WORKS BY THE ZKM | HERTZ-LAB FOR THE OPEN CODES EXHIBITION

zkm karlsruhe

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ZKM | HERTZ-LAB

The Hertz-Lab operates as a transdisciplinary research and development platform at the interface of media arts, science and society.
The newly established Hertz-Lab unites the Institute for Visual Media and the Institute for Music and Acoustics in order to expand the existing fields of action in close transcultural exchange with international institutes and research centers and to explore the artistic possibilities of expression and design in the age of rapidly accelerated technological progress and digitization.
The Hertz-Lab focuses on artistic production and media technology research. At the laboratory, contemporary artistic-scientific concepts – for example, extended reality in AR and VR applications, artificial intelligence, immersiveness, or sensor-supported environments as well as research into artistic options within the electromagnetic field – are reflected across media and genres, examined for artistic applicability and realized in productions.
The title of the Hertz-Lab is dedicated to the scientist Heinrich Hertz, who proved the existence of electromagnetic waves in his famous spark experiments at the University of Karlsruhe in 1886. He is regarded as the founder of radio technology, the wireless transmission of information – and is thus the model for the innovation center within the ZKM, the Hertz-Lab. For the first time, the activities of the Hertz-Lab are manifested in the exhibition *Open Codes*, for which artists and scientists of the ZKM have created new works which reflect the digital development critically.

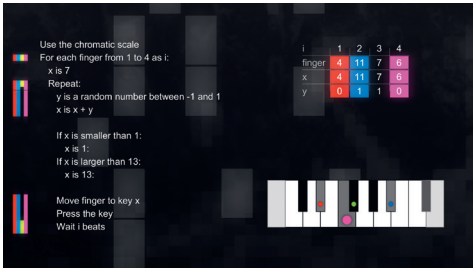
Ludger Brümmer, Peter Weibel

Notation. Prozess. Musik.
2017, Multi-channel video installation and interactive live coding station

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

Yannick Hofmann
***1988 in Offenbach am Main (DE), lives and works in Karlsruhe (DE)**

Peter Weibel
***1944 in Odessa (UA), lives and works in Karlsruhe (DE)**



Screenshot © Patrick Borgeat

#Encoding #ProgrammingSound #Interface

"Normally notes are points and lines on the two-dimensional surface of a piece of paper. The notation of the tone sequences is made up of signs on a surface. Nonetheless, these notes are interpreted as a temporal sequence, a chronological order. This is why music is considered the mother of all the time-based arts." [1]

In this room the transition from classical notation to digital notation is presented. On one screen you see the notation of Beethoven's composition *Ode to Joy* (based on a poem by Friedrich Schiller). Visitors can also visually follow the music they are listening to via headphones with the help of a graphical slider. Classical notation, notes on two-dimensional paper, is a code that must be learned. This code is an instruction for the performers, who learn how to execute this code through years of practice.

In the 1950s a new movement called "Graphic Notation" emerged in music: abstract drawings that could be freely interpreted by the musicians. This was a heroic attempt, fashionable for some time, but soon dropped because firstly the music scene did not understand what is was about and secondly the necessary technology wasn't yet available.

Today, after many experiments, for example the *UPIC* by Iannis Xenakis in 1977, we know: The graphic notation was the beginning of the digital graphic user interface. Each drawing can be mapped and interpreted as source for the computer by a scanning process, i.e. as music.

Today, with a touch screen instead of a paper notation, anybody who touches the screen, following certain instructions and rules, can create different kinds

Live-Coding-Performance by Benoît and the Mandelbrots, photo © Patrick Borgeat, photo: Daniel Bollinger

of music. By touching the notation on the screen the user creates music. The touch screen is the notation and is at the same time the instrument in combination with a computer. It is important to note that the score as graphic user interface is not only an instruction, but also the execution of the instruction. The user becomes both composer and musician by following algorithmic programming. Live coding is exactly that: programming takes place on an open stage and the code is projected onto a screen. This code is written and executed in one and the same moment and made audible as music, because the computer realizes the programmed code in real time as music.

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

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

Through a multi-channel video presentation of *Notation. Prozess. Musik.* [Notation. Process. Music.] on two walls facing each other at the *Open Codes* exhibition, an arc is traced from traditional notation to algorithmic composition to processual live coding by four renowned artists (Alexandra Cárdenas, Juan A. Romero, Dorien Schampaert (Belisha Beacon), Andrew Sorensen). Exhibition visitors can also make their own first attempts at live coding at an interactive station. They learn that classical notation on two-dimensional paper is just an instruction. Digital notation, be it the use of graphic user interface or coding, is instruction and execution as the same operation. This is a proof that the Pythagorean philosophy and G. W. Leibniz are right in their hypothesis that music is an arithmetic exercise.

1 Peter Weibel, "Zellulare und molekulare Musik – Zur Kluft zwischen zwei Tönen," in: Peter Weibel, *Enzyklopädie der Medien, Band 2, Musik und Medien*, University of Applied Arts Vienna, ZKM | Karlsruhe, Hatje Cantz, Berlin, 2016, p. 383.

CodeChain
2017, Interactive sound installation, app, tablet PC
Production by the ZKM | Hertz-Lab

Ludger Brümmer
*1958 in Werne (DE),
lives and works in Karlsruhe (DE)

Elizabeth Pich
*1989 Friedberg (DE),
lives and works in Karlsruhe (DE)

Photo © ZKM | Karlsruhe

#Encoding #ProgrammingSound #Interface

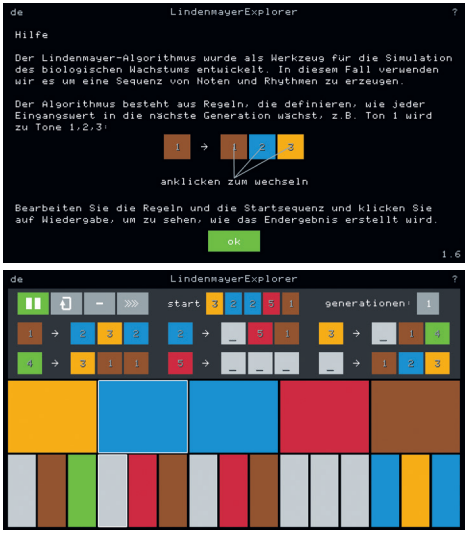
Devices connected to each other enable chain processes involving several players. In *CodeChain*, sounds are generated according to the principle of the popular children's game "whisper down the lane" or "telephone," which are sent to other players and processed by them. Thus the players alter a sound step-by-step, and may change it until it bears no resemblance to the initial sound. The chain begins with rushing sounds, various oscillators, frequency modulators, and own or prepared recordings, which users select via double click. The selected sound is sent to one of the devices in the pool, where a fellow player can add effects. Available effects are echoes and reverberations, delay, treble and bass filters, granular synthesis, and distortion. In addition the sounds can be formed into a melody with a sequencer. After the sound has had as many effects as desired added to it, it is sent to the next player. Each player changes the sound one more time. The sounds resulting from this process are therefore the result of a collective, partially random, partially deliberate process.

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

LindenmayerExplorer
2017, Interactive sound installation, computer, monitor, mouse
Production by the ZKM | Hertz-Lab

Idea:
Ludger Brümmer
*1958 in Werne (DE),
lives and works in Karlsruhe (DE)

Programming, Interface-Design:
Dan Wilcox
*1981 in Orange (US),
lives and works in Karlsruhe (DE)



User interface for *LindenmayerExplorer*, photo © ZKM | Karlsruhe

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

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

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

MarkowKetten Explorer
2017, Interactive sound installation, computer, monitor, mouse
Production by the ZKM | Hertz-Lab

Idea:
Ludger Brümmer
*1958 in Werne (DE),
lives and works in Karlsruhe (DE)

Programming, Interface-Design:
Benjamin Miller
*1986 in Paris (FR),
lives and works in Karlsruhe (DE)

Sami Chibane
*1995 in Échirrolles (FR),
lives and studies in Grenoble (FR)

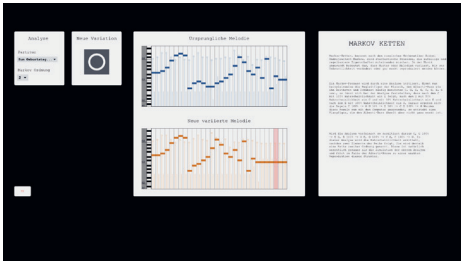


Photo © the artists

Markow chains, named after the Russian mathematician Andrey Markov, are stochastic processes that connect random and rule-based properties. Applied to music, this means that patterns or melodies that have been varied beyond recognition can be changed or even reproduced exactly.
A Markow process is initiated through an analysis. Take, for example the Alberti bass, an accompaniment figure in classical music that was used frequently by Beethoven and Schubert: following the pattern of C, G, E, G, C, G, E, G, etc., the analysis determines that there is a 100% chance that a C will be followed by a G, a 50% chance that a G will be followed by a C and a 50% chance that it will be followed by an E, and a 100% chance that an E will be followed by a G. This means that the rules are as follows:

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

If these rules are applied by a computer, a sound figure is created that is similar, but not identical, to the Alberti bass.
For a second-order Markow chain, the analysis is refined through a more precise description of the past.

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

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

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

CellularAutomataExplorer
2017, Interactive sound installation, computer, monitor, mouse
Production by the ZKM | Hertz-Lab

Idea:
Ludger Brümmer
*1958 in Werne (DE),
lives and works in Karlsruhe (DE)

Programming, Interface-Design:
Benjamin Miller
*1986 in Paris (FR),
lives and works in Karlsruhe (DE)

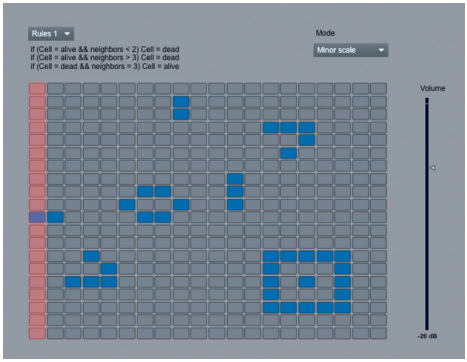


Photo © ZKM | Karlsruhe

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

– A dead cell with exactly three living neighboring cells will be reborn in the next generation.
– Living cells with fewer than two living neighbors die of loneliness in the next generation.
– A living cell with two or three living neighbors remains alive in the next generation.
– Living cells with more than three living neighbors die of overcrowding in the next generation.

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

MusiCode
2017, Interactive sound installation, computer, mouse, monitor
Production by the ZKM | Hertz-Lab

Ludger Brümmer
***1958 in Werne (DE),**
lives and works in Karlsruhe (DE)

Dan Wilcox
***1981 in Orange (US),**
lives and works in Karlsruhe (DE)

User interface for *MusiCode*, photo © ZKM | Karlsruhe

#Encoding #ProgrammingSound #Software #Interface

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

1. Start at **40** (that is, E2) with the time **0**,
2. **raise** the tone by one step [y = x + **1**], and jump **0.25** seconds forward,
3. carry out this procedure **20** times – finished.

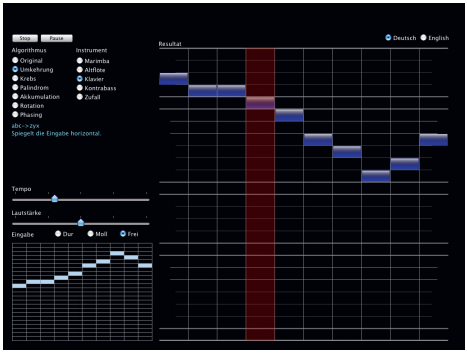
Now the numbers can be changed or the **+** can be replaced by a –, changing the upward musical scale into a downward arpeggio.
Visitors to the *MusiCode* installation can play with different code fragments, changing them to create their own sound structures. Become a composer of computer music!

Pattern Machine
2004, Interactive sound installation
Production by the ZKM | Institute for Music and Acoustics,
Update by the ZKM | Hertz-Lab

Ludger Brümmer
*1958 in Werne (DE),
lives and works in Karlsruhe (DE)

Chandrasekhar Ramakrishnan
*1975,
lives and works in Zürich (CH)

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



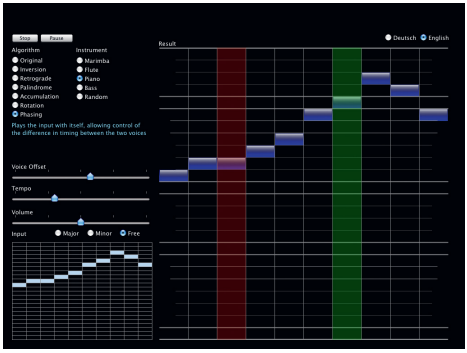


Photo © ZKM | Karlsruhe

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

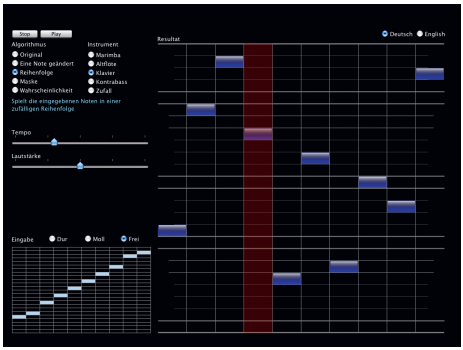
Random Machine

2004, Interactive sound installation
Production by the ZKM | Institute for Music and Acoustics,
Update by the ZKM | Hertz-Lab

Ludger Brümmer
*1958 in Werne (DE),
lives and works in Karlsruhe (DE)

Chandrasekhar Ramakrishnan
*1975,
lives and works in Zürich (CH)

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



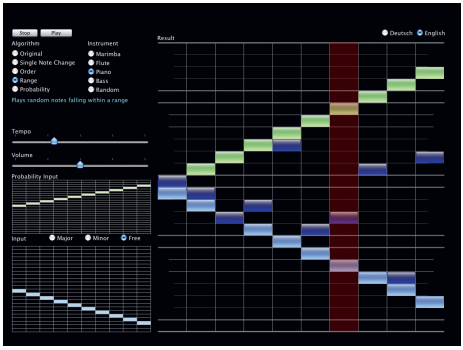


Photo © ZKM | Karlsruhe

Random processes have tremendously creative, easily controllable, and constantly changing results.
Wolfgang Amadeus Mozart already understood how to utilise such processes in his work, for example, *Musikalisches Würfelspiel* [musical dice game] (KV 294d), which was constantly recreated by using dice. The random method creates a constantly transforming, though always uniformly distributed series of values. The most consistent users of this method in music are the American composer John Cage and the Greek composer Iannis Xenakis.
All users of *Random Machine* realize: producing randomness is very simple; the artistic challenge, however, is to develop artistic usages, because for human perception, randomness is only interesting in connection with clear rules. In the installation created by the ZKM | Institute for Music and Acoustics, different kinds of randomness and their application are presented. With the help of this instrument, even a musically inexperienced user can work with the phenomenon, and utilize randomness artistically.

Rotating Scores

2016, Interactive sound installation
Production by the ZKM | Institute for Music and Acoustics,
Update by the ZKM | Hertz-Lab

Idea:
Ludger Brümmer
*1958 in Werne (DE),
lives and works in Karlsruhe (DE)

Anton Himstedt
*1952 in Wiesbaden (DE),
lives and works Geisenheim (DE)

softwareentwicklung:
Chikashi Miyama
*1979 in Otsu (JP),
lives and works in Karlsruhe (DE)

Alex Rodrigues
*1993 in Covilhã (PT), lives and works in Castelo Branco (PT)

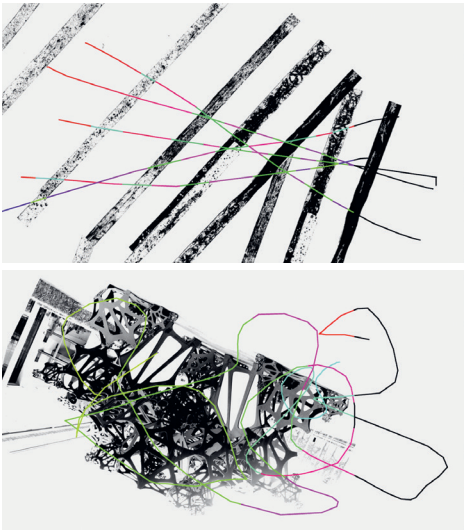


Photo © ZKM | Karlsruhe

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

… wie der Computer Musik macht

2017, Interactive sound installation, computer, monitor, mouse, headphones
Production by the ZKM | Hertz-Lab

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

Inspired by:
Peter Weibel

Consulting:
Ludger Brümmer, Benjamin Miller

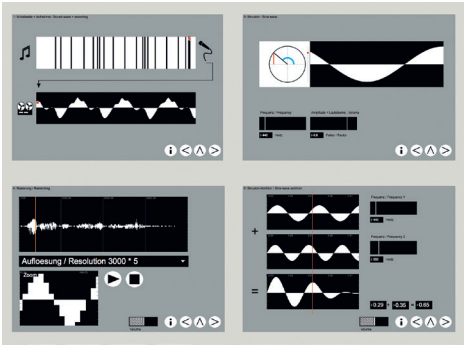


Photo © ZKM | Karlsruhe

#Encoding #ProgrammingSound #Software #Interface

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

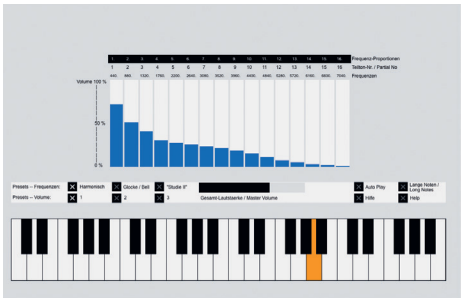
With the sounds of traditional instruments we usually have an intuitive idea of how the sounds are generated, and how their characteristics can be influenced. For example, when someone wants to produce a piercing sound on a recorder, he/she has to blow hard into it. But to produce a soft, warm sound,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

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

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

Add_Synth
2017, Interactive sound installation, computer, software, monitor, mouse, headphones
Production by the ZKM | Hertz-Lab

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



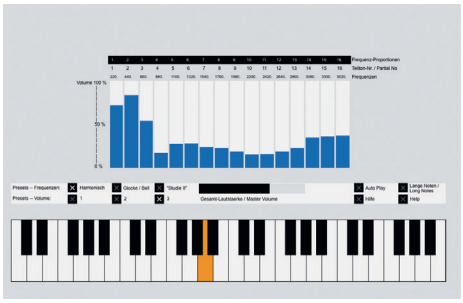
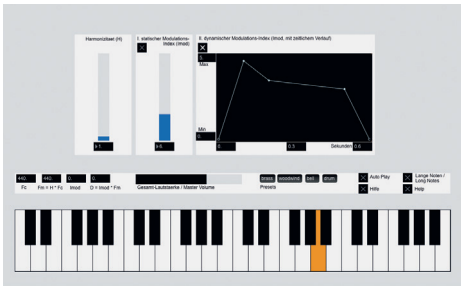


Photo © ZKM | Karlsruhe

With the aid of the two interactive installations *Add_Synth* and *FM_Synth*, visitors are introduced to two classic sound synthesis systems.
In 1822, the French mathematician and physicist Joseph Fourier developed the method known as Fourier synthesis, which to this day is an indispensable tool for mathematicians and engineers. Fourier discovered that every periodic signal can be represented as a sum of simple sine waves. When applied to sounds, this is known as the harmonic series. In 1863, the German physicist and physiologist Hermann von Helmholtz advanced the theory that the composition of the harmonic series is responsible for the timbre of a sound. Building on this, the additive sound synthesis was developed in electronic music of the twentieth century, in which sounds from single pure tones (tones with sinusoidal waveforms) are assembled. Theoretically, a composer can produce all tone colors in the world using this method.
In the installation *Add_Synth*, the visitors can assemble a tone themselves from pure tones. They can regulate the strength of each and every harmonic individually, and via headphones they can observe the effect on the tone color.

FM_Synth
2017, Interactive sound installation, computer, monitor, mouse, headphones
Production by the ZKM | Hertz-Lab

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



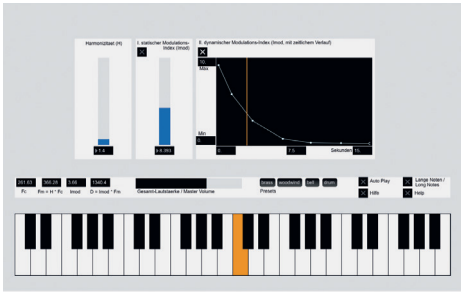


Photo © ZKM | Karlsruhe

The two interactive installations *Add_Synth* and *FM_Synth* enable visitors to get to know two classic sound synthesis methods.
The frequency modulation (FM) method was developed for radio technology. Through it, audio signals such as language and music can be transmitted wirelessly via electromagnetic waves. In this process, the low-frequency audio signal (with frequencies up to a maximum of 20 KHz) is effectively imprinted onto a high-frequency electromagnetic wave (with a frequency of approx. 100,000 KHz). In Germany, FM is used for VHF radio.
In the 1970s, the American composer John Chowning discovered that FM could also be used for sound synthesis. He developed FM synthesis, which was used by the Yamaha company in commercial synthesizers. Unlike radio transmission, FM synthesis works without a high-frequency signal, instead using two low-frequency signals. The major advantage that FM synthesis holds over additive synthesis (see *Add_Synth*) is how economical it is: complex tones can be created with just two modulators. Visitors to the *FM_Synth* installation can try this out for themselves.

016

Guido's Code #A
2018, Playback device, headphones or speaker
Production by the ZKM | Hertz-Lab

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

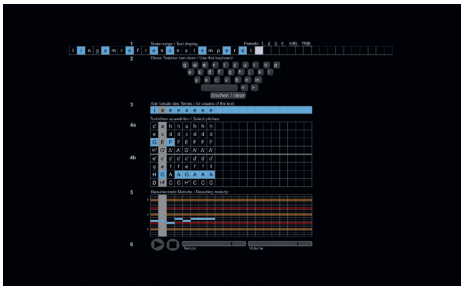
Photo © ZKM | Karlsruhe, Photo: Barbara Nerness

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

The installations *Guido's Code #A* and *#B* refer to what is probably the oldest music algorithm in European history, formulated almost exactly a thousand years ago by the Benedictine monk Guido of Arezzo.
Using Guido of Arezzo's method, any text can be used to generate music. He employed the simple rule of assigning different pitches to vowels from which the composer could then choose. The vowel "a," for example, was assigned the pitches G' E c and a, while vowel "e" was assigned A' F d and b, and so on. Guido of Arezzo described the algorithm in Chapter 17 of his famous work *Micrologus de disciplina artis musicae*, one of the most important works of music theory of the Middle Ages. The installation Guido's Code #A employs this very algorithm to generate music from the original text of Chapter 17 of *Micrologus*. The resultant melody is played back through loudspeakers or headphones.
In outputting its own sequence of tones, the algorithm results in a self-referential piece, a metaphor for the loop and the recursive, which provide important elements in many programming languages today, while also being typical of "loop-based" electronic music.

Guido's Code #B
2018, Computer, monitor, mouse, headphones
Production by the ZKM | Hertz-Lab

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



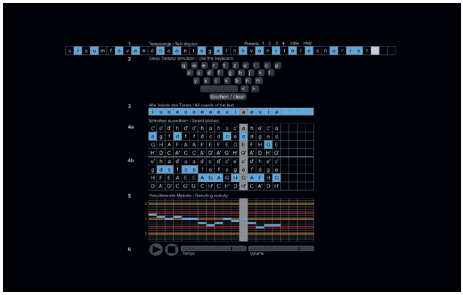
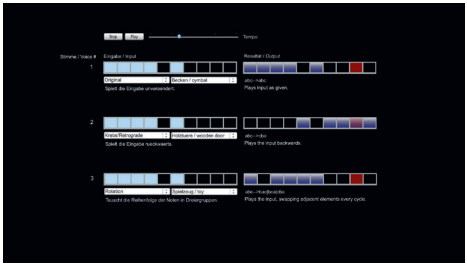


Photo © ZKM | Karlsruhe

The installations *Guido's Code #A* and *#B* refer to what is probably the oldest music algorithm in European history, formulated almost exactly a thousand years ago by the Benedictine monk Guido of Arezzo in his famous work *Micrologus de disciplina artis musicae*.
In the installation *Guido's Code #B*, visitors can experience for themselves how Guido of Arezzo's algorithm works. They enter a text into the computer, which is converted into a melody according to Guido of Arezzo's rules and then played back. The algorithm allows the user certain freedoms and choices. This encourages the visitors to form their own assessment as to whether the melody is a successful outcome. This exploration of the melody was an important aspect for Guido of Arezzo, who wanted to provide the readers of his book with a tool that enabled them to learn how to compose themselves.
In addition to the algorithm used here, Guido of Arezzo introduced a number of groundbreaking innovations to the practice of music, such as the clef. His innovations were aimed at making this exclusive knowledge, restricted to monks, accessible to a wider range of people. In this sense, Guido of Arezzo was an early pioneer of today's "open source" and "open access" movements.

algoRhythm Machine
2017, Interactive sound installation, computer, monitor, mouse, headphones
Production by the ZKM | Hertz-Lab

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



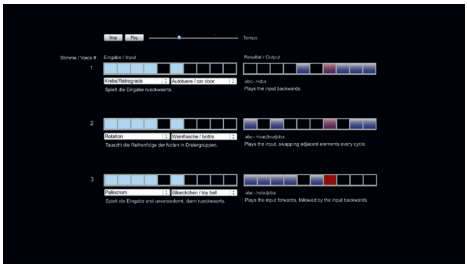


Photo © ZKM | Karlsruhe

The installation *algoRhythm Machine* is a sort of drum computer through which rhythms can be algorithmically generated or varied. Some of the algorithms that are utilized have been used in music for centuries, including the cancrizans, for which one section is played backwards, creating a sort of crabwalk. Other algorithms, such as the various algorithms based on randomness, were first used broadly in the twentieth century.
algoRhythm Machine is inspired by the installations *Pattern Machine* and *Random Machine* from 2004, both are also being shown at the *Open Codes* exhibition. The same algorithms that generate melodies in those installations are used here to generate rhythms. Visitors can pursue the fascinating question of whether the algorithms are equally well suited for both uses.
Unlike with *Pattern Machine* and *Random Machine*, no variation in the pitch is possible with *algoRhythm Machine*. Instead, *algoRhythm Machine* is polyphonic, such that patterns can be layered in interesting ways. Visitors can explore what settings lead to interesting listening experiences.

Monocause. Dialectics of the Post-Truth Era
2017, Interactive sound installation, iOS-App

Yannick Hofmann
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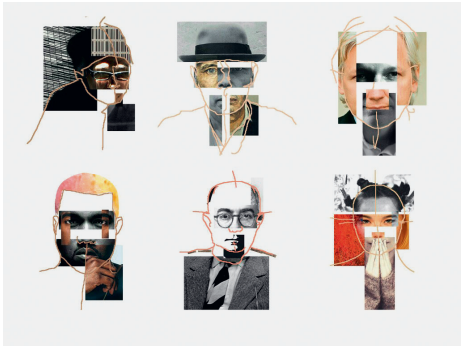
Illustration and production assistant:
Fiona Marten



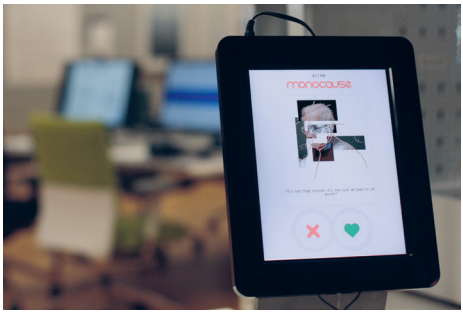


Photo © Yannick Hofmann, photo: Fiona Marten

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

Sacrophonie
2017, Interactive sound installation
Production by the ZKM | Hertz-Lab

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

Programming:
Alexandre Rodrigues

Photo © ZKM | Karlsruhe, photo: Jonas Zilius

In the sound installation *Sacrophonie*, sounds that have been recorded at the religious functions of various cultures and faith traditions, including the sound of leafing through a prayer book, Japanese ceremonial hand clapping, the blowing of the shofar, and the ringing of church bells, are treated as a code. Through this code, people seek to establish contact with God. The inclusion of songs, sacred texts, or prayers – that is, sounds that clearly relate to a specific religion – has been deliberately avoided. The intentional background and ambient sounds that accompany rituals, on the other hand, have been recorded and compiled.
In the exhibition, visitors can call up and play sounds from a "library" of compositions and sounds that is made up of the recorded sounds of rituals. Via built-in sensors and with the help of exhibited artifacts, these sound compositions can in turn be tonally altered and moved in virtual space.

SoundARt IDEAMA

2012, Interactive augmented reality installation, AR audio database browser for iPad
Production by the ZKM | Institute for Visual Media,
Update by the ZKM | Hertz-Labor

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

Julia Gerlach
*1967 in Hannover (DE),
lives and works in Frankfurt a. M. (DE) and Berlin (DE)

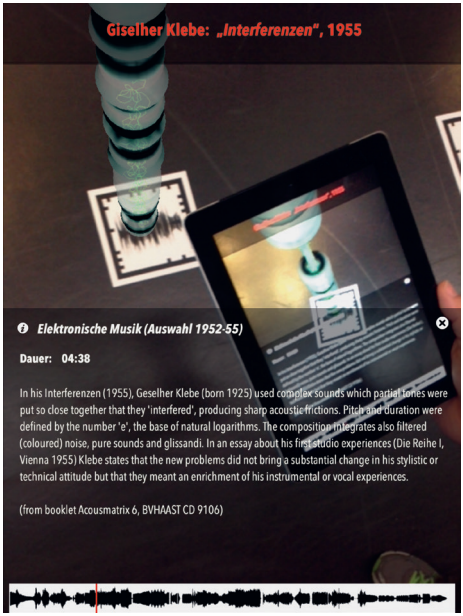
Peter Weibel
*1944 in Odessa (UA),
lives and works in Karlsruhe (DE)

Concept:
Bernd Lintermann,
Julia Gerlach, Peter Weibel

Curator:
Hartmut Jörg

Software:
Bernd Lintermann

Technical coordination:
Manfred Hauffen



Snapshot of the augmented reality app © ZKM | Karlsruhe

The IDEAMA (International digital electro-acoustic music archive) was created in 1990 with the aim of globally protecting the most important early works of electro-acoustic music against deterioration, and make them accessible to the public. The IDEAMA basic collection consists of over a hundred hours of music, which is part of the holdings of the ZKM | Media Library.
SoundARt IDEAMA presents selected works from the music archive. At four stations, works from the areas of musique concrète, electronic music, computer music, and music for loudspeakers are staged in special ways and made available to visitors. On a beam showing computer-readable codes, four topics from the IDEAMA database are marked out as examples: for each work a square code – similar to the familiar QR-code – is applicated on the floor as well as an oscillograph of the work. With the aid of an on-site rentable iPad, the work can be experienced, heard, and seen in a 3-D simulation as augmented reality experience as soon as the iPad's camera registers the code. Here, the iPad functions as a pickup which scans the sound carrier.

SynSeeThis
2013, iOS app for iPad
Production by the ZKM | Institute for Visual Media,
Update by the ZKM | Hertz-Labor

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

Manfred Hauffen
***1956 in Karlsruhe (DE), lives and works in Karlsruhe**

Peter Weibel
***1944 in Odessa (UA), lives and works in Karlsruhe (DE)**

Software:
Bernd Lintermann

Performance:
Peter Weibel

Sound:
Manfred Hauffen,
Hartmut Bruckner

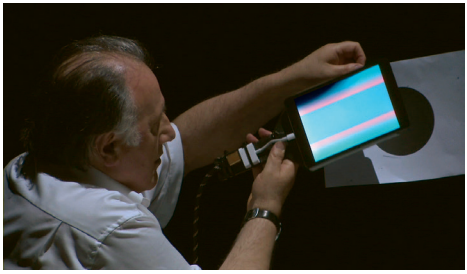


Photo © ZKM | Karlsruhe, photo: Bernd Lintermann

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

VRMe
2017, Interactive installation
for VR headset
Production by the ZKM | Hertz-Lab

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

Creating 3-D point clouds:
Konrad Berner, degree program Geodesy & Navigation, Karlsruhe University of Applied Sciences

Technical support:
Manfred Hauffen

Photo © ZKM | Karlsruhe, photo: Bernd Lintermann

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

CloudBrowsing:
Open Codes
2009/2017, Interactive installation
for the PanoramaScreen
Production by the ZKM | Institute
for Visual Media,
Update by the ZKM | Hertz-Lab

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

Torsten Belschner
*1966 in Freiburg i. B. (DE),
lives and works in Freiburg i. B.

Mahsa Jenabi
*1982 in Teheran (IR)

Werner A. König
*1978 Ravensburg (DE),
lives and works in Worms (DE)

Photo © ZKM | Karlsruhe, photo: Anatole Serexhe

On display in the exhibition from
November 1, 2017 to January 7,
2018 at the PanoramaLabor

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

Photo © ZKM | Karlsruhe, photo: Christina Zartmann

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

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).

Bibliotheca Digitalis: Three Phases of Digitalization
2017, Interactive installation with polarized light and augmented reality technology
Production by the ZKM | Hertz-Lab

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

Nikolaus Völzow
*1980 in Koblenz (DE),
lives and works in Karlsruhe (DE)

Peter Weibel
*1944 in Odessa (UA),
lives and works in Karlsruhe (DE)

Idea:
Peter Weibel

Concept:
Bernd Lintermann,
Nikolaus Völzow

Software development:
Nikolaus Völzow

Book design:
Jan Zappe

Installation Design:
Matthias Gommel

Technical collaboration:
Jan Gerigk, Manfred Hauffen

Photo © ZKM | Karlsruhe, photo: Jonas Zilius

The world of the 19th century was marked by the industrial revolution based on machines and materials. Our post-industrial digital world, the age of communication and information technology, is dominated by media and data.
The artistic work *Bibliotheca Digitalis* illustrates the life form in the digital world of immaterial data through the form of presentation. The information is separated from the technical carrier medium, i.e. the book.
A camera mounted above the reading desk captures the book opened by the visitor, which consists of blank pages except for the page numbers. The text in an analogue real book would be visible to the human eye. However, the text projected onto the screen by the light and the textual information stored in the computer are not visible. The digital version of the book becomes visible through the glass pane coated with a polarization filter. The reading experience in the analogue space captured by the natural sense organs shows empty pages. Virtual information can only be received with the aid of a technical apparatus.

With the help of this installation, the three phases of digitalization become comprehensible for the viewer. Digitalization began in 1623 with the sentence by Galileo Galilei, which reads roughly: "The Book of Nature is written in the language of mathematics." Two masterpieces have completed this first phase of digitalization, the mathematization of physics: Isaac Newton's *Philosophiae Naturalis Principia Mathematica* (1686) and Joseph-Louis de Lagrange's *Mechanique analytique* (1788).

The second phase, the mathematization of thought, began with George Boole. He intended to do what Lagrange had achieved for physics, i.e. its transformation into algebraic operations, to do also for logic, i.e. the algebraization of logical operations. With the two works *The Mathematical Analysis of Logic* (1847) and *An Investigation of the Laws of Thought* (1854) he created Boole's algebra, which transformed logic into mathematics. Boole used already the grandiose invention of G. W. Leibniz (*De progressione Dyadica*, 1679), i.e. the representation of numbers not by 10 digits (1–9, 0), but only by the two digits 0 and 1, the so-called binary code.

This mathematization of thinking was taken to the next level by many other authors, e.g. by Gottlieb Frege (*Begriffsschrift*, 1879) and above all by Bertrand Russel's / Alfred North Whitehead's three-volume work *Principa Mathematica* (1910–1913), an echo of Newton's *Principia Mathematica* (1686). After Kurt Gödel, in "On formally undecidable propositions of Principia Mathematica and related systems I" (1931), had described what cannot be mathematized completely, Alan Turing, in "On computable Numbers, with an Application to the Entscheidungsproblem" (1936), showed what is calculable and computable, and thus wrote an essential work on the justification of the computer.

Claude Shannon's work *A Symbolic Analysis of Relay and Switching Circuits* (1937) stands for the third phase of digitalization, the implementation of mathematical physics and mathematical logic in electronics. Shannon showed that circuits can be arranged in such a way that, on the one hand, they follow the binary code, i.e. that the current voltage represents the digit 1, whereas 0 stands for "no current voltage", and that, on the other hand, these circuits can thus represent Boolean propositional logic. Shannon proved the equivalence of Boolean and switching algebra. Thus, it became possible to convert immaterial formalized, mathematized thought processes into material electronic switching states. The development of transistors and integrated circuits, i.e. an immense micro-miniaturization, led in the 1950s and 60s to electronic devices, from portable radios to mobile phones, which transferred electronics and the associated databased communication and information technologies into everyday life. At this historic moment, digitalization became marketable and attractive to the general public.

#Encoding #GenetischerCode #Decodierung #Software #Hardware #Interface #QuellIcode #QuantifiziertesSelbst

YOU:R:CODE
2017, Interactive installation with multi-channel projection
Production by the ZKM | Hertz-Lab

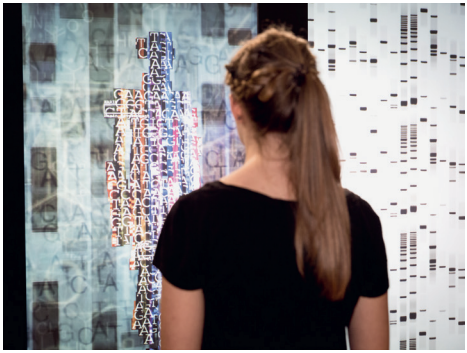
Bernd Lintermann
***1967 in Düsseldorf (DE), lives and works in Karlsruhe (DE)**

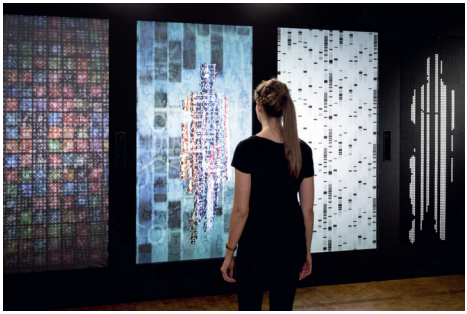
Peter Weibel
***1944 in Odessa (UA), lives and works in Karlsruhe (DE)**

Ludger Brümmer
***1958 in Werne (DE), lives and works in Karlsruhe (DE)**

Yannick Hofmann
***1988 in Offenbach am Main (DE), lives and works in Karlsruhe (DE)**

Christian Lölkes
***1990 in White Plains, New York (US), lives and works in Karlsruhe (DE)**





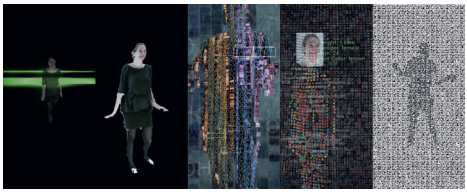


Photo © ZKM | Karlsruhe, Photo: Bernd Lintermann

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

The mirror is a medium that collects and reflects data, but does not store it. Social media, on the other hand, are mirrors that also store data. In front of the digital mirror of the installation, the viewer follows the rotation of his images, even though he does not move. The data thus do not behave like a shadow attached to the human being; rather, the data detach themselves from the viewer and others use them to do what they want, e.g. sell data. The so-called "Big Five" (the Internet companies Apple, Alphabet, Microsoft, Amazon, Facebook) sell these user-generated data and earn millions from them. People produce data that they voluntarily and gratuitously hand over to distribution companies that merely provide the distribution medium, i.e. the platforms.
The distribution and storage of gigantic amounts of data (the famous "Big Data-problem") enables the correlation of data by means of artificial intelligence. The data traces in the network serve to better profile and identify the behavior of the data producers and thus ultimately make them predictable and controllable. People increasingly find themselves in a prison of multiple codes (gender code, dress code, genetic code, social code, etc.). All these codes are used for predictive data analysis and thus for social control. We live in an unleashed world of codes.
YOU:R:CODE, this installative path through the world of codes, displays humans as data hunters and data carriers – with the goal of liberating humans from the code prison.

Idea:
Peter Weibel

Concept, realization:
Bernd Lintermann

Audiodesign:
Ludger Brümmer,
Yannick Hofmann

Flip-Dot-Display:
Christian Lölkes

Technological support:
Manfred Hauffen, Jan Gerigk

Setup, planning:
Thomas Schwab

oh cet echo
2012, Sound installation
Production by the ZKM | Institute of Music and Acoustics,
Update by the ZKM | Hertz-Lab

Peter Weibel
*1944 in Odessa (UA),
lives and works in Karlsruhe (DE)

Software development:
Götz Dipper

Artistic-scientific assistance:
Barbara Nerness

Photo © ZKM | Karlsruhe, photo: Jonas Zilius

#Encoding #ProgrammingSound #Software #Interface

The sound installation *oh cet echo* enables visitors to speak into a microphone, while their voice is simultaneously simulated by a musical instrument (piano, marimba, vibraphone, or flute, each using short or longer tones). Visitors can change from one instrument to the next using a push-button, and are also provided with a short recording of previous visitors (with a time delay of one second). Over time, the words of the visitors create a joint musical composition.

Monochord
2012, interactive audiovisual installation for computer and screen
Production by the ZKM | Institute of Music and Acoustics,
Update by the ZKM | Hertz-Lab

Peter Weibel
*1944 in Odessa (UA),
lives and works in Karlsruhe (DE)

Computer animations:
Ludger Brümmer
*1958 in Werne (DE),
lives and works in Karlsruhe (DE)

Interactive environment:
Götz Dipper
*1966 in Stuttgart (DE),
lives and works in Karlsruhe (DE)

Photo © ZKM | Karlsruhe, photo: Jonas Zilius

#Encoding #ProgrammingSound #Software #Interface

The installation "Monochord" makes it possible for the first time to visualize for the human eye the vibration when the string of a flageolet is struck. The string's vibration is simulated through a set of equations that represent Newtonian mechanics, which are depicted by the computer as series of images. By clicking on the vertical blue lines on the screen, the viewer can experience the sound and vibration of the overtones on the horizontally depicted string.
When a string is struck, it generates a clearly recognizable sound. A harmonic spectrum always results from the string's vibration. Like every sound, however, the sound of the string is made up of multiple tones. The harmonic spectrum contains a series of clearly arranged partial tones, each of which corresponds to an integer multiple of the base frequency. For example, a string that has a fundamental tone of 400 Hz encompasses partial tones of 800, 1200, 1600, 2000, 2400, 2800 and 3200 Hz. One can play this sound on all string instruments through the playing technology that is designated as a flageolet: the finger, which is a blue vertical line in the case of "Monochord", is only placed lightly on a certain position on the string without pushing down all the way on it. When the string is struck now, all of the deeper vibrations are suppressed and only the overtones are heard.

Sponsor: *Genesis*, physical Modeling Environment: ACROE, Grenoble

Sonorama – Karlsruhe
2017, Sound installation

Chikashi Miyama
*1979 in Otsu (JPN)
lives and works in Karlsruhe (DE)

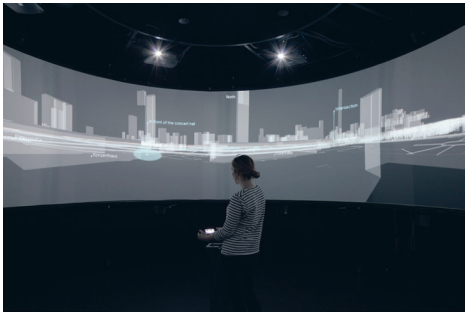


Photo © ZKM | Karlsruhe, photo: Jonas Zilius

On display in the exhibition
from May 30, 2018 to August 5,
2018 at the PanoramaLabor

#Encoding #ProgrammingSound #Software #Interface

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

033

Rhythm of Shapes
2016, Interactive sound installation

Chikashi Miyama
*1979 in Otsu (JPN),
lives and works in Karlsruhe (DE)

Photo © ZKM | Karlsruhe, photo: Jonas Zilius

#Encoding #ProgrammingSound #Software #Interface

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

Tether
2018, Interactive sound installation, balls, bungee cords, depth sensor, computer, custom software
Production by the ZKM | Hertz-Lab

Dan Wilcox
*1981 in Orange (US),
lives and works in Karlsruhe (DE)

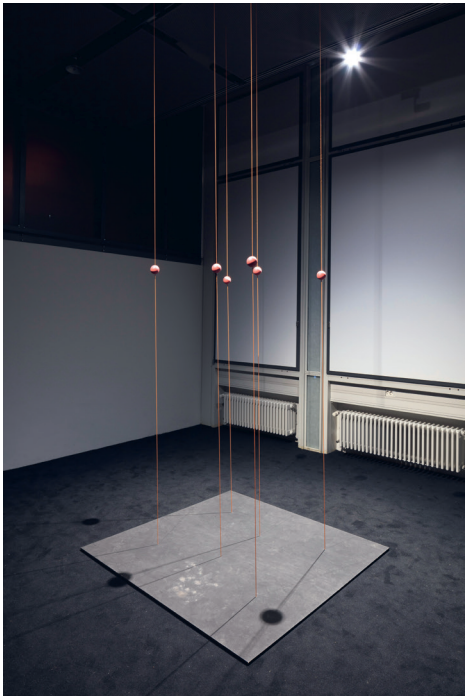


Photo © ZKM | Karlsruhe, Photo: Jonas Zilius

Tether is an interactive study on the movement of loosely bound particles in space. Simultaneously free, yet gravitating towards a distinct rest point along a cord, each particle exists in a fluid area between the potential and kinetic. This motion (or lack thereof) of individuals is directly translated into voices which coalesce into a community chorus. Outside actors are encouraged to disturb this state by pulling individual cords to knock particles out of rest. How does the community respond?
Fundamentally, *Tether* is a translation of physical position and motion into audio, yet it is also a study on observation and influence. A computer vision system tracks individual particles, yet cannot directly influence their position. The community desires harmony, yet outside forces (or individuals within) seek to displace this regularity. How do individuals respond to the disturbance of their neighbors? To what degree does the community remain together or fall apart?

Genealogy of the Digital Code
2017, Installation
Production by the ZKM | Institute for Visual Media,
Update by the ZKM | Hertz-Lab

ZKM | Zentrum für Kunst und Medien
with *Linear Navigator* (1999)
by Jeffrey Shaw

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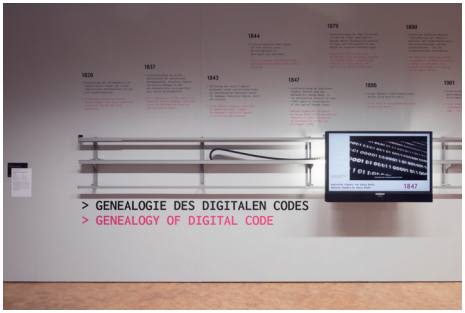

Photo © ZKM | Karlsruhe, photo: Jonas Zilius

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

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

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