Augmented Reality Garden

bridge — possibilities of the garden

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PhD thesis
Prepared under the direction dr hab. Darka Gajewskiego

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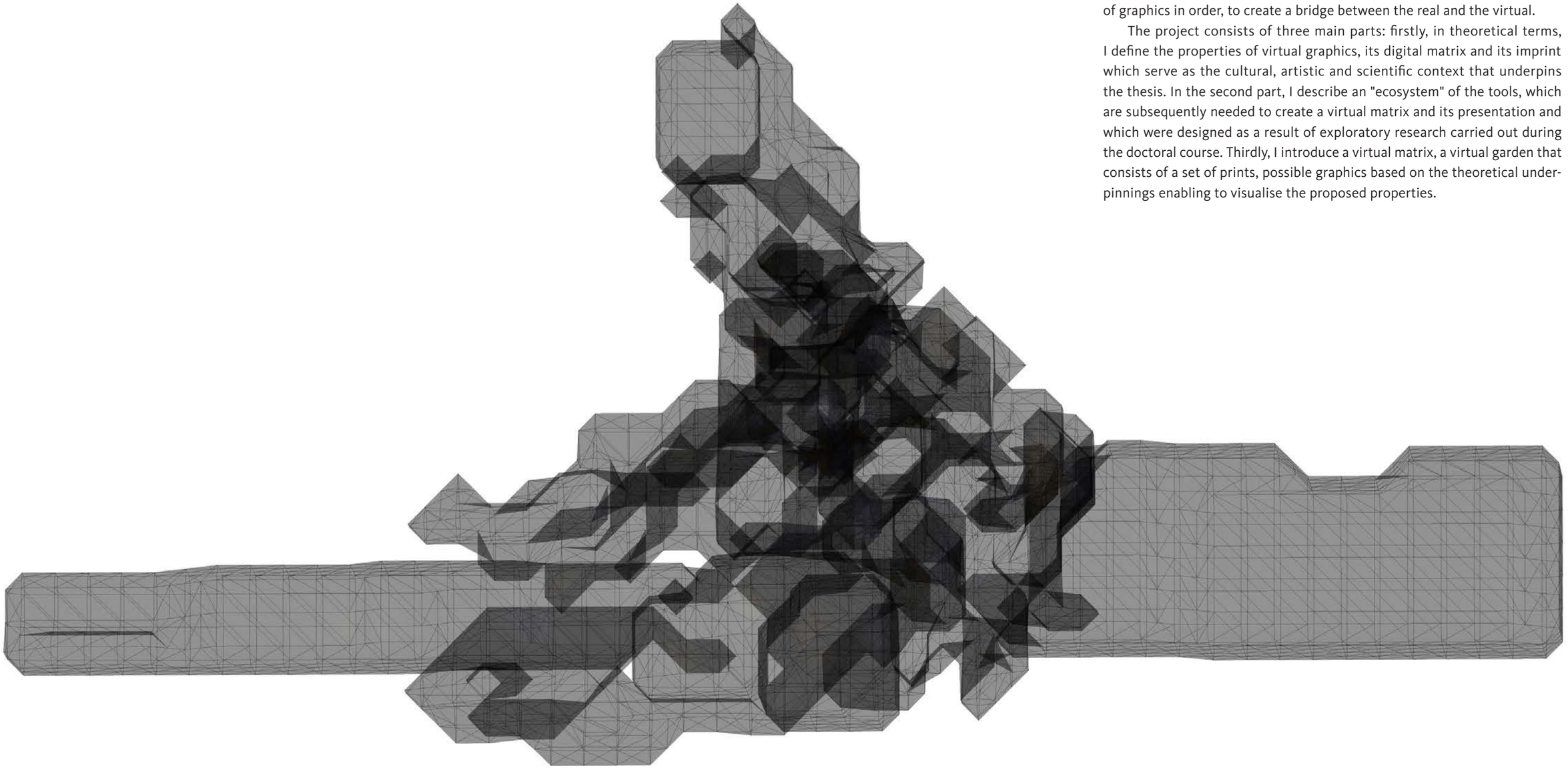
Table of Contents

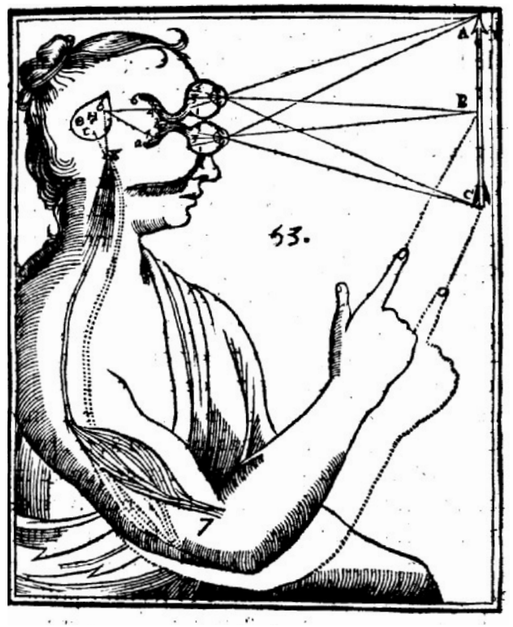
Introduction

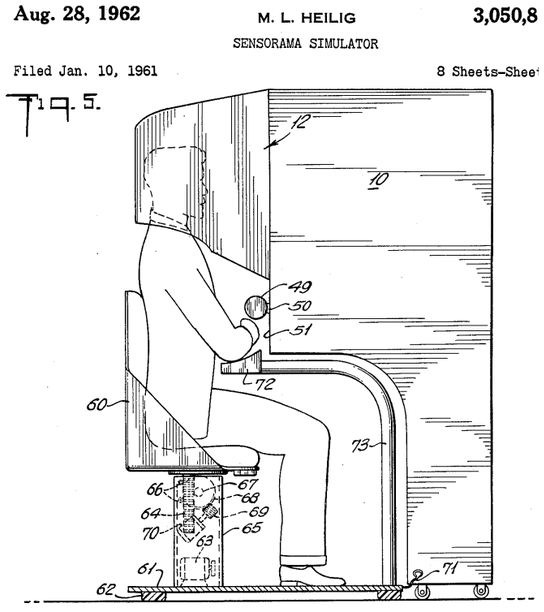


AR Garden 2017r06m05d 02-21-17; iteracja (I) - 0; renderer (R) - PBR; transp. - 0.24

My PhD project focuses on the issue of the virtual digital matrix. The boundary between reality and unreality, space and time, is contextualised in the hybrid phrase "in between," as the Augmented Reality Garden, a bridge – and the subsequent possibilities of the garden The aim is to describe the collision of these realities, their mutual relations and their influence in the field of graphics in order, to create a bridge between the real and the virtual.

The project consists of three main parts: firstly, in theoretical terms, I define the properties of virtual graphics, its digital matrix and its imprint which serve as the cultural, artistic and scientific context that underpins the thesis. In the second part, I describe an "ecosystem" of the tools, which are subsequently needed to create a virtual matrix and its presentation and which were designed as a result of exploratory research carried out during the doctoral course. Thirdly, I introduce a virtual matrix, a virtual garden that consists of a set of prints, possible graphics based on the theoretical underpinnings enabling to visualise the proposed properties.





▲Sensorama, U.S. Patent #3050870, s. 3

◀Sensory experiences are transmitted through the nerve system to the pineal gland, where they produce a reaction which in turn is transferred to the muscles. Image from L'homme, et un Traitte de la formation du foetus, 1664. [1]

1. René Descartes, L'Homme de René Descartes et un Traité de la formation du fœtus, Charles Angot, Paris, 1664, p. 155

2. Platon (427–347 BC.), Republic, T. 2, book VII, 514a–516 c, p. 63–66; The fruitful teaching of the Plato's Academy resulted in numerous texts, most in the form of dialogues. The "Republic" belongs to dialogues created half way through Plato's academic life work. The cave myth plays a significant role. Through this Plato visualised his philosophical system.

3. René Descartes, 1596–1650. French philosopher, mathematician, physicist and one of the most eminent scholars. "I think therefore I am" is the statement that creates a state of thinking and existence linked together, which can also be applicable in virtual reality. J. Hintikka, "Cogito, Ergo Sum: Inference or Performance?", The Philosophical Review, Vol. 71, No. 1 (Jan., 1962), p. 3–32

Virtuality

It should be stated from the outset that the virtuality referred to in this study is only a narrow section of a broader debate on reality, which in philosophical discourse reaches at least 380 BCE, philosophical anecdotes and Plato's cave,[2] contained in his work 'Republic'. Virtuality as a concept contributes to the discussion on the recognition of reality, the ability to understand and perceive it through the limited human senses. The dualistic concept of Descartes[3] was based on two opposites: the res cogitans and res extensa. The latter was used to describe the physical world, while the former was used to denote beings perceiving in subject's minds. Thus, according to Descartes, the reality consists of two fundamentally different substances. The material world operates on a mechanical basis, while the spiritual/virtual world is an area of freedom; which make up the persona of people.[4]

Nowadays the understanding of virtual reality[5] is no longer about distinguishing between these two worlds. It is rather about substituting reality with the signs of reality, that is, an operation where, instead of the real process its operational version comes out to the fore, a programmable homeostatic sign maker, which offers all signs of reality and all its vicissitudes in short.[6]

By the twentieth century, virtuality had abolished the distinction between realis and virtualis. The idea of virtual reality was initiated by Marton Heilig, an American artist who in 1960 built a kind of capsule in which a person was able to view panoramic screens, making a world appearing on monitors resemble the real world. This constructed "Sensorama" fulfilled the basic postulate of virtuality, namely technical falsification of reality. Heim assumes that behind every new technology there is a vision of the world and that particular technologies are the product of those visions.[7] As pointed out by Michael Heim virtual reality is a world that seems to be real, though it is not.[8] It is a world, or alternate worlds as described by Marshall McLuhan.

The twentieth-century acceleration of technological industry, with the introduction of computers, brought a new vision of virtuality. The new form of communication and artistic presentation replaced the basic tools of sensory perception with cognition via electronica. Digital virtuality, which directly influences our senses and how we perceive reality had widened the possibilities of perception while questioning its authenticity. The concept of virtuality triggered a series of questions concerning both the particular philosophical sciences and the scope of media theory, media history, sociology and image aesthetics. In the philosophical context, virtuality can be contextualised on an ontological level as an attempt at addressing a number of questions related to the coexistence of matter and an idea, the problem of virtual reality as an opposition to the realm of reality, or issues related to the immaterial dimension of multimedia art. [9]

Currently, artists using the new technologies are faced with a question that remained unanswered throughout the whole 20th century: should artists engage in the technological revolution and thus change society "from the inside" or should they remain on the margins of the changes by building alternative media realities? Photography, cinematography, television, computers and finally digital techniques combining all the new media, questioned in an increasingly insistent manner where does the art fit and what is, and should be, an artist's attitude to technoculture that takes up more and more areas of social reality?

4. Ariew and others, Historical Dictionary of Descartes and Cartesian Philosophy, Lanham, Maryland - Toronto – Oxford: The Scarecrow Press, Inc, 2003, p. 41, 183

5. 60's. XX century

6. Jean Baudrillard, The Precession of Simulacra in T. Komendant: Postmodernizm. Antologia przekładów, Cracow 1997, p. 177–178.

7. J. Lanier is the founder of the term virtual reality, which he first used in 1989, M. Krueger created the terms artificial reality, which he introduced in 1991.

8. M. Heim Metaphysics ot Virtual Reality Oxford 1993 „Virtual reality is an event or entity that is real in effect but not in fact".p. 109.

9. Roman Konik, Virtuality as the rehabilitation of illusion. The history of virtuality: from illusion to immersion, „Diametros – An Online Journal of Philosophy" 2009, no 21 (September 2009), p. 79, http://www.diametros.iphils.uj.edu. pl/index.php/diametros/article/view/355/pl [accessed: 28.05.2017]

Digital technology does not allow for a more comprehensive answer as it introduces us to the world of doubled reality ("We enter a world where there is not one, but two realities: real and virtual," says Paul Virillo). The world of fluid, flexible, malleable images, the cyberculture world, where the status of all media is constantly changing. [10]

On the contrary to the art and literature of new media, cyberspace [11] functions as a space within the Internet, artistic activity on the web or live social networks which are possible through online communication. We can talk about graphics in cyberspace [12], shown as the exhibition display, about a work of digital language (numeric), about cyberspace ways of presenting work, where the data of the work is represented in a visual form.

To explore the digital reality of virtual reality, one first needs to understand the laws that govern it. It is necessary to identify relevant factors influencing the reception of digital art, for example, its digital virtual matrix, contexts and sources of origins as well as the final presentation process.

This seems especially important, when considering the advancement of immersive virtual worlds in the XXI. The categories of identity, similarity, originality or copy began to be re defined. These are the main conceptual aspects which I further examine in practical terms within the subsequent part of my project through graphic implementation.

To discuss the philosophical dimension of virtuality I use the term 'cybernetic matrix'. The matrix's nature and description of the virtual sphere emanate the notion of virtual reality being treated as an alternative reality to the real world. Virtual realis, as a result of the development of the electronic environment, is gaining traits of the human reality - having its particular properties, distinct from the reality. [13]

Virtuality is nestled within the area of new technology, but when entering human reality, it gains a broader meaning and character. Being a subject of interest in the different areas of modern science, the concept of virtuality has gained a certain degree of usability and appears in various meanings in a range of disciplines. Virtuality seems to be an open and capacious concept, covering, for example, socio-cultural, artistic, media and political issues.

The apparent difficulty in describing virtuality seems to be due to the characteristics of the concepts being compared to the technology-related virtuality of the subject matter such as culture or philosophy. There is a distinct difference between virtual technology or the media, and its existence in the electronic environment of the cyberspace or the medialised world. [14] In order to describe the concept of virtuality, This paper will refer to the research of Paul Milgram and Fumio Kishino 1994. Utilising their diagrams to define the concept of Reality-Virtual Continuum as a sequence that begins with the real environment and ends with a virtual environment (VR).

The Real Environment expanded by virtual objects is the basic concept of Augmented Reality (AR), and Virtual Reality (VR) extended by the real objects, is the basic concept of Augmented Virtuality (AV). The whole as a continuum is a Mixed Reality (MR), sometimes called a hybrid reality. The concept of "bridge" refers to a project that builds connections between these realities and allows them to move smoothly from one to the other. The virtual matrix, which is the subject of this work, is created in an Augmented Reality with the use of the dedicated tool designed for processing digital matter in

10. Michał Ostrowicki, Wirtualne realis. Estetyka w epoce elektroniki. Taiwan Universitas, Cracow, ISBN 97883-242-1189-0, p. 14 https://www.nexto.pl/upload/sklep/universitas/ebook/wirtualne_realis-ostrowicki_michaluniversitas/public/wirtualne_realisuniversitas-demo.pdf [accessed: 28.05.2017]

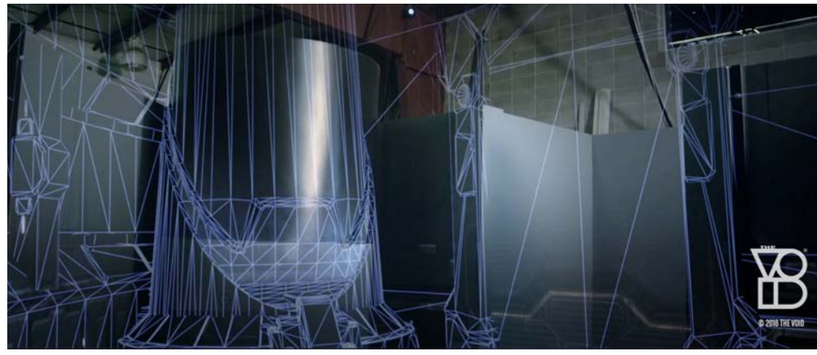
11. The terms ‚cyberspace' was first used in1984 by William Gibsona in a Burning Chrome. Computer generated world the author also called the matrix.

12. According to Pierre'a Levy (famous French sociologist) cyberspace Is flexible, fluid and computable with high accuracy and processability in the real time, hypertextual, interactive and finally virtual.

13. Michał Ostrowicki, Virtual ... op. cit., s. 14

14. Ibidem, s. 15

►The VOID presents an example of expanded virtuality. The experience of virtual reality involving sight is supported by real elements affecting other senses. Walls, physical object, changes in temperature or wind all enhance the virtual experience of the presented virtual world. [15]

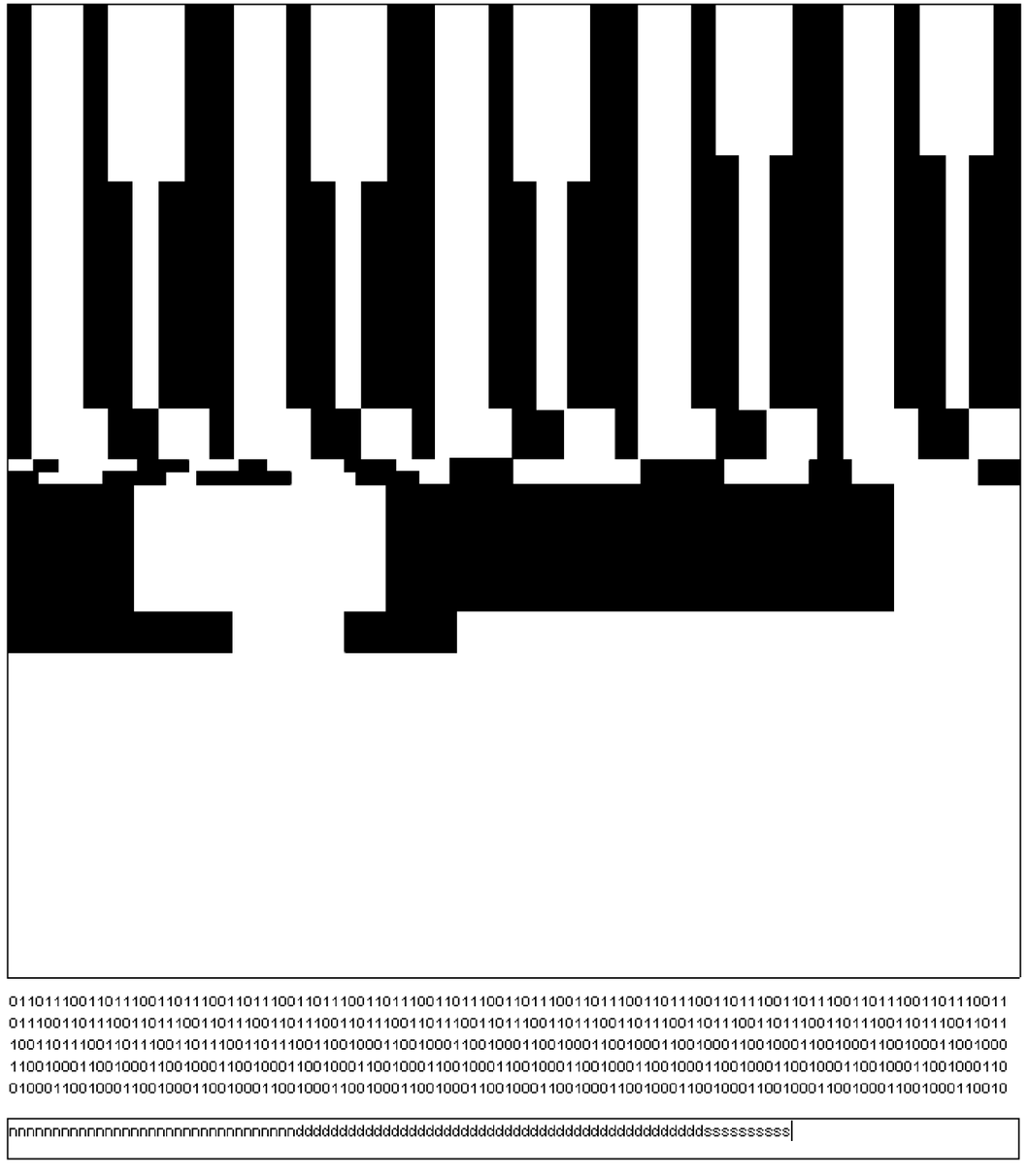


the form of three-dimensional spatial graphics. Matter and matrix of digital graphics remain virtual, stored on a physical medium, which can be in the form of any digital data carrier while being stored on a virtual server connected to the Internet or digital data cloud. A graphic imprint from a virtual matrix may remain unphysical, in the form of a digital recording of a particular presentation's capabilities under certain conditions. The digital virtual graphic does not have a defined end state, it is interpretable, depending on the presentation tool used. The virtualized graphic image has been materialized as digital printing, spatial printing, played on monitors, and mapped with projectors and presented in AR and VR media.

▲R-V continuum - linear relation between reality and virtuality by Paula Milgram and Fumio Kishino; 1994 [16]

15. Frame from the promotional video The VOID - YouTube channel The VOID https://www.youtube.com/watch?v=cML814JD09g [accessed: 28.05.2017]

16. Milgram Paul, Kishino Fumio, A taxonomy of mixed reality visual displays, IEICE Transactions on Information Systems, E77-D(12), 1994.



▲Haiku - composition „nds”

Genesis

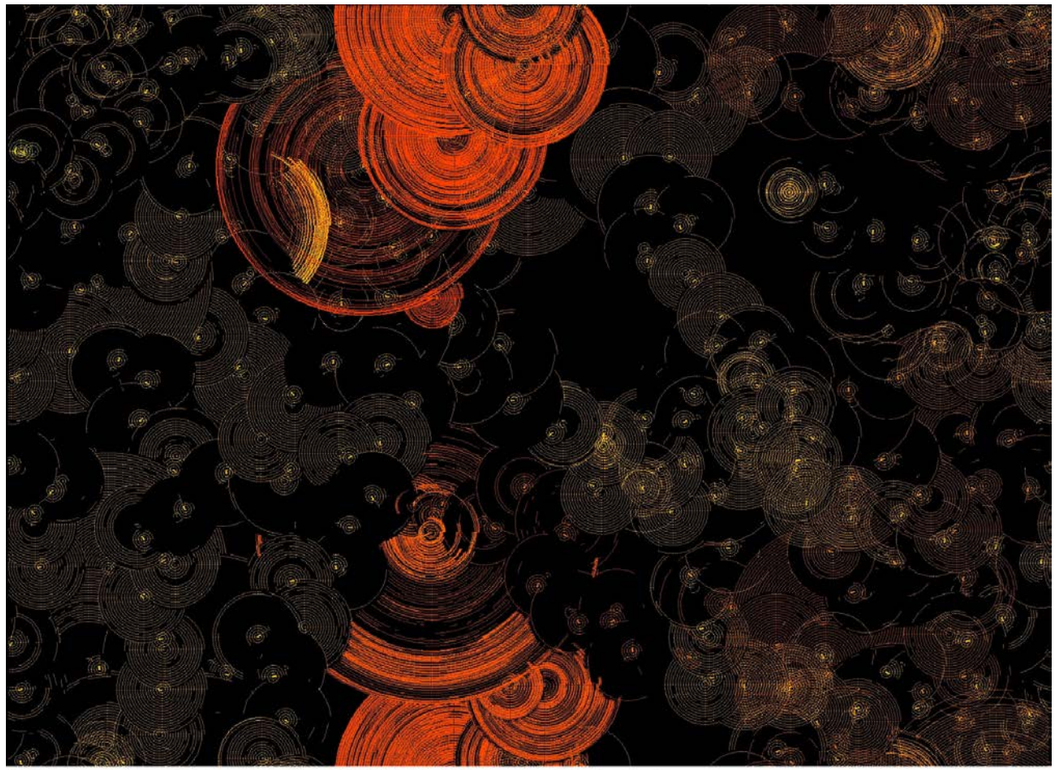
The ARGarden bridge is a project that results directly from my previous research and continues the debate on issues relating to digital graphics and their capabilities and properties. The first implementation, Interactive Bonsai Graphics (IBG), was inspired by the desire to define the definition of digital graphics. My attempt to determine the basis of its characteristic features has led me to the following conclusions:

- A digital image matrix should be created and should stay in within digital environment;
- It should be unique but replicable;
- It should create a bridge between real and digital (virtual) worlds;
- Time should be a relevant factor.

These criteria are met by incorporating generative digital graphics and interactive digital graphics. In its design IBG refers to the above postulates and tries to answer them. The emphasis is put on interactions, not on manipulation, and randomness which is not present in the digital environment. Some IBG parameters such as length of existence, the speed of formation, the delta interaction, the output shape, the way of determining a starting point are programmed and subject to change. Other elements and coefficients such as the colour or the starting point are determined by the IBG initialization image. However, the final form is never determined, it is the nature of the IBG itself. IBG is a "fed" interaction, its form is dependent on its external factors. This is possible due to the interface for communicating with graphics. This interface is a webcam. All the communication with the IBG is done through the camera input. At the time of "planting," initiating Interactive Bonsai Graphics, the camera captures the image, and the software averaged its value. The IBG output colour is determined on this basis. Graphics are created in the process of drawing concentric circles. Circles are created by drawing stamps - an average image from a webcam is reduced to 16 fields. In the specified unit of time, subsequent stamps are drawn with 4x4 pixels and colour depending on the intensity of interaction with IBG. Interaction is determined by the individual change of black and white pixels on the stamp template. The greater the interaction, the more intense the colour saturation. The stamps that result from the interaction are either drawn on the upper layer overwriting the previous pixels, or they are drawn on the bottom layer. In the case of intensive interaction beyond the one-time change of eight or more pixels on the stamp, a branch is formed, and the IBG goes to draw a new circle. The graphics have a preset, adjustable length of existence to be set during the initial period of the plantation. The closer to the end of its existence, the more the output colour tends towards black. Its saturation, temporarily, can only be increased by interaction.

Interactive Bonsai Graphics is a unique recording of time and space focused on detecting changes in the environment and in particular changes in light access.

The next implementation of the topic of digital graphics was Haiku's interactive installation. We visualize our thoughts encoding them in words, writing "tomato" we encode the image of a red object in the shape of a slightly flattened sphere with a green peduncle in the middle. The person who reads



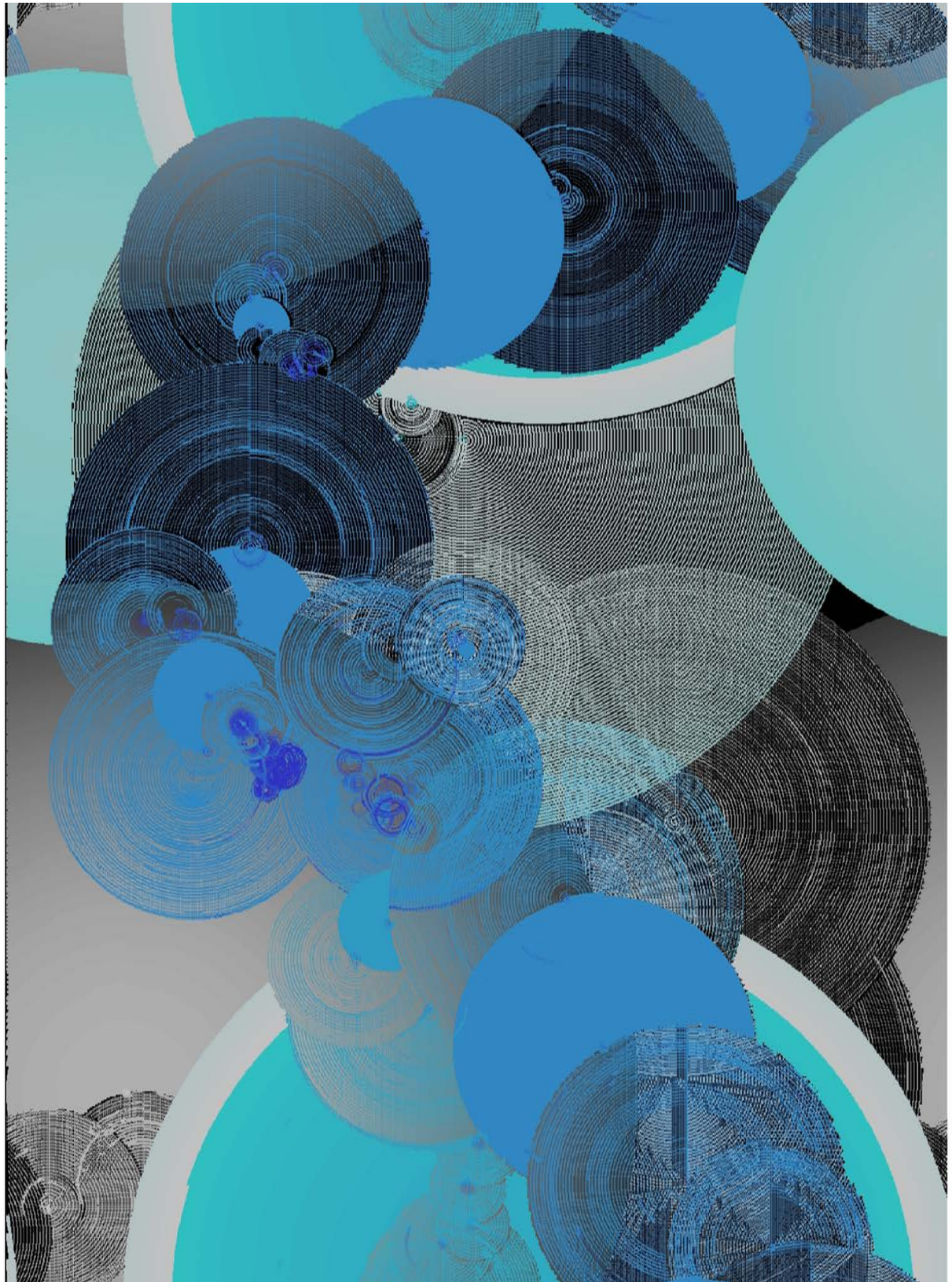
▲jakub_cikala/a_space-time_recording_of_interactive_graphic:'bonsai:an_interactive_lifeform'/filename:print_20080420-160003_end.tiff/date:20-04-2008/place: entrance of GCK Katowice, Poland/lifespan_of:160003cycle

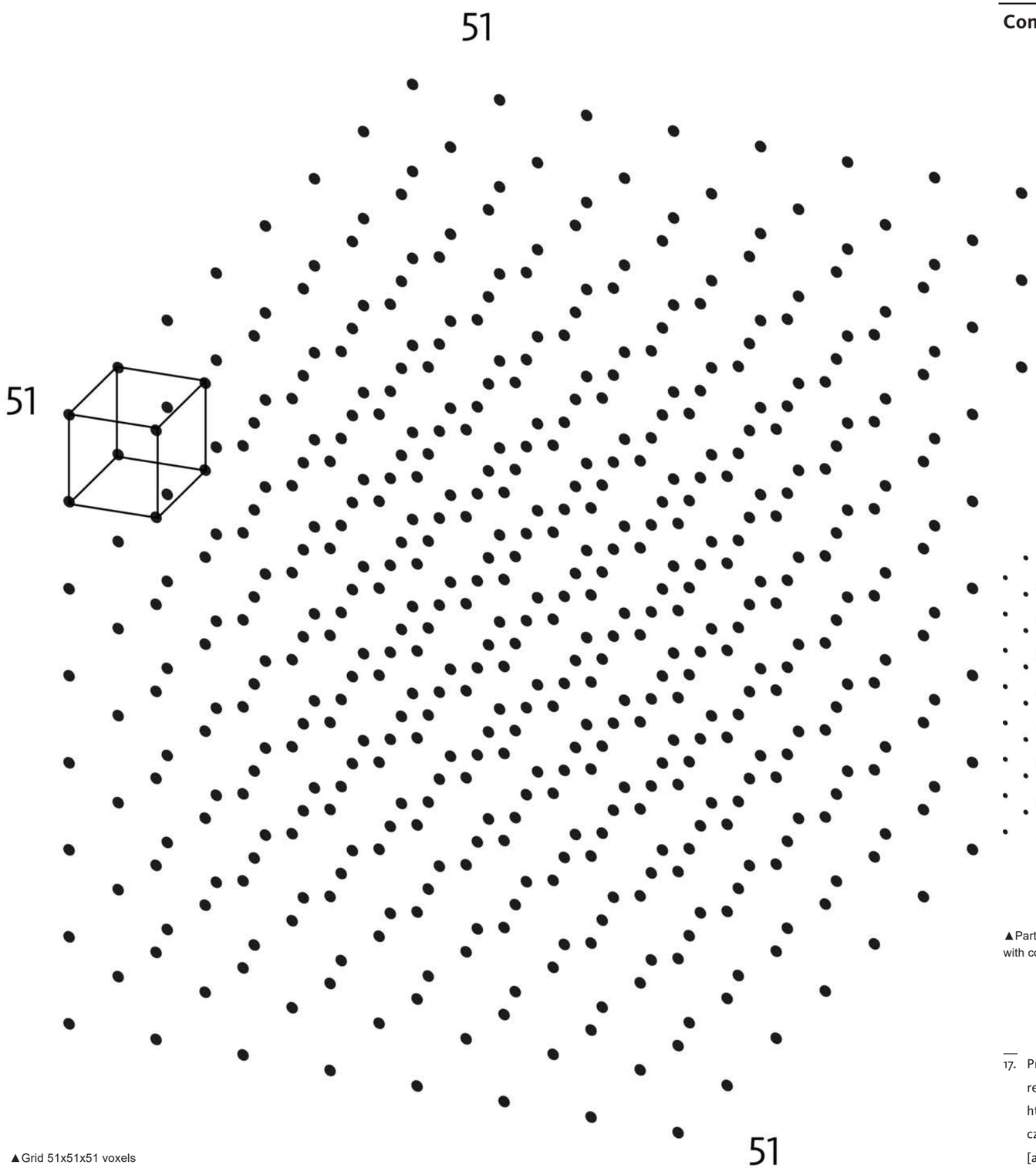
▲Interactive Graphic Bonsai – camera with a filter transforming the picture to a sketch mode.

►jakub_cikala/a_space-time_recording_of_interactive_graphic:'bonsai:an_interactive_lifeform'/filename:print_20080420-160003_end.tiff/date:20-04-2008/place: entrance of GCK Katowice, Poland/lifespan_of:160003cycles

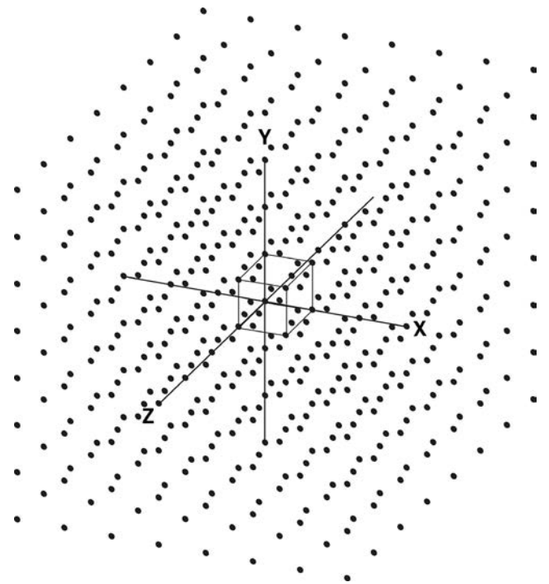
this word decodes, provided that it is derived in a culture of similar coding, just such a picture of a tomato. The word itself is a graphic image, encoded by a thought or idea. The context of digital graphics that encodes words in the binary system of zeros and ones highlights considerations for the smallest digital components. The purpose of these graphics is to trace the graphic image from the idea through human verbal encoding, binary encoding and re-coded graphics. As a result, graphics are created from binary word images. These graphics are written as zeros and ones – letters, words, sentences, whole stories. We do not know how to decode them. We try to understand them intuitively like haiku poetry, which was the inspiration for these considerations. Their simplicity, intuitive reception, and graphical writing were the starting point for furthering the idea of digital graphics.

In Haiku graphics, the image is generated by the conversion of the text entered by the recipient. The user enters a string of graphemes that are the smallest unit of a writing system that is converted to the ASCI code that represents them, and then to a binary string. The next stage converts 0 and 1 to white and black squares, pixels, stacking them in succession, the size of the pixels is inversely proportional to their amount on screen. The key idea is to change the graphic encoding from the graph to the corresponding representation of pixel elements. Various graphics are created that carry the same content.





▲Grid 51x51x51 voxels



▲Part of base grid of a virtual digital matrix grid with coordinate system applied.

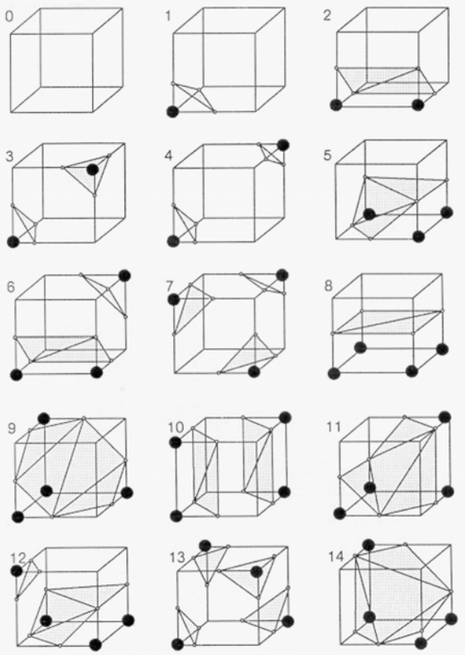
The ARGarden virtual matrix is created in an augmented reality with a digital application for creating spatial graphics. During the creation of the matrix, the print of digital graphics and the matrix remains virtual, stored on the device on which the application is installed. It can be saved on a virtual server connected to the Internet at any time. The graphic print based on the virtual matrix may remain unphysical, and without a defined final state, it is interpretable and dependant on a presentation tool. A virtualized graphic image can be reproduced in a number of different techniques and technologies: digital printing, stereolithography, displayed on monitors, mapped using architectural projectors or presented in virtual reality.

The matrix as defined by prof. Mariusz Pałka is such a form, whose main feature is the ability to memorise information and which we can then reproduce in the so-called duplication process. [17] The digital matrix, thanks to its virtuality, gains a number of properties that are not desirable to its analogue counterpart, namely its capability of being stored, duplicated and updated from anywhere at anytime and anywhere. It is decentralised, programmable, generative, updatable and platform-independent.

ARGarden is a dedicated software developed as a part of my doctoral project. It allows the user to edit, interact and view digital virtual matrix and graphics in augmented reality. To operate the software a flat or spatial graphic marker is required, which can be downloaded using the link provided in the application. The marker must be printed and, in the case of a spatial marker, be applied appropriately to the cube. The size of the marker is closely related to the size of the displayed graphic.

ARGarden works on mobile devices, such as phones and tablets running Android or iOS. After downloading and installing, the application can be used immediately. The interface that the application uses is the camera built into the device. The camera image is read and processed using the Vuforia platform for rotation of the XYZ coordinate system and its scale. The software basing on the location of the image of the graphic marker reads the distance of the device from the image. It subsequently determines its position and the rotation in the XYZ axes system. The centre of the physical graphic tag becomes the centre of the virtual coordinate system. The virtual digital matrix is built on a 51x51x51 spatial structure that forms a cube whose middle correlates with the center of the virtual coordinate system. Each point on this grid is described by the XYZ coordinate. The method used to create 3D models based on the spatial grid is Marching Cubes. Cells created by dividing space into even mesh are often referred to as voxels (volume element), elements of space analogous to pixels [21] that are picture elements. Marching Cubes (MC) is an algorithm introduced by Lorensen and Cline to extract surfaces from 3D data sets. It works by dividing the entire dataset into cubes. Each triangle creates triangles to determine whether each corner in

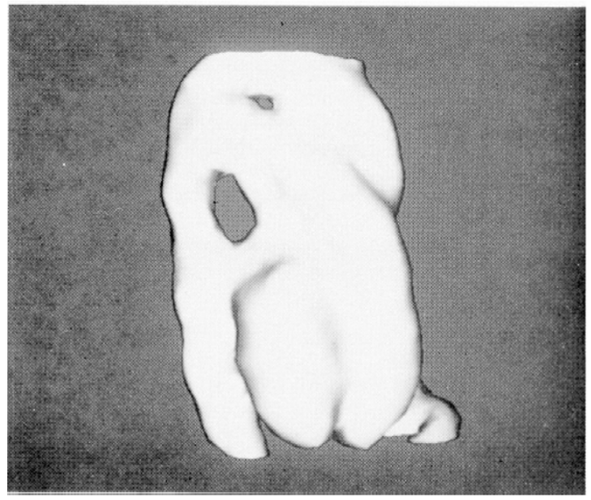
17. Prof. Mariusz Pałka „BSP 4 - Matrix czyli reaktywacja matrycy", ASP Katowice http://aspkat.edu.pl/zobacz/matrix-czyli-reaktywacja-matrycy [accessed: 28.05.2017]

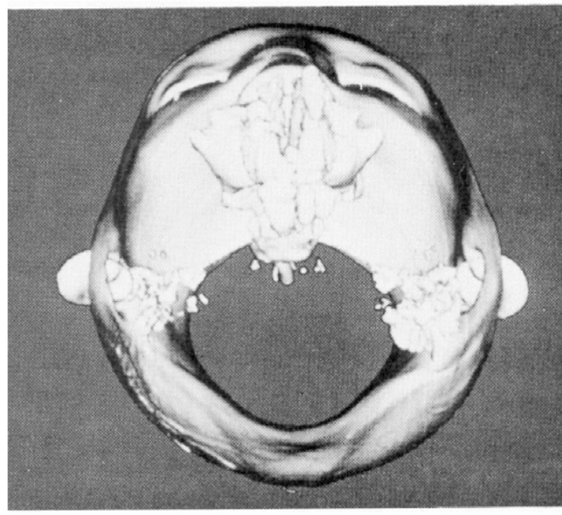


▲Algorytm marching cubes. Triangulated cubes - 14 basic patterns or building a block, which through symmetry and rotation result in 256 different variations of a cube [18]

18. William E. Lorensen, Harvey E. Cline; MARCHING CUBES: A HIGH RESOLUTION 3D SURFACE CONSTRUCTION ALGORITHM; General Electric Company Corporate Research and Development Schenectady, New York; 12301 SIGGRAPH ,87, Anaheim, July 27-31, 1987; Computer Graphics, Volume 21,Number 4, July 1987, s. 165.

the cube is inside or outside the object. Since there are 2 ^ 8 = 256 different cube configurations, it is possible to implement any spatial form effectively. Using the matrix search function, you specify where the triangles should be placed. [22]





Algorithm Matching Cubes was created for medical purposes to providing more detailed visualisation ensuring the minimal number of mistakes and deformations. First visualisation with the use of Marching Cubes Algorythm.
▲Volume of blood in a inflated heart; [19]
►Soft matter, view from above. [20]

19. Ibidem, s. 167

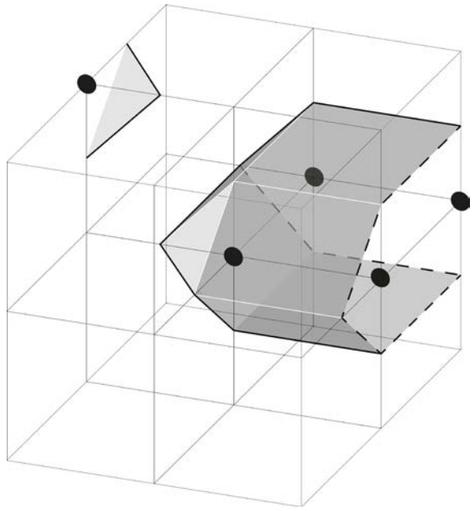
20. Ibidem, s. 168

21. Foley, James D.; Andries van Dam; John F. Hughes; Steven K. Feiner (1990). „Spatial-partitioning representations; Surface detail". Computer Graphics: Principles and Practice. The Systems Programming Series. Addison-Wesley. ISBN 0-201-12110-7

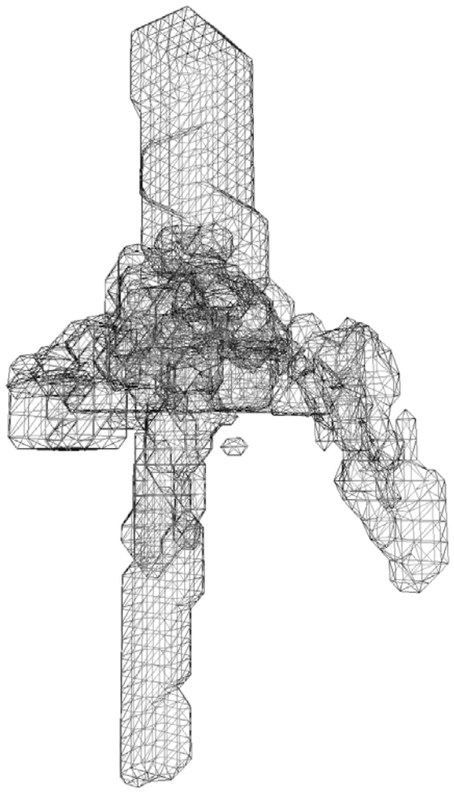
22. Erik Smistad, Marching Cubes implementation using OpenCL and OpenGL ,https://www.eriksmistad.no/marching-cubes-implementation-using-opencl-and-opengl/, · May 30, 2016 [accessed: 28.05.2017]

By moving the mobile device in the physical space, the user activates consecutive points on the virtual grid, resulting in a spatial object that is also the first digital imprint. An additional attribute of the application is a straightforward and intuitive interface that does not require any prior specialised training. The Application allows the user to add elements of the "garden", change existing ones or remove unnecessary ones. There are several sizes of the object that activate matrix points. This allows the user to control the number of points that are activated simultaneously, which directly translates to the shape of the object being created. The application allows for easy viewing of spatial graphics by rotating the graphic marker or moving the mobile device relative to the tag. The user is able to generate screenshots which are produced in three files. The first is the current view from the camera along with the virtual graphic, the second is the image from the camera of the device and the third contains only the virtual digital image on a uniform background. Another way to generate a print from a matrix is to export the image to a .OBJ file, which is one of the most universal and widely used formats for 3D graphics. It is also possible to write the resulting matrix to the .AG1 files, dated at the time of saving, to the mobile device memory. One of the key features is the ability to download and save a virtual matrix on a virtual server, from where you can download it from any place on the planet.

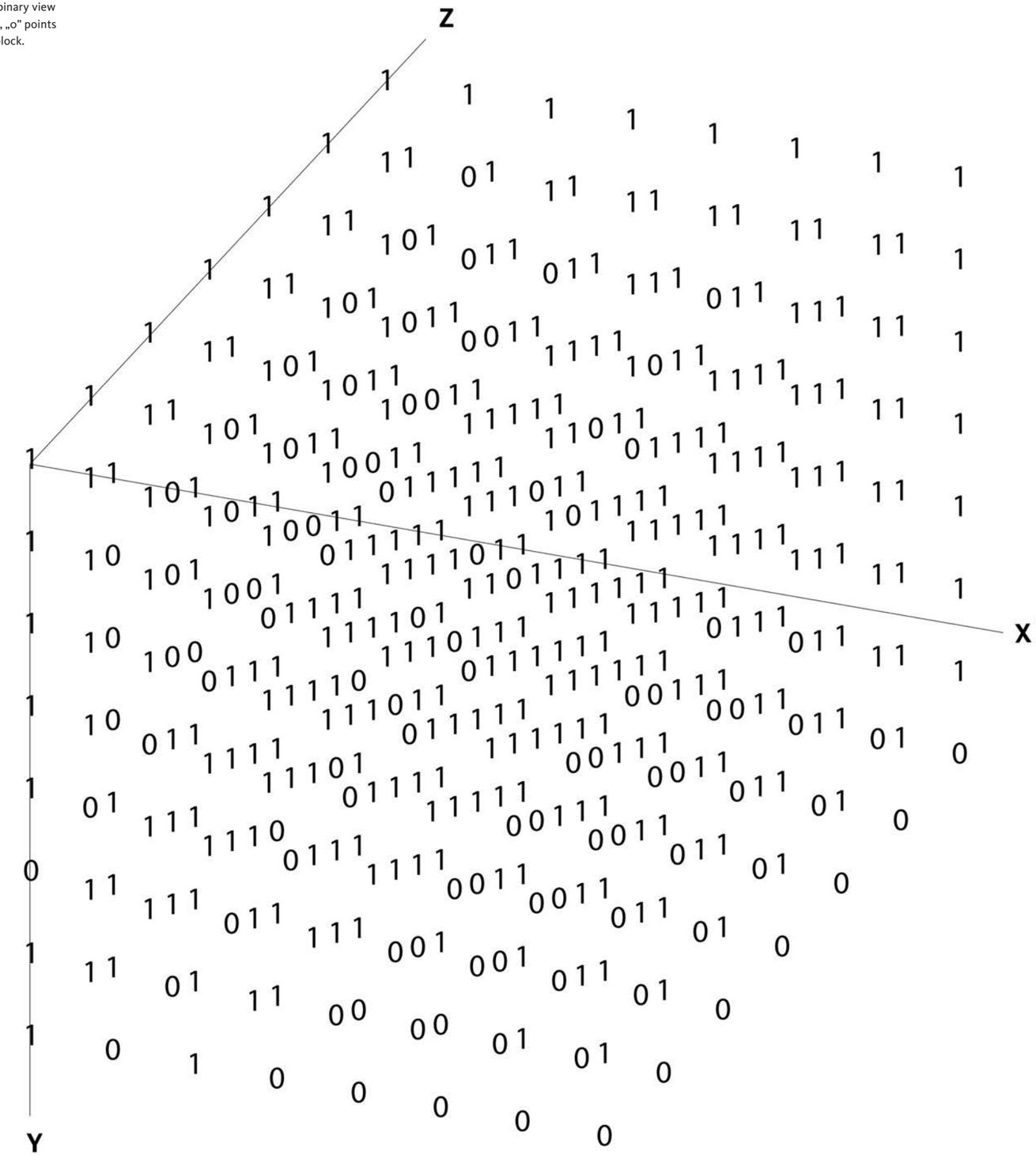
VRGarden is a tool for viewing a virtual digital imprint with a computer set including a virtual goggle display - HTC Vive. The device allows the viewing with a resolution of 2160 × 1200 pixels, with a refresh rate of 90Hz. Two screens give the user the ability to see 110 degrees and a tracking tower



▼Pint of the digital matrix in a form of a gild of triangle and dots.



◄ Triangulated cubes – basic patterns build 2D surfaces, which joined create closed 3D blocks
► Virtual digital matrix grid in a binary view showing active, as „1" and passive, „0" points contributing to the shape of the block.



▲Sample of binary record of a file in a standard serializer in C# in .AG1 format virtual digital matrix ARGarden.

system 4.5 × 4.5 meters of space to move in physical/virtual reality. Tracking the position of the user is translated into the movement of the virtual camera and is translated by accelerometer, gyroscope and magnetometer.

Goggles create an immersive virtual reality that, thanks to the partial detachment from reality, allows the user to observe prints in an impossible way. Starting with scaling by viewing the insides of a closed object.

▲Marina Abramovi, Jeff Koons and Olafur Eliasson present work of art on a new artistic platform of Modern Art, Acute Art. The objective of the digital gallery VR is to test the response and encourage people to move from physical art to new on line age. Project is due to commence in Autumn 2017.

Gardens are a key feature of this puzzle. They were an important element of inspiration in the search for the final form of created graphics. This inspiration was not geared to a given period or garden style. Inspiration was rather the idea of a garden as a harmonious combination of human effort and natural forces that made sense of balance as the basis of the visual image of the garden.24 Reference search took place on many levels from a macro to micro scale, from design to a chance and a natural form. Gardens are spatial compositions that take into account not only the scale of the components relative to each other but also, or even primarily, the context of the recipient. A recipient who has a different perception of what is naturally and artificially produced.

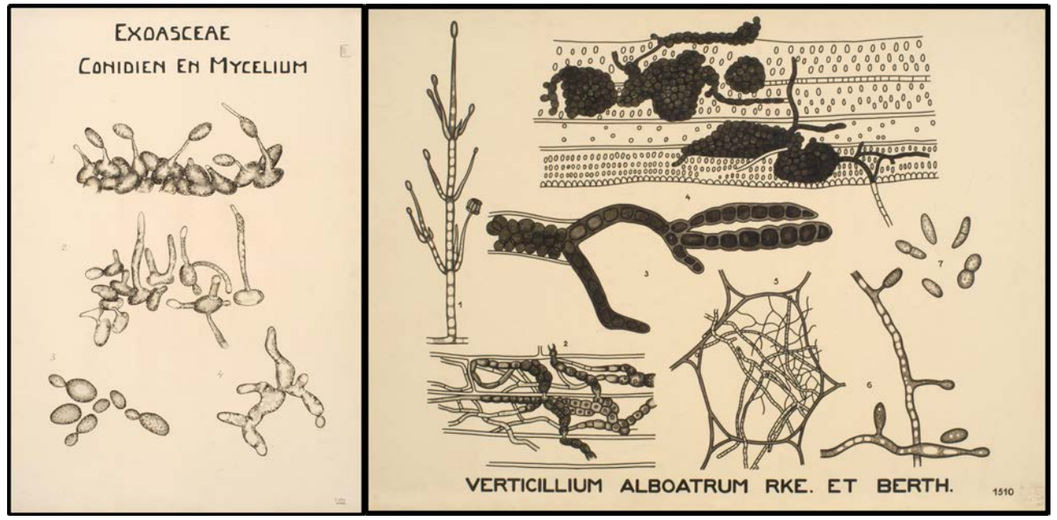
The idea of creating a composition that on the one hand is rigorous, technology dependent and on the other, due to innumerable external factors, natural, unpredictable, and random, translates into the final digital graphics, which is limited by technology but constantly looking for individual and unpredictable values. It is looking for authenticity often found in error (glitch art) or various types of tools to transfer an analogue image to a digital matrix. The ARGarden matrix realises the design principles of the gardens allowing the recipient to form a miniature Bonsai at one time to feel a few meters tall tree a few seconds later. Four different approaches to the visual aspect of a garden project, based on four initial principles, inspired ARGarden's principles:

- Creating a landscape in accordance with the laws of architecture;
- Organisation of the landscape on the basis of a visible, rational principle resulting from its production functions;
- Direct representation of natural features of the landscape mainly the vegetation;
- Representation of the existing landscape, both real as well as imaginary.[25]

23. Anna Cafolla; Marina Abramović & Jeff Koons front new online VR gallery, DAZZED http://www.dazeddigital.com/artsandculture/article/36302/1/marina-abramovic-jeff-koons-front-first-online-vr-gallery [access: 27.05.2017]

24. ISC Historic Gardens and Sites ; Elena Micoulina (1993), The History of Gardens and the Evolution of the Environment, ISBN 955-613-033-0, s.73,

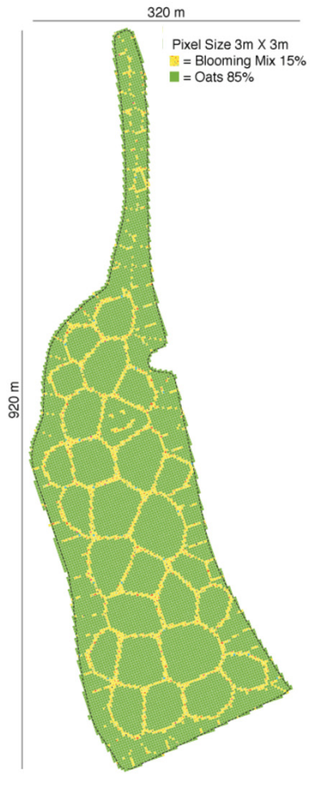
25. Ibidem, p. 72a



▲ Verticillium Alboatrum Rke. et Berth.,Vliet, dr. J.IJ. van. Date of creation 18-04-1905; http://www.geheugenvannederland.nl [access: 27.05.2017]

►Salomon Kleiner, "Orange Grove" - Engraving - 1738 (Österreichisches Museum für angewandte Kunst (Vienna, Austria)) http://en.wahooart.com/@@/8XZNR5-Salomon-Kleiner-Salomon-Kleiner--Orange-Grove [access: 27.05.2017]

▲Jean-Charles Krafft, Plans des plus beaux jardins pittoresques de France, d'Angleterre et d'Allemagne, et des édifices, monumens, fabriques, etc; Paris, 1809–1810, s. 452; ETH-Bibliothek Zürich; Shelf Mark: Rar 9248; http://dx.doi.org/10.3931/e-rara-48092 [access: 27.05.2017]



◄▲Avena + Test Bed – printing in a landscape. Process of establishing the relations between landscape, agriculture and digital graphics. The project uses the idea of printing in order to improve the coexistence of fauna and flora in a natural environment. Author: Benedikt Gros. Printing with seeds. External GPS / GLONASS reference station for maximum accuracy. Plants: 85% oat (Avena sativa),15% 11 different kinds of flowers and herbs Dimentions: 11,5 ha (320m×920m), pixel size 3m×3m, w Unterwaldhausen, Southern Germany http://benedikt-gross.de/log/2013/06/avena-testbed_agricultural-printing-and-altered-landscapes/ [accessed: 27.05.2017]

Aspects

The 90s were about virtuality. We were fascinated by the new virtual spaces that are possible by using computer technology. Images of escaping into a virtual space that leaves useless physical space, cyber-space images - a virtual world that exists parallel to ours - dominated the decade. This phenomenon began with the obsession of media with virtual reality (VR). In the middle of the decade, the graphical web browsers have made a cyberspace a reality accessible to millions of users. (...) The virtuality has been domesticated. Filled with ads and controlled by big brands, it was neutralised. In short, to use Norman Klein's expression, it has become an "electronic suburb". [26]

In terms of the concepts of real environment and virtual environment, instead of treating them simply as opposites, it is more convenient to conceptualise them as lying at opposite ends of the continuum that we call the Reality-Virtuality (RV) continuum.[27]

There is a reason why you can not have an ebook, song or second hand program - because all bits are the same. The process of 'reading' an ebook is the process of copying its bits from storage, interpreting them, and displaying them, and every time you create a perfect digital simulacrum of something that has no original.

These three ideas have inspired and contributed to link a daily experience with the digital matrix. An attempt was intended to define the foundations of properties and processes that are subject to creativity based on a digital workshop and above all a digital matrix. These reflections led to the creation of a list of aspects of the digital virtual matrix. This list is considered rather in the sense of a research thesis than a finite, defined set. This list is primarily intended to act as a reference point when attempting to create a digital workpiece, which may give rise to the logic of work:

- Programmability
- Interpretability
- Coexistence
- Independence from time and space
- Scalability
- Interactivity
- Identity of the copy

Programmability

The basic building blocks of a digital matrix are the bits, that is information written in binary code - zeros and ones. This record is then encoded with higher programming levels that allow reading through a given software tool group. The ultimate form is a file, a data set described by the so-called extension, which recognises which software can serve as an interpreter for a given digital matrix.

The Bridge Project assumes that the virtual digital matrix, in addition to the data that determines the voxeli spatial structure on which the graphic is built, also has version's information version - an iteration and a date of creation. Based on these three parameters, the mathematical concept of a cellular automaton, originally proposed by

26. L. Manovich, The poetics of augmented space, „Visual Communicatons" 2006, Vol. 5 (2), p. 219–240.

27. Scheme of Continuity of Reality acc. to Paul Miligram and Fumio Kishino z 1994. http://web.cs.wpi.edu/~gogo/hive/papers/Milgram_Takemura_SPIE_1994.pdf [accessed: 27.05.2017]

▲The same 3D model before and after coding using Disarming Corruptor by Matthew Plummer Fernandeza.

28. http://www.plummerfernandez.com/Disarming-Corruptor/ [accessed: 28.05.2017]

29. Complex Systems 1; 1987; s.373–400; "Candidates for the Game of Life in Three Dimensions"; Carter Bays; Department of Computer Science, University of South Carolina, Columbia, SC 29208, USA

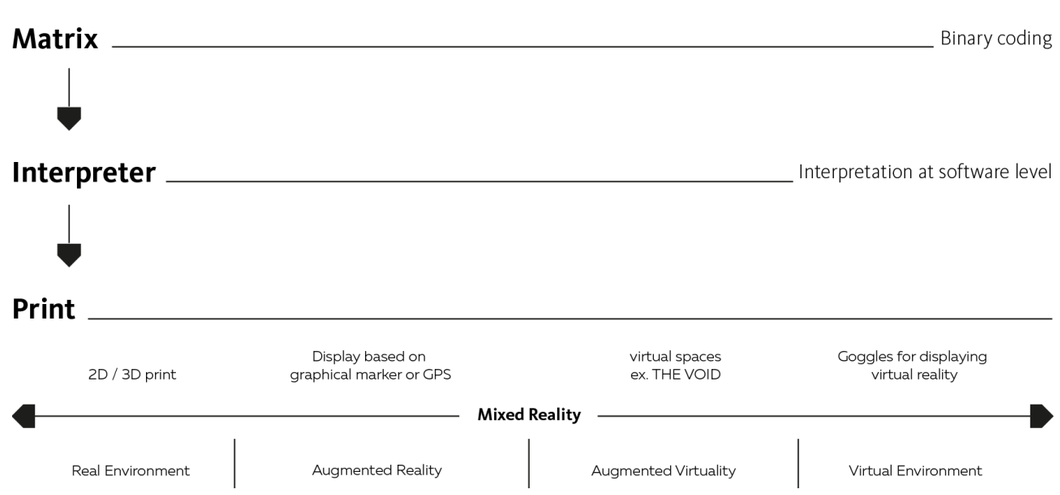
30. Martin Gardner, „Mathematical Games," Scientific American, vol. 223, no. 4, October 1970, p. 120-123.

▼Disarming Corruptor uses and algorithm that codes STL files modifying them through deformation and rotation of the 3D grid so that they are visually unrecognisable. [28]

John Conway for the two-dimensional space, has been implemented in the "Game of Life" mechanism. It was further developed for the three-dimensional space by Carter Bays. [29] "Game of life" is governed by four simple rules. Any live cell with fewer than two live neighbours dies as if caused by underpopulation. Any live cell with two or three live neighbours lives on to the next generation. Any live cell with more than three live neighbours dies, as if by overpopulation. [30] Any dead cell with exactly three live neighbours becomes a live cell, as if by reproduction. Finally, in a three-dimensional matrix was programmed "Game of life" based on the principle R = (5766) with an additional modifier 2≤E≥2 to better consolidate the linear structures. Each day, based on the device's clock of the instrument on which ARGarden is running, one iteration is made. Thanks to those principles, the same matrix every day changes its character. In addition, the principle of domination is implemented, namely larger objects have priority over the allocation of active points in the verification process after each iteration is implemented, imitating the structures where the "natural selection" rule is in effect for their benefit.

Interpretability

A virtual matrix is a set of instructions that, through the capabilities and limitations of an interpretive program, are materialised in a given form. The ARG matrix is an open file saved with standard C# serialization in a binary format. The same choice of .OBJ format for storing 3D matrix was dictated by the versatility of its format and usability. This format can be opened on any stationary or mobile device. The only thing that is required is the software which enables to read this format. The same applies to the PNG format in



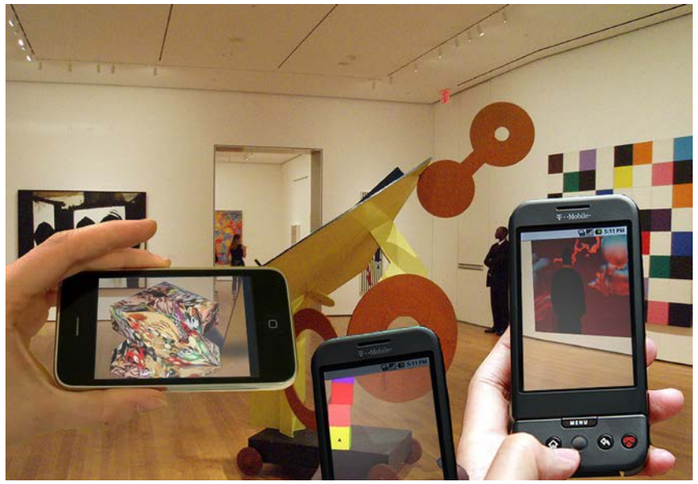
▲The process of matrealizing the virtual digital matrix in the form of any print realized within the framework of the continuum of reality.

which a screenshot from the ARGarden application is stored - a two-dimensional image of the matrix or its fragment. The .PNG format is just like.OBJ one of the most popular formats for displaying 2D graphics.

Interpretability manifests itself at the level of software that we use to display or print a particular digital image format. In the case of display, we

deal not only with the possibility of interpretation by the program but also by the display itself or a projector, its calibration or the technology used. The print from the same file will look differently on a 60" TV, a large format projection mapping on a building, or on a 4" black and white e-Ink display.

The matrix of digital virtual graphics has the ability to materialise throughout the whole Reality-Virtuality space. The print from a single matrix depending on the interpreter used can be materialised in any possible form. It can take the form of a two-dimensional printed graphic on any medium such as paper, wood, plexiglass, fabric; 3D printing in any size and technology: stereolithography (SLA), selective sintering and laser melting (SLS, SLM), deposition of fused material (FDM, FFF). It can take a form of a graphic embedded in virtual reality or augmented reality. The practical part of this project includes graphic compositions made in the techniques mentioned above.



▲ "WeARinMoMA" 2010 exhibtion organized by Sandera Veenhofa

Coexistence

The concept of coexistence is most likely to be seen in Bill Thompson's description, "Do not Mind Digital." The process of "reading" an e-book is the process of copying its bits from memory, interpreting them and displaying them, each time creating an excellent digital image, something that has no original.[31] The same matrix, the same bits of information independent of the place of storing or publishing. Dispersed trough physical media are always identical, file check is identical, so it is impossible to distinguish copies from the original. There is only a potentially infinite collection of the originals. In the case of ARGarden coexistence, it is of particular importance. The matrix is sent to the server from which it can be processed from anywhere on earth processed and uploaded again while remaining the same matrix.

Independence of time and space

As each digital copy of the matrix is also the original, it is also independent of time and space. It can be written and read at the same time anywhere on earth. For example, thinking about the parameters of a particular graphic or matrix can be assumed that it has ended its geolocation display ability to one or more locations on earth and thus possible to be watched only in augmented reality. A good example of this aspect is the exhibition "WeARinMoMA" which took place in 2010. It was organised by Sander Veenhofa and took place in the MoMA building in New York without the knowledge of the organisation. [32]

Scalability

In the context of digital graphics and capabilities of the materialisation of

31. Bill Thompson's "Don't Mind Digital" at #digiconf14: http://www.thebillblog.com/2014/04/dont-mind-digital-talking-at-digiconf14/ [accessed: 28.05.2017]

32. Sander Veenhof, "WeARinMoMA" 2010 http://www.sndrv.nl/moma/?page=invitation [accessed: 28.05.2017]

▼„Venus of Google" ,
Matthew Plummer Fernandez ,2013

its size the only limitation is the technology used. A copy of the same virtual digital graphic that is displayed on different screens sizes or resolutions will result in different outcomes. The projection can be displayed on the scale of the building or a human scale. Impact on our perception of the size of the prints will have both the camera settings in virtual reality or the size of the graphic marker in the case of augmented reality. Paper size and 3D printer size parameters are the only endpoints. The matrix itself is dimensionless. The final size of the print is assigned at the time of materialisation, to convert the file type, or a decision to target a display or printout.

Interactivity

While the first association of digital matrix are a two or three-dimensional image files .jpg, .png, .tiff, pdf, .svg, obj, .fbx a digital matrix may also take a form of a program. Code that runs in the environment executes pre-programmed functions where the image can be generated algorithmically, generative or interactive. The last property allows interaction with the audience and the environment where it alters a final image trough randomness or chance, which, by definition, is not possible in the case of purely algorithmic action. A good example of this case is Font. Font is the digital equivalent of typesetting font, which together with the shapes of letters stores a number of other features such as kerning, which arranges individual pairs of letters at an appropriate distance from each other or ligatures replacing with one sign the corresponding pairs of letters. Interesting examples of this type of solutions are in the works of Golan Levin. Eyecode (Golan Levin, 2007) is an interactive installation whose display is wholly constructed from its own history of being viewed. Using a hidden camera, the system records and replays brief video clips of its viewers' eyes. Each clip is articulated by the duration between two of the viewer's blinks. The unnerving result is a typographic tapestry of recursive observation. [33]

Identity of the copy

Copying is not a new phenomenon, but it was never as effective before the digital era. It never allowed for creation of a perfect copy. Bordering between reality and virtuality, and passing from one to the other and back again created virtual copies of physical objects and physical copies of virtual objects, which often did not have a third dimension before gaining it only in the process of copying or playback. "Venus of Google" (Matthew Plummer Fernandez, 2013), was "found" through a Google search using the "search using image" Search engine Google displayed visually similar results, and one of them was the image of a woman posing in a corset. Then the 'Hill-Climbing' algorithm was applied to control the automated construction of 3D object based on the two-dimensional sophisticated pattern.[34]

33. Eyecode (Golan Levin, 2007) http://www.flong.com/projects/eyecode/ [accessed: 28.05.2017]

34. Matthew Plummer Fernandez "Venus of Google" 2013; 17×9×30 cm; 3D Printed (plaster, ink, adhesive) http://www.plummerfernandez.com/Venus-of-Google [accessed: 28.05.2017]

Podsumowanie

My work ARGarden combines achievements in scientific research, digital virtual matrix based graphics, mathematics and study of digital prints by performing them in print 2D, 3D, display and introduction of virtual and augmented reality. My project demonstrates that the digital prints of virtual matrix can present countless different creations. Writing, drawing simple rules of logic processes through the use of computational tools contributes to the creation of complex forms, which are subject to interactions. I used relevant scientific theories and models to create patterns for graphics algorithms. I expressed preference towards natural phenomena as the sets of rules that are introduced to the computer with the use of programming. I'm creating graphics system generatively scrambled to lead to certain results. All this assuming that these are experimental, digital virtual graphics with their, earlier discussed, inherent properties of rules and processes of their formation.

As I declared from the outset, the created list of the attributes of a virtual digital matrix is not final. Changing and emerging new technologies redefine the above properties, retire them or introduce new conditions. For this reason, an attempt to define the final digital matrix seems to be impossible. It will always have the nature of a set of boundary values or microdefinitions describing its current status

The elements

Below is a description of the formal structure – the components of the practical part of the dissertation in the arrangement of the exhibition in the room Intermedia Experiment Gallery LAB303 at the Academy of Fine Arts in Katowice

2D prints
"BridgeF_v_0.1-0.4"; 670 x 300 cm digital print on Japanese paper
"BridgeF_v_1.2-1.6"; 67 x 300 cm digital print on Japanese paper
"BridgeF_v_1.1-1.5"; 67 x 300 cm digital print on Japanese paper
"BridgeF_v_1.1.3"; 50 x 50 cm digital printing
"BridgeF_v_1.3.1"; 100 × 70 cm digital printing
"BridgeF_v_4.1.1"; 100 × 70 cm digital printing

3D printing
"BridgeV_i_0.0" 15 × 15 × 15 cm; Spatial graphics; 3D printing PLA
"BridgeV_i_1.0" 10 × 15 × 13 cm; Spatial graphics; 3D printing PLA
"BridgeV_i_2.0" 13 × 8 × 12 cm; Spatial graphics; 3D printing PLA

Projection
"BridgeD_v_1.1" mp4; 1920 × 1080 px; h.264; 0:20 p. Loop; screening media 250 x 300 cm; Projector 2500 ANSI

Screen
"BridgeD_v_2.1.2" mp4; 1366 x 768 px; h.264; 0:20 p. Loop; display 16: 9, 32, "" bridgeD_v_3.2 "mp4; 1280 x 960 px; H.264 0:20 p. loop monitor is 4: 3, 21'

Augmented reality - ARGarden
Virtual Graphics can be viewed using a mobile device with the application - ARGarden spatial and a marker graphic installed. The application can be downloaded on mobile devices running Android and iOS.

Virtual reality - VRGarden
Connected in real time with ARGarden print – a dimensional form of graphics-based virtual matrix ARGarden.

Virtual reality - Internet
Graphics dimensional interactive 3D models uploaded to www.sketchfab.com Graphics are to be viewed through a web browser or the VR using Google Cardboard and an appropriate mobile device.
https://sketchfab.com/jakubcikala

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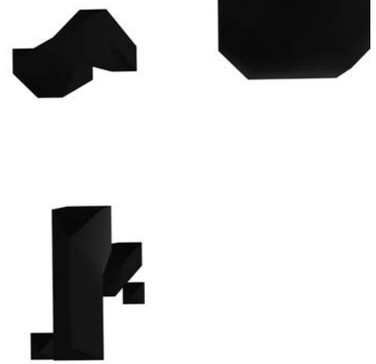
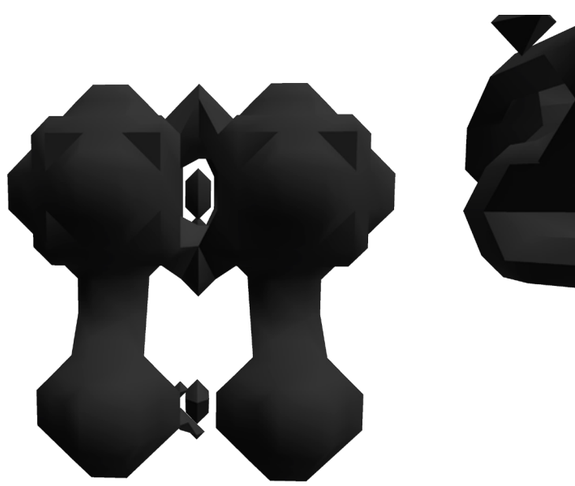
► Augmented reality - ARGarden; screencast.
ARGarden 2017r05m26d 16-38-24_1

►"BridgeV_i_0.0" 15 × 15 × 15 cm; Spatial graphics; 3D printing PLA
"BridgeV_i_1.0" 10 × 15 × 13 cm; Spatial graphics; 3D printing PLA
"BridgeV_i_2.0" 13 × 8 × 12 cm; Spatial graphics; 3D printing PLA

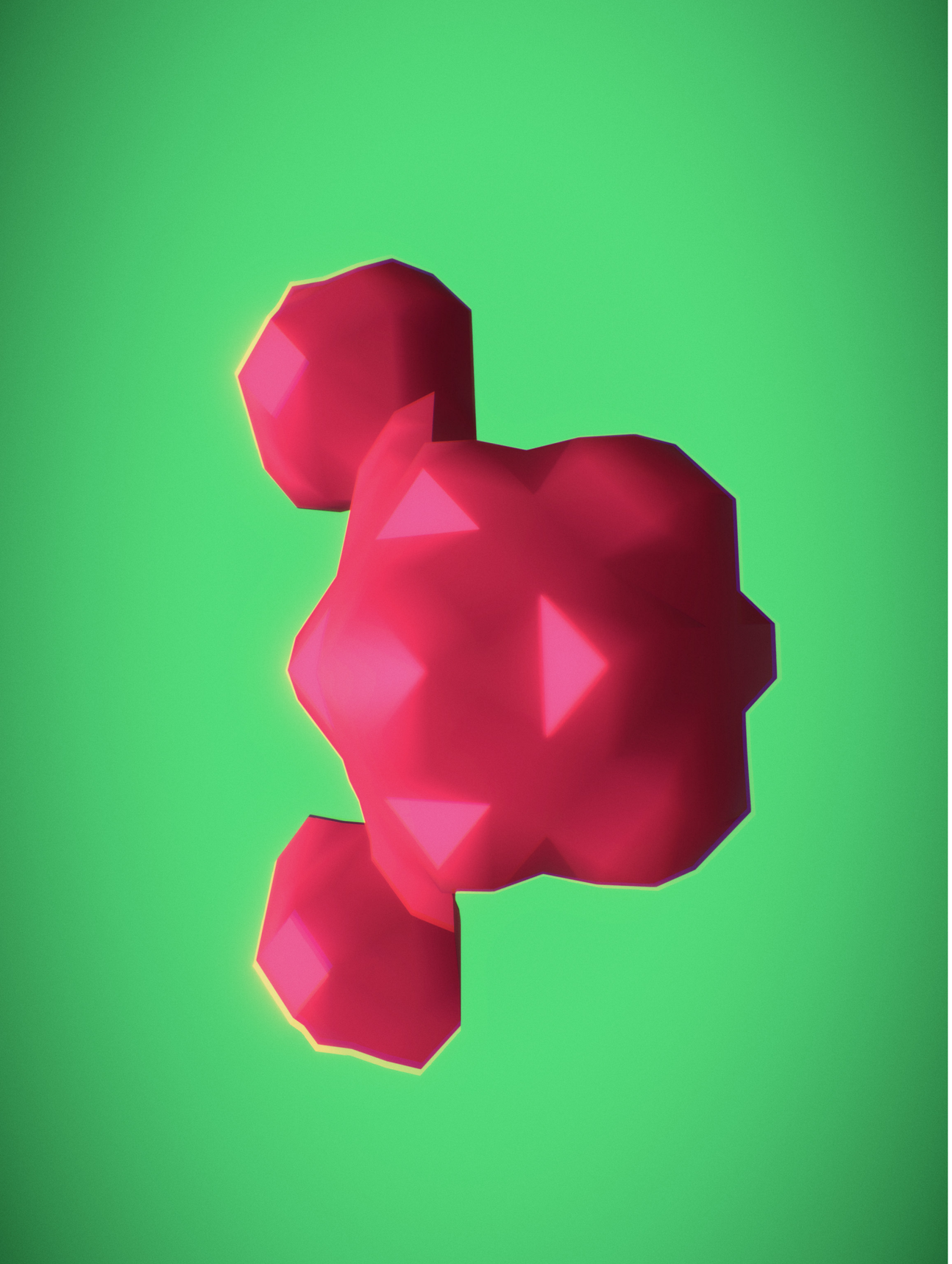
“bridgeF_v_4.1.1”; 100 × 70 cm digital print

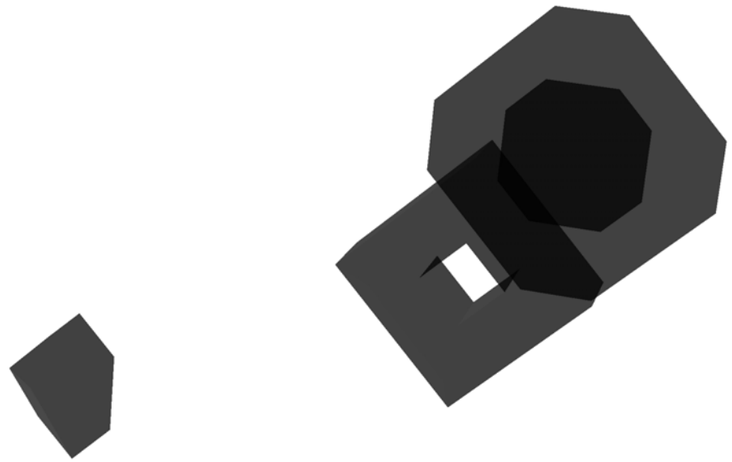


◀
“bridgeD_v_3.2” mp4; 1280 × 960 px;
h.264; 0:20 s. loop; screen 4:3, 21"



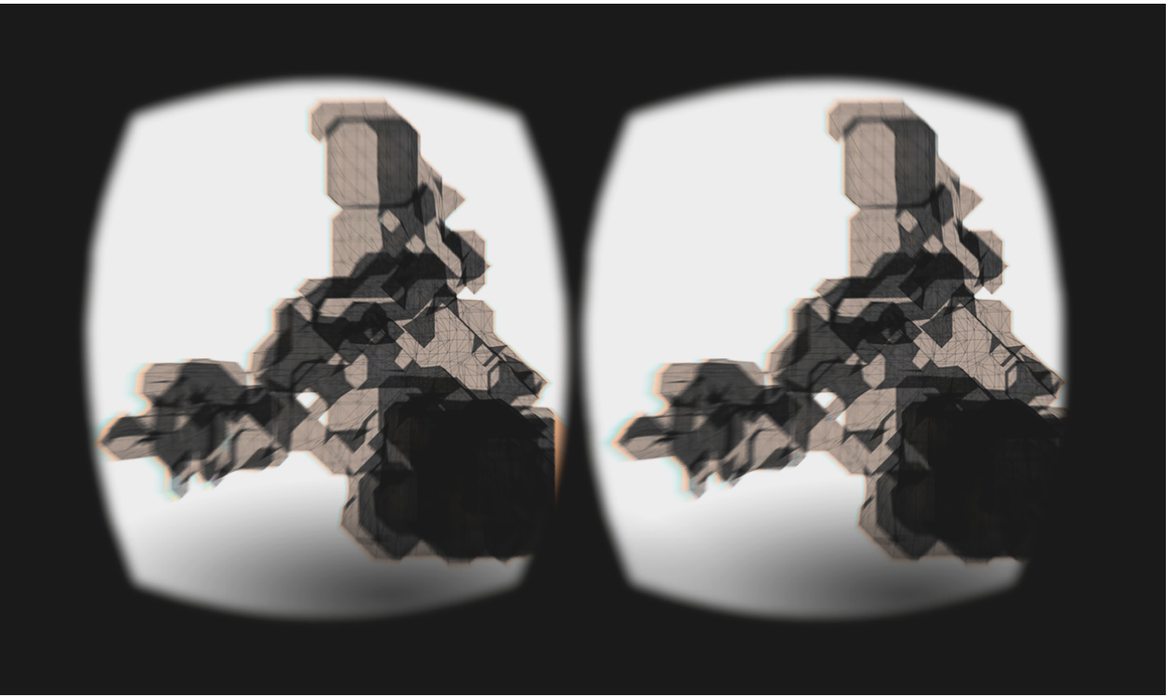
◀
“bridgeD_v_2.1.2” mp4; 1366 × 768 px;
h.264; 0:20 s. loop; screen 16:9, 32"





◀
“bridgeF_v_1.3.1”; 100 × 70 cm
digital print

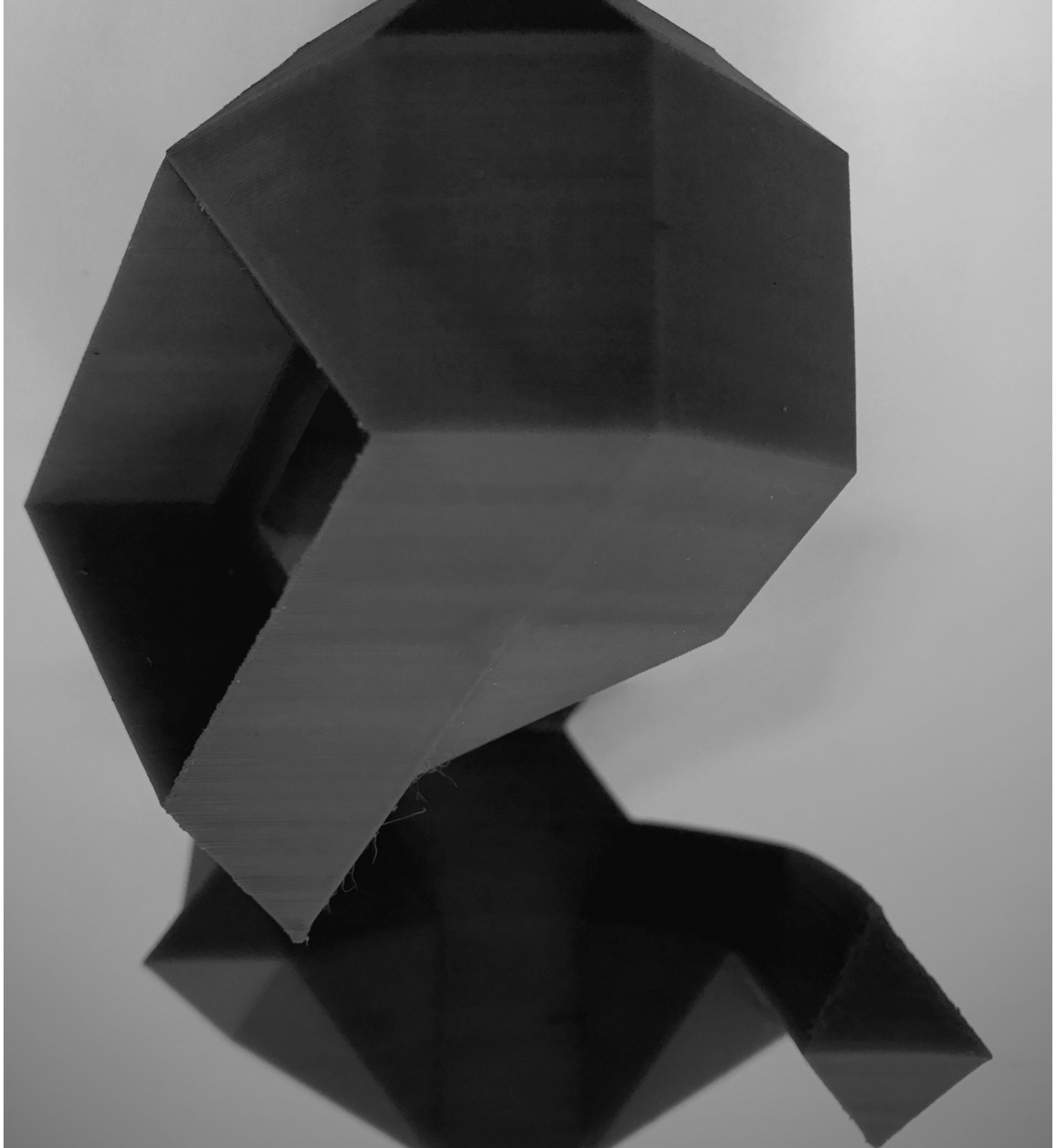
◀“bridgeF_v_1.1.3”; 50×50 cm
digital print



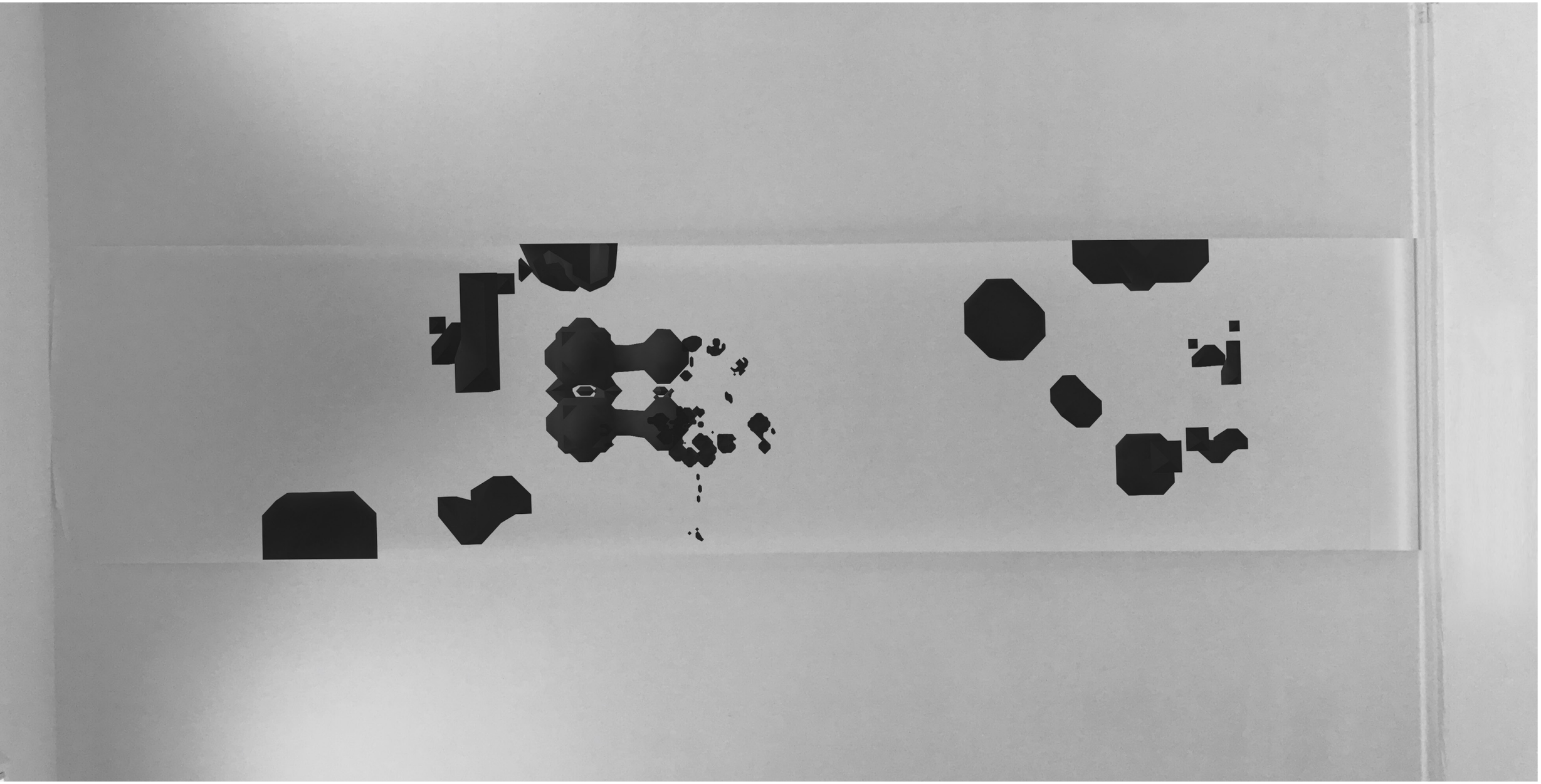
▲VRGarden,googgles screen view.

►“bridgeF_v_0.1-0.4”; 670 × 300 cm
druk cyfrowy na bibule japońskiej

“bridgeF_v_5.3.1”; 100×70 cm digital print



◀“bridgeV_i_0.0” 15 × 15 × 15 cm; spacial graphic; 3D print PLA,



▲“bridgeF_v_1.2-1.6”; 67 × 300 cm digital print on Japanese paper