generation of dynamic processes. The machine codes are responsible for this at the exhibition. Machine codes in this sense lead us into the world of the mathematical analysis devised by Isaac Newton and Gottfried Wilhelm Leibniz; the world of mechanics from Leonhard Euler to Joseph-Louis de Lagrange and Pierre-Simon Laplace; and also the world of automata, calculators, and computers created in the modern era, plus the world of algorithms created through programming. Charles Babbage, Alan Turing, Kurt Gödel, Konrad Zuse, Howard Aiken, John von Neumann, Claude E. Shannon, and Gustav Knuth are all significant here, to name some important pioneers. Mathematically, the machine codes at the exhibition have to do with areas such as differential equations, difference equations, mathematical logic, Boolean algebra, finite automata, cellular automata, Petri nets, and algorithms. For all of these areas there are associated mathematical theories, which can be used in dealing with dynamic processes and the associated machine codes. The programming systems for social networks such as Facebook, as well as operating systems for personal computers (such as smartphones) and the application systems for them (e.g. Google) are current practical examples of machine codes. Because of the business models associated with them, in many ways these represent counterexamples to the concept of “open codes” in an information technology sense. They are, however, addressed in the *Open Codes* exhibition.

Codes:
Historical Technical Components and Writings

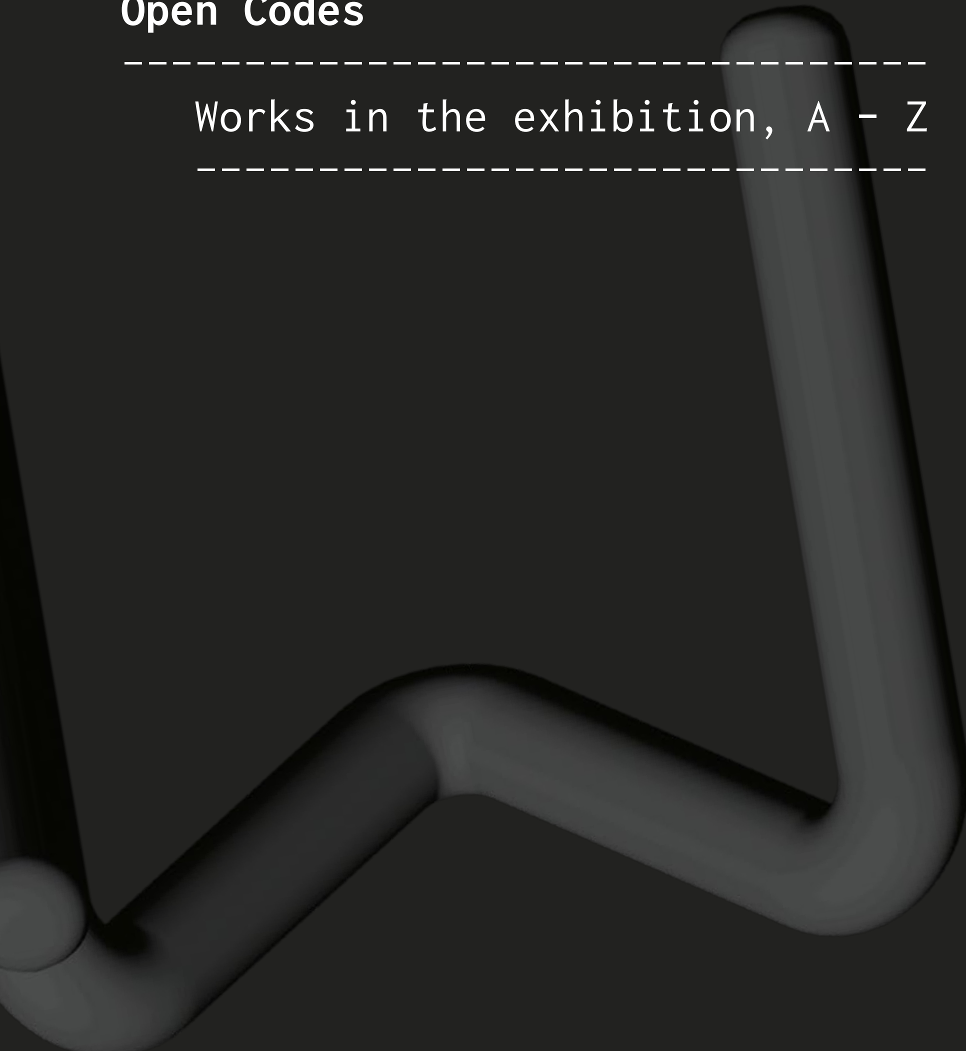
Building blocks for “open codes”

Besides its focus on art, science, and society, the *Open Codes* exhibition also addresses the historical development of the technical components and systems necessary to generate, transmit, and process codes. These are: mechanical or electrical counting mechanisms; memory modules created by mechanical, magnetic, or electronic technology; and combinatorial circuits ranging from simple routers with plug contacts to the microelectronic gates and microprocessors in use today. Because of the historical significance of Morse code, the exhibition devotes particular attention to this system. With regard to the development of computers, various forms and models of calculating machines are exhibited in the exhibition. The technical and mathematical development of codes and their use as signal codes or machine codes is presented through seminal texts, from Ramon Llull’s Ars Magna and Friedrich von Knaus’s book on the miraculous writing automata he constructed to the mathematical works of George Boole, Claude E. Shannon, and John von Neumann.

Franz Pichler

In the *Open Codes* exhibition around eighty objects from the Pichler Collection are on show. Large parts of this collection were added to the ZKM | Collection in 2011.

Works in the exhibition, A – Z



A

Jean-Michel Alberola
*1953 in Saïda (DZ), lives and works in Paris (FR)

001 ***A Mathematical Sky – Henri Poincaré***
2011, 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.

#GenealogyOfCode

Morehshin Allahyari
*1985 in Tehran (IR), lives and works in Boston (US)

002 ***Lamassu*** from the series *Material Speculation: ISIS*, 2015
Ebu from the series *Material Speculation: ISIS*, 2015
South Ivan Human Heads: Bearded River God, 2017
3-D printed plastic resin and electronic components, 22.2 × 20.3 × 6.4 cm, edition of 3; courtesy of Upfor Gallery, Portland

#Encoding
#Decoding #Escapism

AppSphere AG
founded in Ettlingen (DE), in 2010

003 ***Digitale Transformation. Die Kunst des modernen Arbeitslebens***
Presentation of ideas for modern and forward-looking IT workplace models; Microsoft Surface Hub, Microsoft Studio, Microsoft Surface Book, Microsoft Hololens; with the kind support of Microsoft.

#Labor&Production
#Programming #Work4.0

B

Lisa Bergmann
*1979 in Nuremberg (DE), lives and works in Karlsruhe (DE)

004 ***All We Know We Know from Light***
2017, HD video, color, sound, 45 min.

#Encoding
#VirtualReality
#ComputerSimulatedEnvironments

Michael Bielicky, Kamila B. Richter
*1954 in Prague (CZ), lives and works in Karlsruhe and Düsseldorf (DE)
*1976 in Olomouc (CZ), lives and works in Karlsruhe and Düsseldorf (DE)

005 ***Narzisstische Maschine***
2017, interactive installation, camera, computer, software, mosquito nets; software development: Lukas Böhm, Lukas Feller; sound: Lorenz Schwarz

#Encoding
#QuantifiedSelf #Algorithm

Patrick Borgeat
*1985 in Öhringen (DE), lives and works in Karlsruhe (DE)

006 ***Notation. Prozess. Musik.***
2017, video presentation

#Encoding
#ProgrammingSound #Interface

James Bridle
*1980 in London (GB), lives and works in Athens (GR)

007 ***Autonomous Trap 001***
2017, performance documentation, Ditone archival pigment print, 150 × 200 cm; courtesy of NOME, Berlin

#Labor&Production
#Industry4.0 #SelfDrivingCars #Automation

Ludger Brümmer (idea), Benjamin Miller (programming, interface design)
*1958 in Werne (DE), lives and works in Karlsruhe (DE)

*1986 in Paris (FR), lives and works in Karlsruhe (DE)

008 ***CellularAutomataExplorer***
2017, interactive sound installation, computer, monitor, mouse; production of the ZKM_Hertz-Lab

#Encoding
#ProgrammingSound #Software #Interface

Ludger Brümmer, Elizabeth Pich

*1958 in Werne (DE), lives and works in Karlsruhe (DE)
*1989 Friedberg (DE), lives and works in Karlsruhe (DE)

009 ***CodeChain***
2017, interactive sound installation, app, tablet PC; production of the ZKM_Hertz-Lab

#Encoding
#ProgrammingSound #Software #Interface

Ludger Brümmer, Dan Wilcox

*1958 in Werne (DE), lives and works in Karlsruhe (DE)
*1981 in Orange (US), lives and works in Karlsruhe (DE)

010 ***LindemayerExplorer***
2017, interactive sound installation, computer, monitor, mouse; production of the ZKM_Hertz-Lab

#Encoding
#ProgrammingSound #Software #Interface

Ludger Brümmer (idea), Benjamin Miller, Sami Chibane (programming, interface design)

*1958 in Werne (DE), lives and works in Karlsruhe (DE)
*1986 in Paris (FR), lives and works in Karlsruhe (DE)
*1995 in Échirrolles (FR), lives and studies in Grenoble (FR)

011 ***MarkowKetten Explorer***
2017, interactive sound installation, computer, mouse, monitor

#Encoding
#ProgrammingSound #Software #Interface

Ludger Brümmer, Dan Wilcox

*1958 in Werne (DE), lives and works in Karlsruhe (DE)
*1981 in Orange (US), lives and works in Karlsruhe (DE)

012 ***MusiCode***
2017, interactive sound installation, computer, mouse, monitor; production of the ZKM_Hertz-Lab

#Encoding
#ProgrammingSound #Software #Interface

Ludger Brümmer, Chandrasekhar Ramakrishnan, Götz Dipper

*1958 in Werne (DE), lives and works in Karlsruhe (DE)
*1975, lives and works in Zurich (CH)
*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)

013 ***Pattern Machine***
2004, interactive sound installation

#Encoding
#ProgrammingSound #Software #Interface

Ludger Brümmer, Chandrasekhar Ramakrishnan, Götz Dipper

*1958 in Werne (DE), lives and works in Karlsruhe (DE)
*1975, lives and works in Zurich (CH)
*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)

014 ***Random Machine***
2004, interactive sound installation

#Encoding
#ProgrammingSound #Software #Interface

Ludger Brümmer, Anton Himstedt (idea), Chikashi Miyama, Alex Rodrigues (programming)

*1958 in Werne (DE), lives and works in Karlsruhe (DE)
*1952 in Wiesbaden (DE), lives and works Geisenheim (DE)
*1979 in Otsu (JP), lives and works in Karlsruhe (DE)
*1993 in Covilhã (PT), lives and works in Castelo Branco (PT)

015 ***Rotating Scores***
2016, interactive sound installation

#Encoding
#ProgrammingSound #Software #Interface

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)

016 ***PLAY***
2016, lacquered MDF, wood beams, Plexiglas, table tennis net, 274 × 152 × 76 cm; the project was created in collaboration with Louis Kohlmann (Projektraum LOTTE – Land of the Temporary Eternity, Stuttgart)

#Encoding
#Work4.0

Can Büyükberber, Yagmur Uyanik

*1987 in Izmir (TR), lives and works in San Francisco (US)
*1992 in Antalya (TR), lives and works in San Francisco (US)

017 ***Morphogenesis***
2016, virtual reality installation, 3 prints, 91,5 × 114,3 cm each

#VirtualReality
#Encoding
#Escapism #ComputerSimulated Environments #HMD

C

Emma Charles

*1985 in London (GB), lives and works in London

018 ***White Mountain***
2016, 16 mm film transferred to HD video, color, sound, 20 min.

#AlgorithmicGovernance
#BigData

Matthieu Cherubini

*1984 in Aigle (CH), lives and works in Shanghai (CN)

019 ***Ethical Autonomous Vehicles***
2014, touchscreen, 3 prints, 42 × 59,4 cm each

#MachineLearning
#ArtificialIntelligence #AutonomousSystems #SelfDrivingCars

Tyler Coburn

*1983 in New York (US), lives and works in New York

020 ***NaturallySpeaking***
2013-2014, mixed-media installation, text, screensaver, monitors, furniture

#MachineLearning
#PatternRecognition #Interface

Max Cooper, Andy Lomas

*1980 in Belfast (GB), lives and works in London (GB)
*1967 in Welwyn Garden City (GB), lives and works in London (GB)

021 ***Chromos***
2017, HTC Vive, Unreal Engine software

#VirtualReality
#GeneticCode
#HMD #ComputerSimulated Environments #DNA

Shane Cooper

*1964 in Yorba Linda (US), lives and works in New Zealand (NZ)

022 ***Remote Control***
1999, interactive network installation

#AlgorithmicGovernance
#Binary

Larry Cuba

*1950 in Atlanta (US), lives and works in Santa Cruz (US)

023 ***3/78 (Objects and Transformations)***,
1978, 16 mm film transferred to HD video, b/w, 6 min.
Two Space
1979,16 mm film transferred to HD video, b/w, 8 min.
Calculated Movements
1985, 16 mm film transferred to HD video, b/w, 6 min.

#Encoding
#Algorithm

024 ***Animation Notebook 2010***
2010, generative animation, video, 70 min.

Animation Notebook 2012
2012, generative animation, video, 13 min.
#Encoding
#Algorithm
#ComputerGeneratedDesign

D

Frederik De Wilde

*1975 in Brussels (BE), lives and works in Brussels

025 ***Rzl-Dzl-AI***
2016, HD video, color, sound, 7:46 min.
#MachineLearning
#AlgorithmicGovernance
#ArtificialIntelligence
#PatternRecognition #Drones

Simon Denny

*1982 in Auckland (NZ), lives and works in Berlin (DE)

026 ***Blockchain Future States***
2016, mixed-media installation, digital prints, HD video, 3 min.; courtesy of Galerie Buchholz, Berlin / Cologne / New York
#AlgorithmicGovernance
#AlgorithmicEconomy
#Bitcoin #Cryptocurrencies
#Blockchain

Götz Dipper

*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)

027 ***Add_Synth***
2017, interactive sound installation, computer, software, monitor, mouse, headphones; production of the ZKM_Hertz-Lab

028 ***algoRhythm Machine***
2017, interactive sound installation, computer, monitor, mouse, headphones; production of the ZKM_Hertz-Lab

029 ***FM_Synth***
2017, computer, monitor, mouse, headphones; production of the ZKM_Hertz-Lab

030 ***…wie der Computer Musik macht***
2017, interactive sound installation, computer, monitor, mouse, headphones; idea: Peter Weibel; consulting: Ludger Brümmer, Benjamin Miller; production of the ZKM_Hertz-Lab
#Encoding
#ProgrammingSound #Software
#Interface

Harm van den Dorpel

*1981 in Zaandam (NL), lives and works in Berlin (DE)

031 ***Death Imitates Language***
2016/2017, website, two prints (unique edition), 100 × 100 cm, 70 × 70 cm
#MachineLearning
#GeneticCode
#Encoding
#PatternRecognition
#AutonomousSystems #Algorithm
#Software

Constant Dullaart

*1979 in Leiderdorp (NL), lives and works in Amsterdam (NL)

032 ***DullDream***
2015, neural network application; courtesy of DullTechTM
#MachineLearning
#PatternRecognition #Software

E

Margret Eicher

*1955 in Viersen (DE), lives and works in Berlin and Mannheim (DE)

033 ***Das Große Rasenstück***
2013, tapestry, digital collage, jacquard fabric, 275 × 425 cm
#Labor&Production
#ComputerGeneratedDesign
#Programming

Jonas Eltes/Fabrica

*1993 in Kungsbacka (SE), lives and works in Treviso (IT)

034 ***Lost in Computation***
2017, mixed-media installation, 2 screens, 2 Raspberry Pis; courtesy of Fabrica, Catena di Villorba
#MachineLearning
#Encoding
#PatternRecognition
#AutonomousSystems

César Escudero Andaluz, Martín Nadal

*1983 in Ávila (ES), lives and works in Linz (AT)
*1978 in Madrid (ES), lives and works in Linz (AT)

035 ***BitterCoin***
2016, installation, calculator
#AlgorithmicEconomy
#Bitcoin #Cryptocurrencies #Blockchain

Claire L. Evans

*1984 in Swindon (GB), lives and works in Los Angeles (US)

036 ***2001 100011***
2011, screenplay, 21,6 × 27,9 cm
#Encoding
#Binary

F

Harun Farocki

*1944 in Nový Jičín (CZ), †2014 in Berlin (DE)

037 ***Parallele***
2012–2014, 4 Videos
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
#VirtualReality
#Encoding
#ComputerSimulatedEnvironments

Thierry Fournier

*1960 in Oullins (FR), lives and works in Paris (FR)

038 ***Oracles***
2017, UV prints on Plexiglas, foam, LED lights, 210 × 65 × 15 cm
#MachineLearning
#PatternRecognition

Fraunhofer IOSB and ZKM | Karlsruhe

039 ***Autonome Fahrzeuge***
2017, HD video, sound, color, approx. 8 min.
#MachineLearning
#Labor&Production
#AutonomousSystems #Drones #Robots #Industry4.0

040 ***Industrie 4.0***
2017, HD video, sound, color, approx. 8 min.
#Labor&Production
#MachineLearning
#AlgorithmicGovernance
#InternetOfThings #SmartFactories #Automation #Industry4.0

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

founded in Karlsruhe (DE) in 1985

041 ***The Human Brain Project***
2017, HD video, sound, color, approx. 8 min.
#GeneticCode
#Encoding
#Computing #Robots

G

Kristof Gavrielides

*1973 in Cologne (DE), lives and works in Stuttgart (DE) and Paris (FR)

042 ***Spatial Code Lab***
2017, mixed-media installation; sponsors: ZKM | Center for Art and Media Karlsruhe; Baden-Württemberg Ministry of Science, Research, and the Arts; BW-Stipendium / Cité des Arts Paris; msa / mediaspaceagency; sam / studioadvancedmedia
#VirtualReality
#Labor&Production
#Encoding
#Robots #Algorithm #Software #Hardware #ComputerSimulated-Environments #Automation

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Melanie Gilligan

*1979 in Toronto (CA), lives and works in New York (US) and London (GB)

043 ***The Common Sense***
Phase 1, 5 Episodes
2014/2015, 5-channel video installation, site-specific installation, 15 LED TVs, powder-coated steel tubes, wireless headphones, HD video, color, sound, each 6-7 min.; Julia Stoschek Foundation e.V., Düsseldorf
#AlgorithmicGovernance
#Escapism #QuantifiedSelf

Fabien Giraud, Raphaël Siboni

*1980 in Caen (FR), lives and works in Paris (FR)
*1981 in Romorantin-Lathenay (FR), lives and works in Paris (FR)

044 ***The Unmanned***
1997 – The Brute Force (2014)
1759 – Mil Troi Cens Quarante Huyt (2017)
2-channel video installation, HD, color, sound, video, loop, 26 min.; with the support of Casino Luxembourg – Forum d'Art Contemporain, Palais de Tokyo and Le Fresnoy, Studio national des arts contemporains.
#GenealogyOfCode

H

Daniel Heiss

*1978 in Munich (DE), lives and works in Karlsruhe (DE)

045 ***KryptoLab***
2017, Bitcoin ASIC miner, various computers
#AlgorithmicEconomy
#AlgorithmicGovernance
#Bitcoin #Cryptocurrencies #Blockchain

046 ***S2T2T2M2L***
2017, computer, screens, LED-strip
#MachineLearning
#Encoding
#MorseCode #Binary #Algorithm #Software

Yannick Hofmann

*1988 in Offenbach a. M. (DE), lives and works in Karlsruhe (DE)

047 ***Monocause. Dialectics of the Post-Truth Era***
2017, interactive sound installation, iOS app; illustration and production assistant: Fiona Marten
#Encoding
#AlgorithmicGovernance
#Binary

I

Simon Ingram

*1971 in Wellington (NZ), lives and works in Auckland (NZ)

048 ***Looking for the Waterhole***
2017, installation, painting machine
#Labor&Production
#Industry4.0 #Robots #Computing

ICD ITKE ITECH

Institute for Computational Design and Construction and Institute of Building Structures and Structural Design with Integrative Technologies and Architectural Design Research Program at the University of Stuttgart

049 ***ICD/ITKE Research Pavilion 2016-17***
2016-2017, glass and carbon fiber structure; ICD Institute for Computational Design and Construction (Prof. Achim Menges), ITKE Institute of Building Structures and Structural Design (Prof. Jan Knippers), University of Stuttgart
#MachineLearning
#Labor&Production
#Industry4.0 #PatternRecognition #AutonomousSystems #Drones #Robots #Automation

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Institute of Theoretical Informatics, DebateLab, KIT

Gregor Betz, *1976 in Peine (DE); Michael Hamann, *1988 in Mühlacker (DE); Tamara Mchedlidze, *1981 in Tbilisi (GE); Sophie von Schmettow, *1992 in Aachen (DE); Christian Voigt, *1979 in Hamburg (DE); the artists live and work in Karlsruhe (DE)

050 ***OpinionMap: What Should One Eat?***

2017, software; KIT, Institute of Theoretical Informatics, DebateLab
#Encoding
#AlgorithmicGovernance
#BigData #Algorithm #Software #Interface #QuantifiedSelf

K

Eduardo Kac

*1965 in Rio de Janeiro (BR), lives and works in Chicago (US)

051 ***Transcription Jewels***
2001, objects, glass, purified "Genesis" DNA, gold, wood
#GeneticCode
#DNA #Phenotype #DNADataStorage #Genotype

Helen Knowles

*1975 in London (GB), lives and works in London and Manchester (GB)

052 ***The Trial of Superdebthunterbot***
2016, installation, HD video, color, sound, 45 min., birch laminate ply and leatherette jury bench, 5 drawings
#AlgorithmicGovernance
#MachineLearning
#Algorithm #PatternRecognition #BigData #ArtificialIntelligence

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Beryl Korot

*1945 in New York (US), lives and works in New York

053 ***Babel 1***
1980, pigment on handwoven linen, photographic reproduction, 77.7 × 58.9 × 6.4 cm; courtesy of bitforms gallery, New York
Babel 2
1980, pigment on handwoven linen, photographic reproduction, 183 × 98.4 cm; courtesy of bitforms gallery, New York
#Encoding
#Decoding #Babel

Anton Kossjanenko

* in Kerch (SU), lives and works in Karlsruhe (DE)

054 ***Sacrophonie***
2017, interactive sound installation; programming: Alexandre Rodrigues
#Encoding
#ProgrammingSound #Interface

Brigitte Kowanz

*1957 in Vienna (AT), lives and works in Vienna

055 ***Morse Alphabet***
1998, light installation
#Encoding
#Decoding #MorseCode

L

Marc Lee

*1969 in Knutwil (CH), lives and works in Eglisau (CH)

056 ***The Show Must Go On.***
2017, ongoing, online news channel
#AlgorithmicGovernance
#BigData

Jan Robert Leegte

*1973 in Assen (NL), lives and works in Amsterdam (NL)

057 ***Portrait of a Web Server***
2013, JavaScript, HTML, CSS, Apache HTTP Server source code (written in C)
#Encoding
#Software #SourceCode #Computing

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.

058 ***Drone***
2017, 2-channel video installation, color, sound, loop, 5 min.; sponsors: Hexagram, Milieux: Institute for Arts, Culture and Technology
#Labor&Production
#Industry4.0 #Drones #Automation #Programming

Lawrence Lek
*1982 in Frankfurt a.M. (DE), lives and works in London (GB)
059 ***Sinofuturism (1839–2046 AD)***
2016, HD video essay, 60 min.
#MachineLearning
#GenealogyOfCode
#ArtificialIntelligence
#Computing

Armin Linke
*1966 in Milan (IT), lives and works in Berlin (DE)
060 ***Phenotypes/Limited Forms***
2007, interactive installation, photographs, RFID Tags, 16 RFID readers, 2 touchscreens, 2 PCs, 2 BOCA micro-ticket printers, thermal paper tickets, video projector
#Encoding
#Decoding #Phenotype #Interface

Bernd Lintermann, Torsten Belschner, Mahsa Jenabi, Werner A. König
*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
*1966 in Freiburg i. B. (DE), lives and works in Freiburg i. B.
*1982 in Teheran (IR)
*1978 Ravensburg (DE), lives and works in Worms (DE)
061 ***CloudBrowsing: Open Codes***
2009/2017, interactive installation for the PanoramaScreen; 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).
#GenealogyOfCode
#Computing #Interface

Bernd Lintermann, Nikolaus Völzow
*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
*1980 in Koblenz (DE), lives and works in Karlsruhe (DE)
062 ***Three Phases of Digitalization***
2017, interactive installation with polarized light and augmented reality technology; idea: Peter Weibel; concept: Bernd Lintermann, Nikolaus Völzow; software development: Nikolaus Völzow; design: Matthias Gommel; book design: Jan Zappe; technical collaboration: Jan Gerigk, Manfred Hauffen
#Encoding
#GenealogyOfCode
#Interface #Software

Bernd Lintermann, Jan Gerigk
*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
*1963 in Pforzheim (DE), lives and works in Karlsruhe (DE)
063 ***Site Map: Open Codes***
2017, interactive augmented reality installation for iPad and HoloLens; 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
#Encoding
#Interface #AugmentedReality

Bernd Lintermann, Julia Gerlach, Peter Weibel

*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
*1967 in Hannover (DE), lives and works in Frankfurt a.M. and Berlin (DE)
*1944 in Odessa (UA), lives and works in Karlsruhe (DE)

064 ***SoundARt IDEAMA***
2012, interactive augmented reality installation, AR audio database browser for iPad; concept: Bernd Lintermann, Julia Gerlach, Peter Weibel; curator: Hartmut Jörg; software: Bernd Lintermann; technical coordination: Manfred Hauffen; production: ZKM | Institute for Visual Media

#Encoding
#ProgrammingSound #Interface #AugmentedReality

Bernd Lintermann, Manfred Hauffen, Peter Weibel

*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)
*1956 in Karlsruhe (DE), lives and works in Karlsruhe
*1944 in Odessa (UA), lives and works in Karlsruhe (DE)

065 ***SynSeeThis***
2013, iOS app for iPad; idea, conception, software: Bernd Lintermann; performance: Peter Weibel; technical support: Manfred Hauffen; sound: Manfred Hauffen, Hartmut Bruckner; production: ZKM | Institute for Visual Media

#Encoding
#ProgrammingSound #Interface

Bernd Lintermann

*1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)

066 ***VRMe***
2017, interactive installation for VR headset; production of the ZKM_Hertz-Lab

#VirtualReality
#Escapism #HMD #ComputerSimulatedEnvironments #QuantifiedSelf #Work4.0

067 ***YOU:R:CODE***
2017, interactive installation with multi-channel projection; idea: Peter Webel; concept, realization: Bernd Lintermann; audiodesign: Ludger Brümmer, Yannick Hofmann; flip-dot display: Christian Lölkes; technological support: Manfred Hauffen, Jan Gerigk; setup, planning: Thomas Schwab; production of the ZKM_Hertz-Lab

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

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Fei Liu

*1986 in Harbin (CN), lives and works in New York (US)

068 ***The Qualified Life***
2014, interactive installation; in cooperation with Akademie Schloss Solitude

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

Christian Lölkes

*1990 in White Plains (US), lives and studies in Karlsruhe (DE)

069 ***Arecibo-Nachricht***
2017, installation

#GenealogyOfCode
#Encoding
#Decoding

070 ***Code Styles***
2017, installation

#Encoding
#Software

071 ***Codierte Informationen***
2017, installation

#Encoding
#Decoding

072 ***Game of Life***
2017, installation

#Encoding
#AlgorithmicGovernance
#GenealogyOfCode

073 ***Sound of Sorting***
2017, installation

#Encoding
#Algorithm

Solimán López

*1981 in Burgos (ES), lives and works in Valencia (ES)

074 ***Column 1-0***
2016-2017, video installation, digital print on canvas, image data, video projection, loop, ca. 120 × 200 cm; assistance: Toni Vaca
#Encoding
#Interface #NumeralSystem

M

Shawn Maximo
*1975 in Toronto (CA), lives and works in New York (US)
075 ***Open Doors***
2017, digital print
#Labor&Production
#Work4.0 #Automation #Programming #Algorithm #Software

Rosa Menkman
*1983 in Arnhem (NL), lives and works in Berlin (DE)
076 ***DCT:SYPHONING. The 1000000th (64th) Interval***
2017, virtual 3-D environment
#VirtualReality
#Encoding
#Escapism #HMD #Computer-SimulatedEnvironments #Binary

Chikashi Miyama
*1979 in Otsu (JP), lives and works in Karlsruhe (DE)
077 ***Rhythm of Shapes***
2016, interactive sound installation
078 ***Sonorama - Karlsruhe***
2017, sound installation, ZKM_PanoramaLab
#Encoding
#ProgrammingSound #Software #Interface

Andreas Müller-Pohle
*1951 in Braunschweig (DE), lives and works in Berlin (DE)
079 ***Blind Genes***
2002, 2 digital lambda prints, Cibachrome on aluminum under acrylic glass, 11 × 100 × 5 cm, 45 × 100 × 5 cm; Bettina and Thomas Hebell
#GeneticCode
#Encoding
#DNA #SourceCode #Genotype
080 ***Digital Scores I (after Nicéphore Niépce)***
1995, 8 panels, Iris 3047 inkjet print on Aquarell Arches grain Satiné 300 g/m², 68,5 × 68,5 × 4 cm each
#GenealogyOfCode
#ComputerGeneratedDesign

Jörn Müller-Quade
*1967 in Darmstadt (DE), lives and works in Karlsruhe (DE)
081 ***Code beautiful like a clock***
2017, monitor, software, stencil; Kompetenzzentrum für angewandte Sicherheitstechnologie (KASTEL) [Competence Center for Applied Security Technology], Karlsruhe Institute of Technology - KIT; scientific collaboration: Jeremias Mechler
#GenealogyOfCode
#Encoding
#Interface

N

Greg Niemeyer
*1967 in Switzerland, lives and works in Berkeley (US)
082 ***Sonic Web Instrument***
2017, JavaScript code, touchscreen, sound
#AlgorithmicGovernance
#Encoding
#Algorithm #Software #ProgrammingSound

Helena Nikonole
*1982 in Moscow (RU), lives and works in Moscow
083 ***deus X mchn***
2017, multimedia installation
#MachineLearning
#AlgorithmicGovernance
#ArtificialIntelligence #InternetOfThings

P

Julian Palacz

*1983 in Leoben (AT), lives and works in Vienna (AT)
084 ***Fragmentierungen***
2015, glass engravings on hard disks
#Encoding
#Interface #Hardware

Matthew Plummer-Fernandez
*1982 in London (GB), lives and works in London
085 ***Vertigo in the Face of the Infinite***
2017 ongoing, web application and e-shop, 3-D printed plastic figures, 3-D prints, tablets on stands, monitors
#Encoding
#Computing #Software #Interface #BigData #ComputerGenerated-Design

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Julien Prévieux
*1974 in Grenoble (FR), lives and works in Paris (FR)
086 ***Patterns of Life***
2015, HD video, color, sound, 15:30 min.
#MachineLearning
#AlgorithmicGovernance
#Encoding
#PatternRecognition
#QuantifiedSelf
087 ***What Shall We Do Next? (Sequence #2)***
2014, HD video, color, sound, 16:47 min.
#MachineLearning
#Encoding
#PatternRecognition

R

Peter Reichard, Manfred Kraft, Michael Volkmer
*1969 in Mainz (DE), lives and works in Wiesbaden (DE)
*1966 in Heidelberg (DE), lives and works in Berlin (DE)
*1965 in Augsburg (DE), lives and works in Wiesbaden (DE)
088 ***NOxSTADT_LUFT_ANZEIGER***
2016-2017, outdoor: LED installation in an urban space; indoor: interactive LED display; collaboration: Tom Kresin
#Encoding
#Software #Binary

Matthias Richter, Josef N. Patoprsty
*1986 in Bonn (DE), lives and works in Karlsruhe (DE)
*1987 in Vienna (AT), lives and works in Austin (US)
089 ***Die Leidmaschine***
2017, PC, Arduino, software: *Python* (OpenCV, DLib), *Lua* (LÖVE)
#MachineLearning
#Encoding
#ArtificialIntelligence #Pattern-Recognition #AutonomousSystems #Interface

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Betty Rieckmann
*1986 in Palo Alto (US), lives and works in Karlsruhe (DE)
090 ***Silent Communications***
2017, site-specific installation, LED lights, smart phone application
#Encoding
#GenealogyOfCode
#Decoding #Software #Interface #MorseCode #Computing #Babel

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robotlab
founded in 2000 by Matthias Gommel, Martina Haitz, and Jan Zappe; working in Karlsruhe (DE)
091 ***manifest***
2008/2017, industrial robot, writing desk, computer, software, paper, pen; inspired by: Peter Weibel
#MachineLearning #Industry4.0
#ArtificialIntelligence #Robots #Automation

Curtis Roth
*1986 in Portland (US), lives and works in Columbus (US)
092 ***Real Time***
2017, live-streamed video
#AlgorithmicGovernance
#BigData #QuantifiedSelf #Work4.0

RYBN.ORG

Artist collective, founded in 1999 in Paris (FR), the artists live and work in Paris

093 ***ADM XI***
2017, multimedia installation; 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 ***Antidatamining*** 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.

#AlgorithmicEconomy
#AlgorithmicGovernance
#HighFrequencyTrading

S

saai

Südwestdeutsches Archiv für Architektur und Ingenieurbau, Karlsruhe Institute of Technology

094 Documents on Frei Otto's Mannheim Multihalle
1974-1975, plan: digital print; books: digitized books; saai | Südwestdeutsches Archiv für Architektur und Ingenieurbau, Karlsruhe

#Encoding
#GenealogyOfCode

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.

095 ***N-Polytope: Behaviors in Light and Sound After Iannis Xenakis***
2012/2017, steel cables, microelectronics, LEDs, speakers, software; in collaboration with: Sofian Audry, Adam Basanta, Marije Baalman, Elio Bidinost, Thomas Spier

#MachineLearning
#Encoding
#ArtificialIntelligence #Software

Karin Sander

*1957 in Bensberg (DE), lives and works in Berlin (DE) and Zurich (CH)

096 ***XML-SVG CODE / Source Code of the Exhibition Space***
2010/2017, Oracal 638, plotter foil matte, tricolor

#Encoding
#SourceCode #Computing

Signal Codes and Machine Codes

Zone 1: Morse telegraphy

097 Morse key by Siemens & Halske, Berlin, silent version
1890; ZKM | Karlsruhe

#GenealogyOfCode
#MorseCode

098 Morse's telegraph, German standard with paper tray by Siemens & Halske, Berlin
1870; ZKM | Karlsruhe

#GenealogyOfCode
#MorseCode

099 Franz Schmid, ***Die Telegraphen-Alphabete und Zeichen Österreichs in ihrer Historischen Entwicklung***, Vienna
1891; ZKM | Karlsruhe

#GenealogyOfCode
#MorseCode

100 Undersea cable receiver by Lauritzen, "Great Northern Telegraph Company," Copenhagen, ca. 1890; ZKM | Karlsruhe

#GenealogyOfCode
#MorseCode

101 Morse "Knatterfunkensender" with an induction coil by Firma Max Kohl, Chemnitz; oscillator spark gap after Heinrich Hertz (self-made) and morse key; ZKM | Karlsruhe

#GenealogyOfCode
#MorseCode

102 Morse coherer receiver with reception bell (self-made with historical elements); ZKM | Karlsruhe
#GenealogyOfCode
#MorseCode

103 Morse color-inker and sounder, demonstration model
The model includes: Morse-Undulator by Siemens & Halske, Berlin; Morse-Undulator by Gebr. Naglo, Berlin; morse key; switch; tapper-case with tapper; Museum für Kommunikation, Frankfurt am Main
#GenealogyOfCode
#MorseCode

Zone 2: Signal codes
1. Exhibits on Boolean Algebra

104 Erich Hochstetter, ***Herrn von Leibniz' Rechnung mit Null und Eins***, Siemens-Aktiengesellschaft, Berlin
1966; courtesy of Peter Weibel
#GenealogyOfCode
#NumeralSystem #Computing #Binary

105 George Boole, ***The Mathematical Analysis of Logic***, Basil Blackwell, Oxford
1969 (Reprint); courtesy of Franz Pichler
#GenealogyOfCode
#NumeralSystem #Computing #Binary

106 Claude E. Shannon, "The Synthesis of Two-Terminal Switching Circuits," in: ***The Bell System Technical Journal***, 28,1, pp. 59-98
January 1949; courtesy of Franz Pichler
#GenealogyOfCode
#NumeralSystem #Computing #Binary

107 ***Rudolf Mosse-Code Book***, Rudolf Mosse Publishing House, Berlin
no year; courtesy of Franz Pichler
#GenealogyOfCode
#MorseCode

2. Memory modules

108 Punch cards from the IT Center of the University of Linz for a Philips office computer and punch cards from the library of the IBM Laboratory in Vienna; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Software

109 Impulse repeater, long-distance telephone technology by Siemens & Halske, Berlin
1951; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

110 Matrix with ferrite storage rings
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

111 Core memory block from the computer IBM 705, USA
1955; ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

112 Core memory – circuit board by the Nixdorf Computer AG, Paderborn
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

113 Magnetic tape, multi-system tape by IBM; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

114 Magnetic disc station
1970s; ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

115 PC hard drive; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

116 Laptop disk drive by Toshiba, 80 GB; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

117 Tube flip-flop, IBM 650
ca. 1958; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

118 Tube flip-flop, ZUSE Z22
ca. 1958; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

119 Optical memory disc, compact

disc (CD)
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

120 Microelectronic semiconductor memory, USB drive
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

3. Switching modules

121 Rotary relay from the telephone dialing technology
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

122 Strowger router with relay switching unit by Mix & Genest, Stuttgart
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

123 Crossbar switch for telegraphy by Western Electric Inc., USA
ZKM | Karlsruhe
#GenealogyOfCode
#MorseCode

124 Miniature crossbar switch, telephone extension technology, ITT Corporation; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

125 ESK coupling section by Siemens
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

4. Coding components

126 Relay switching unit for a telephone dialing exchange
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

127 Relay circuit board, electromagnetic combinatorial circuit
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

128 Circuit board with microelectronic elements
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

Zone 3: ENIGMA and pointer telegraphs

129 ENIGMA K cipher machine made for the Swiss Army
ca. 1939; Karlsruhe Institute of Technology, Competence Center for Applied Security Technology (KASTEL)
#GenealogyOfCode
#Babel

130 Johannes Trithemius, ***Polygraphia***, Frankfurt
1550; ZKM | Karlsruhe
#GenealogyOfCode

131 Giambattista della Porta, ***De Furtivis Literarum Notis***, Naples
1563; ZKM | Karlsruhe
#GenealogyOfCode

132 Claude E. Shannon, "Communication Theory of Secrecy Systems," in: ***The Bell System Technical Journal***, 28,4, pp. 656–715
October 1949; ZKM | Karlsruhe
#GenealogyOfCode
#Computing

133 Transmitter for the dial telegraph
ZKM | Karlsruhe
#GenealogyOfCode
#MorseCode

134 Receiver for the dial telegraph of Breguet, Paris ca 1855;
ZKM | Karlsruhe
#GenealogyOfCode
#MorseCode

Zone 4: Mechanical automate, androids, and logical machines

135 P. Gaspare Schotto, ***Magiae Universalis. Naturae et Artis, Pars II Acustica, Bambergae, MDCLXXIV,*** 1674; courtesy of Franz Pichler
#GenealogyOfCode

136 Friedrich von Knauß, ***Selbstschreibende Wundermaschinen***, Vienna
1780; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

137 Siegfried Richter, ***Wunderbares Menschenwerk***, Edition Leipzig
1989; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

138 Alfred Chapuis, Edmond-Droz, ***Mechanical Puppets***, Neuchatel

1956; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

139 M. Raymundus Lullus, ***Ars Magna, generalis et ultima Francofurti MDXCVI***
1596; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

140 Alexander Fidora, Carles Sierra (eds.), ***Ramon Lull, From the Ars Magna to Artificial Intelligence***, Barcelona
2011; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

Zone 5: Counters and mechanical computers

1. Counters

141 Mechanical decadic counter
Courtesy of Franz Pichler
#GenealogyOfCode
#NumeralSystem #Computing #Hardware

142 Magnetic counter 53 by Standard Elektrik Lorenz AG, Stuttgart
1953; ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

143 Mechanical gear with electromagnetic counter, probably from an office machine; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

144 Electromagnetic counter module; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

145 Electronic counting element with Philips counting tube E1T by VEB Vokutronik Dresden; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

2. Mechanical computers

146 Cylindrical slide ruler by Albert Nestler AG, Lahr
1.6 m; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

147 Rolling ball planimeter by Coradi Company, Zurich
ca. 1910; ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

148 Air Data Computer, electromagnetic analog computer, US Airforce
ca. 1965; ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

149 Mechanic counting machine “Comptometer” by Felt & Tarrant, Chicago
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

150 Mechanic leverage counter, “Consul the Educated Monkey” knows the multiplication table; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

151 Mechanical calculator by Mercedes-Euklid; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

152 Mechanical calculator CURTA II by Contina Ltd., Mauren, Liechtenstein
1948; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware

Zone 6: Historical exhibits relating to machine codes, automata, and programming

153 C. E. Shannon, J. McCarthy (eds.), ***Automata Studies***, Princeton University Press, Princeton (NJ)
1956; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

154 Carl Adam Petri, ***Kommunikation mit Automaten***, PhD thesis, Rheinisch-Westfälisches Institut für Instrumentelle Mathematik an der Universität Bonn
1962; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

155 John von Neumann, ***Theory of Selfreproducing Automata***, University of Illinois Press, Urbana (IL)
1966; courtesy of Franz Pichler
#GenealogyOfCode

#Computing
156 Stephen Wolfram, ***Theory and Applications of Cellular Automata***, World Scientific Publishing Co., Singapur
1986; courtesy of Franz Pichler
#GenealogyOfCode
#Computing
157 Konrad Zuse, ***Rechnender Raum***, Springer Fachmedien Wiesbaden GmbH
1969 (Reprint); ZKM | Karlsruhe
#GenealogyOfCode
#Computing
158 Benoît Mandelbrot, ***The Fractal Geometry of Nature***, W.H. Freeman and Company, New York (NY)
1977; courtesy of Franz Pichler
#GenealogyOfCode
#Computing
159 Konrad Zuse, ***The Plankalkül***, Gesellschaft für Mathematik und Datenverarbeitung Bonn, St. Augustin-Birlinghoven
1976; courtesy of Franz Pichler
#GenealogyOfCode
#Computing
160 E.W. Dijkstra, ***A Primer of ALGOL 60 Programming***, Academic Press, London
1962; courtesy of Franz Pichler
#GenealogyOfCode
#Computing
161 Heinz Rutishauser, ***Description of ALGOL 60***, Springer-Verlag Heidelberg
1967; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Babel
162 Heinz Zemanek et al., ***Extension of the Algorithmic Language ALGOL***, Mailüfterl – Vienna, Final Report
July 31, 1961; courtesy of Franz Pichler
#GenealogyOfCode
#Computing
163 P. Lucas, ***Introduction to the Method used for the formal Definition of PL/1***, Technical Report, IBM Laboratory Vienna
1967; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

Zone 7: Microelectronics and digitization

1. Semiconductor devices

164 The development from relays up to the integrated circuit by Nixdorf Computer AG, Paderborn
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware
165 Pure silicium showpiece by Wacker Chemie AG, Burghausen
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware
166 Silicon wafer with processor chips by Siemens Research ZTE, Munich
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware
167 Analog-to-digital converter in microchip technology manufactured by Siemens Munich as „Munich Frauenkirche“ on the occasion of the IFIP Congress 1989
1989; plexiglass with magnifying lens; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware
168 Microprocessor Z80 (3 pieces) by Zilog, USA
1975; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware
169 Cutaway model of a processor chip
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware
170 Circuit board of a microprocessor by Texas Instruments, USA; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware
171 Circuit board of an IBM computer with IBM14 and IBM52 chip; courtesy of Franz Pichler
#GenealogyOfCode
#Computing #Hardware
172 Single chip computer, “Supercomputer” by n-Cube Company, USA
ZKM | Karlsruhe
#GenealogyOfCode
#Computing #Hardware

2. Exhibits on microelectronics

173 Carver Mead, Lynn Conway, ***Intro-***

duction to VLSI Design, Addison-Wesley Publishing Company 1980; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

174 E. Hörbst, C. Müller-Schloer, H. Schwärtzel, ***Design of VLSI Circuits***, Springer-Verlag, Heidelberg
1986; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

175 Franz Pichler, ***Historische Meilensteine der Mikroelektronik***, Trauner Verlag Linz
2012; courtesy of Franz Pichler
#GenealogyOfCode
#Computing

Karl Sims

*1962 in Boston (US), lives and works in the US

176 ***Evolved Virtual Creatures***
1994, computer animation, video, 5 min.
#GeneticCode
#DNA #ComputerGeneratedDesign

Adam Słowik, Christian Lölkes (Software development), Peter Weibel

*1980 Skierniewice (PL), lives and works in Berlin (DE)
*1990 in White Plains (US), lives and studies in Karlsruhe (DE)
* 1944 in Odessa (UA), lives and works in Karlsruhe (DE)

177 ***Alphabet-Space***
2017, mixed-media installation
#Encoding
#GenealogyOfCode
#ComputerGeneratedDesign
#Software #Hardware #Interface

Rasa Smite, Raitis Smits

*1969 in Riga (LV), lives and works in Riga
*1966 in Riga (LV), lives and works in Riga

178 ***Biotricity. Fluctuations of Micro-Worlds***
2014, bacteria battery (2 MFC cells), real-time sonification and visualization of bioenergy, video; 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.
#Encoding
#Bioengineering

Space Caviar

Simone C. Niquille, *1987 in Zug (CH), lives and works in Amsterdam (NL); Joseph Grima, *1977, lives and works in Genoa (IT)

179 ***Fortress of Solitude***
2014, HD video, color, sound, 20:25 min.; comissioned by the Biennale Interieur Foundation; soundtrack by M.E.S.H.
#MachineLearning
#AlgorithmicGovernance
#ArtificialIntelligence
#PatternRecognition
#AutonomousSystems
#InternetOfThings #Automation
#Industry4.0

Barry Stone

*1971 in Lubbock (US), lives and works in Austin (US)

DAILY, IN A NIMBLE SEA
2016; courtesy of Klaus von Nichtssagend Gallery, New York

180 ***20150714-DSCF9064_3.tif Bailey Island, Maine (soft sun), 20150714-DSCF9064_3.txt Bailey Island, Maine (soft sun)***
2016, 2 archival inkjet prints on Polar Matte inkjet paper, 101 × 150.5 cm

181 ***20150714-DSCF9296_3.tif, Bailey Island, Maine (seascape), 20150714-DSCF9296_3.txt, Bailey Island, Maine (seascape)***
2016, 2 archival inkjet prints on Polar Matte inkjet paper, 101 × 67 cm

182 ***20150714-DSCF9297_4.tif, Bailey Island, Maine (seascape), 20150714-DSCF9297_4.txt, Bailey Island, Maine (seascape)***
2016, 2 archival inkjet prints on Polar Matte inkjet paper, 101 × 67 cm
#Encoding

#NumeralSystem

Monica Studer, Christoph van den Berg
*1960 in Zurich (CH), lives and works in Basel (CH)
*1962 in Basel (CH), lives and works in Basel

183 ***Dark Matter – One Million Years Later***
2016–2017, computer generated animation, loop, 10 min.
#Encoding
#Algorithm
#ComputerGeneratedDesign

184 ***Passage Park #7: relocate***
2017, interactive real-time animation, projection, interface
#Encoding
#Algorithm #ComputerSimulated Environments #Interface

T

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)

185 ***The Critical Engineering Manifesto***
2011, print, 84.1 × 118.9 cm
#AlgorithmicGovernance
#Computing

Jol Thomson
*1981 in Toronto (CA), lives and works in Berlin (DE) and London (GB)

186 ***Deep Time Machine Learning***
2017, 3-channel projection, color, sound, 12 min.; 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.
#MachineLearning
#GenealogyOfCode
#ArtificialIntelligence
#PatternRecognition
#AutonomousSystems

Suzanne Treister
*1958 in London (GB), lives and works in London

187 ***Hexen 2.0 / Macy Conferences Attendees***
2009–2011, archival giclée prints; courtesy of Anny Juda Fine Art, London
#GenealogyOfCode
#Cybernetics

U

UBERMORGEN.COM
founded in 1995, active in Vienna (AT) and St. Moritz (CH)

188 ***Chinese Coin (Red Blood)***
2015, mixed-media installation, full HD video with Dolby Surround 5.1, red bench; video and sound: Mike Huntermann
#AlgorithmicEconomy
#AlgorithmicGovernance
#Bitcoin #Cryptocurrencies

V

Ruben van de Ven
*1989 in Lelystad (NL), lives and works in Rotterdam (NL)

189 ***Emotion Hero***
2016, android app, server software, browser-based projection
#MachineLearning
#PatternRecognition

Koen Vanmechelen
*1965 in Sint-Truiden (BE), lives and works in Genk (BE)

190 ***Book of Genome – PCC***
2016, 3 leather bound books of comparative DNA sequence analyses, 8 × 35 × 31 cm each

191 ***DECODE – PCC***
2016, video, color, sound, 60 min.
#GeneticCode
#DNA #Genotype

Ivar Veermäe
*1982 in Tallinn (EE), lives and works in Berlin (DE)
192 ***Center of Doubt***
2012–2015, 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.
#AlgorithmicGovernance
#BigData #Hardware

::vtol::
*1986 in Moscow (RU), lives and works in Moscow
193 ***IVY***
2017, step sequencer
#Encoding
#ProgrammingSound

W

Clemens Wallrath, Felix Held
*1992 in Karlsruhe (DE), lives and studies in Karlsruhe
*1990 in Rinteln (DE), lives and works in Karlsruhe (DE)
194 ***keine zahl ist illegal***
2017, installation, 40 × 40 RGB LED matrix panel
#Encoding
#Computing #Interface #Decrypt

Clemens von Wedemeyer
*1974 in Göttingen (DE), lives and works in Leipzig (DE)
195 ***ESIOD 2015***
2016, HD video, color, sound, 39 min.; courtesy of KOW, Berlin
#AlgorithmicGovernance
#AlgorithmicEconomy
#BigData #QuantifiedSelf

Peter Weibel (idea) **Ludger Brümmer** (computer animation), **Götz Dipper** (interactive environment)
*1944 in Odessa (UA), lives and works in Karlsruhe (DE)
*1958 in Werne (DE), lives and works in Karlsruhe (DE)
*1966 in Stuttgart (DE), lives and works in Karlsruhe (DE)
Production: ZKM | Karlsruhe
196 ***Monochord***
2012, interactive audiovisual installation for computer and screen; sponsor: *Genesis*, physical Modeling Environment: ACROE, Grenoble
#Encoding
#ProgrammingSound #Software #Interface

Alex Wenger, Max-Gerd Retzlaff
*1975 in the Canton of Zug (CH), lives and works in Ettlingen (DE)
*1981 in Warendorf (DE), lives and works in Karlsruhe (DE)
197 ***Daten|Spuren***
2015, multimedia installation
#AlgorithmicGovernance
#BigData #QuantifiedSelf #Decrypt #Programming

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); living and working in Yekaterinburg (RU)
198 ***Symbolism in Circuit Diagrams***
Since 2006 ongoing, mixed-media installation
#Encoding
#Decoding #Software #Hardware #Interface #ComputerSimulatedEnvironments

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Wibu-Systems AG and FZI Research Center for Information Technology, Karlsruhe Institute of Technology (KIT)
199 ***Blurry Box®***
2014, USB dongle, software; at the exhibition from October 20, 2017 to March 25, 2018
#Encoding
#Decrypt #Software

Stephen Willats

*1943 in London (GB), lives and works in London

200 ***A State of Agreement***
1975, 4 panels, gouache, photographic prints, Letraset on card, ink; courtesy of Victoria Miro Gallery, London

201 ***Meta Filter***
1973–1975, HD film, color, sound, 6 min., digital prints

202 ***Six Levels of Interpersonal Organisation***
1974, photographic prints, gouache, ink, Letraset on card

#GenealogyOfCode
#AlgorithmicGovernance
#Cybernetics #Computing

Manfred Wolff-Plottegg, Wolfgang Maass

*1946 in Schöder (AT), lives and works in Graz and Vienna (AT)
*1949 in Frankfurt a. M. (DE), lives and works in Graz (AT)

203 ***Neuronaler Architektur Generator***
1999, computer installation, 2 PCs (CPU 686), 2 projections

#MachineLearning
#Encoding
#ComputerSimulatedEnvironments

World-Information Institute

founded in 1999, active in Vienna (AT)

204 ***Painted by Numbers***
2016, 6-channel video installation

#AlgorithmicGovernance
#AlgorithmicEconomy
#BigData #Algorithm #Software

Cerith Wyn Evans

*1958 in Llanelli (GB), lives and works in London (GB)

205 ***“Astrophotography – Stages of Photographic Development” by Siegfried Marx (1987)***
2007, chandelier (Luce Italia), bulbs, flat screen monitor, computer with Morse code unit; Thyssen-Bornemissza Art Contemporary Collection, Vienna

#GenealogyOfCode
#Encoding
#Decoding #MorseCode

Z

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.

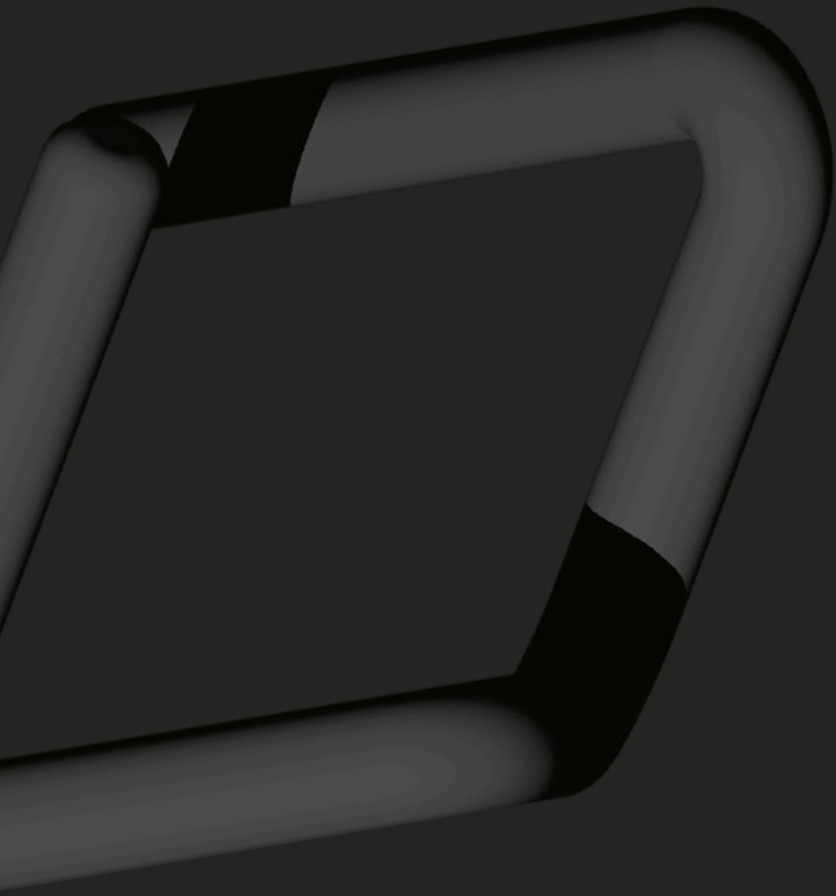
206 ***Robot Ludens***
2017, installation, 2 touch-screens, spider-like robots; sponsors: Hexagram and TAG (Technoculture, Art, and Games)

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

ZKM | Karlsruhe

207 ***Genealogy of the Digital Code***
2017, Installation
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, Christina Zartmann; construction: Nelissen Dekorbouw

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



October 20, 2017 – August 5, 2018
Open Codes. Living in Digital Worlds

Exhibition

Concept: Peter Weibel
Curators: Peter Weibel with Lívia Nolasco-Rózsás, Yasemin Keskintepe, and Blanca Giménez
Scientific advisor: Christian Lölkes
External advisors: Natalia Fuchs, Franz Pichler
Project assistance: Magdalena Stöger, Olga Timurgalieva, Amit Shemma, Hannah-Maria Winters
Curatorial assistant, Hexagram projects: Garrett Lockhard
Head of curatorial department: Philipp Ziegler
Head of technical museum and exhibition services: Martin Mangold
Szenography and interior design: Peter Weibel, Vitra GmbH, feco-feederle GmbH
Technical project management: Thomas Schwab with Andrea Hartinger
Construction team: Andrea Hartinger, Volker Becker, Claudius Böhm, Mirco Fraß, Rainer Gabler, Gregor Gaissmaier, Ronny Haas, Dirk Heesakker, Daniel Heiss, Christof Hierholzer, Werner Hutzenlaub, Gisbert Laaber, Christian Nainggolan, Marius Nestler, Marco Preitschopf, Martin Schläfke, Marc Schütze
External companies: Artinate, Essential Art Solutions, Artbeats
Concept exhibition graphic design: Peter Weibel, Christian Lölkes
Conservation team: Nahid Matin Pour, Sophie Bunz, Ursula Ganß
Logistics, registrar: Natascha Daher
Directorial department: Anett Holzheid, Tobias Klingenmayer, Adrian Koop
ZKM_Hertz-Lab: Institute for Visual Media: Bernd Lintermann, JanGerigk, Manfred Hauffen, Volker Nowicki; Institute for Music and Acoustics: Ludger Brümmer, Yannick Hofmann, Elisabeth Pich, Ben Miller, Götz Dipper, Dan Wilcox, Bernhard Sturm, Dorte Becker, Chikashi Miyama, Sami Chibane
Public relations and marketing: Dominika Szope, Regina Hock, Alexa Knapp, Stefanie Strigl, Sophia Wulle, Marie Schmidt
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Museum communication: Janine Burger, Banu Beyer, Sabine Faller, Regine Frisch, Edgar Guttmann, Barbara Zoé Kiolbassa, Fanny Kranz
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Booklet

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