2023

Building Immersive Environments Towards Non-Human Models of Organizing Against Global Crisis

Varela Reis, Luis Andre

https://pearl.plymouth.ac.uk/handle/10026.1/21247

Copyright

UNIVERSITY OF PLYMOUTH

BUILDING IMMERSIVE ENVIRONMENTS TOWARDS NON-HUMAN MODELS OF ORGANIZING AGAINST GLOBAL CRISIS

by

LUIS ANDRE VARELA REIS

A thesis submitted to the University of Plymouth

in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

School of Art, Design and Architecture

July 2023

Figure 0: MetaPh 2021.7165947. Photographic work © André Sier.

Acknowledgments

The work presented within this dissertation sprouted from a fertile ground, returning at the roots of computational space, extrapolating imaginary arts and starting to encircle it with the non-human, under the form of crafted experiential mythological videogames and bio-electronic aggregates. Imaginary interactive plateaus that could not have been possible without a quasi functional infrastructure made through a plethora of programmable machines, devices and algorithms, accompanying and studied by the author since 1995. Most predominantly, using FLOSS initiatives after 2006, based on advanced and open GNU/Linux systems, joined by early XXIst century open source programmable aesthetic tools, developed by hundreds of artist-programmers in projects like P5, ARD, OF, on top of which most his research projects and libraries of code are implemented. Hence a first word of recognition and acknowledgment is directed at the trailblazing minds carving possibilities that can be executed and performed with machines on innovative bottom up sharing economies.

From the soaring energy of exploring new lands, carving new concepts, for the inspiration and major influence exerted throughout their publications, artworks, tutorial sessions, keynotes, and above all, a brilliant conception of what a Planetary Collegium can be, hosting advanced teaching and research with practitioners at the highest level on a global playground, this research would not have been what it's begun to be without the invaluable contributions of the author's directors of studies and supervisors, Professors Roy Ascott, Mike Phillips and Jane Grant. Thank you for all the support and unwearied artistic and scientific expertise, whose vision were able to help shape formless potential and blunt substances into architectural vectors of influence and regions of frolicking, playing and running about in research as children and dogs in waves. Thanks also extended to travel companions and Planetary Collegium colleagues, in intense sessions among inspiring international conferences and peers, set at Shanghai 2016, Corfu 2017, Plymouth 2018, Athens and Porto 2019, in particular Tommaso Maggio, Julia Heurling, Regina Dürig, Seth Riskin, Rae Wu, Eric Lesdema. If an image could be set, boat diving and fireflies dazzling through the *nyx*, in the warm beginning of summer at Corfu.

Dedication

To M. and D.

Author's declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee. Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment.

Relevant scientific seminars and conferences were regularly attended at which work was often presented. Research outputs consist of: one book/catalogue and seven articles written and published; ten conference presentations and artist talks were addressed; five research and method sharing workshops were oriented; numerous (41+) exhibitions and events of creative output were performed throughout the course of this research since 2016 upon entering the Planetary Collegium's PhD program hub at the University of Plymouth, accounted for in the research outputs section, provided at appendix γ. Video documentation with a selection of 4 mythological videogames and 4 bio-electronic aggregates accompanies the thesis listed at appendix δ.

André Sier has asserted his right in accordance with Section 77 of the Copyright, Designs and Patents Act, 1988, to be identified as the author of this work in the format that was submitted to the University of Plymouth .

Word count of main body of thesis: 67181

Signed: Luis André Varela Reis

(André Sier)

Date: 27/07/2023

Building Immersive Environments Towards Non-Human Models of Organizing Against Global Crisis

André Sier (Luis André Varela Reis)

Abstract

The wolfanddotcom series of artworks seeks to establish new knowledge embedded in its practice within a nascent field combining the areas of aesthetic computation, interactive electronic arts, videogames, mythology, biology, human/non-human computer interfaces. Wolfanddotcom's research leads investigations on bio-electronic and imaginary arts alloyed with a mythological and non-human turn, mainly through the creation of dynamic art-sci constructs, in the form of mythological videogames and bio-electronic aggregates, by establishing multiple lines of flight onto a creative framework, seeking novel, procedural, immersive, cathartic and bio-electronic methods. With a final purpose of exploring new electronic-based arts' aesthetic regions, unexampled connections between generative (Eno) technoetic (Ascott) arts, videogames, mythology, biology, 11 cyber-environments' domains are conceived on a speculative neon paleolitikos epoch strata, a plateau which depicts aesthetic archeology from an imaginary geological age after the Anthropocene, featuring operational bio-electronic symbioses as aggregates combined from ruins of silica, transistors, algorithms, cells, plants, animals, electricity.

The research practice has a particular focus on the wolf, a totem animal that lives in territorialized packs, an apex species for the ecosystemic balance it inhabits, currently endangered worldwide essentially for economic reasons and insensitivity to the issues of biodiversity and sustainable development. The focus on the wolf underlines a distinctive approach to art making, not only to contribute to the creation of new aesthetic knowledge, but also to induce in the user a positively transformative cathartic state in safe ilinxian regions, self-operated by the fruition of the created artworks. Assuming their power to change a person, these aesthetic, interactive and immersive experiences in non-human cybernetic themes and environments can in some way (even if not directly or measurably)

enhance a critically conscious cyber-humanity, thus contributing to transform society and lead it to look at non-human organizational models as better responses to current socio-environmental global crisis, requiring urgent strategic survival action, supportive and coordinated like inbetween wolves, and ants and bacteria too, other natural models investigated in the series.

From the macro-micro-structure of binary encoded information to the processual flow programs execute on hardware, electronic machinic phenomena produce fascinating links with biological processes, providing invaluable research models. The research departs from observations of these micro-electronic worlds akin to living entities, creating art-sci constructs (amalgams of biological and electronic hybrid elements over a variety of media) as experienceable cyber-environments twofold: mythological videogames, where human users, through computer vision, sound, networked or haptic sculptural interfaces, full body immerse as dragons, phoenixes, wolves, minotaurs, on procedurally generated virtual worlds sculpted solely from bio-electronic data; bio-electronic aggregates (lasers, visuals, sounds, electronic byte sequences, genetic and generative algorithms interwoven micro-granularly with biological byte streams, plants, ants, wolves), where the devices forge tangible non-human biological and electronic apparatuses, spurring hybridization upon execution.

The research outcomes include interactive time spaces which summon play (Huizinga) and ilinx (Caillois) for human and non-human engagement, playful laboratories of non-human embodiment – self-inquiry and modification –, which broaden the base for establishing deeper human spiritual connections. They also include new static art-sci artifacts (3D sculptures, drawings, photographs, videos, organic paintings) entwined with the main interactive art-sci works. The overarching research ambition is that its outcomes may be not only effective contribution of new knowledge about interactive and immersive transformative tools/experiences, which subtly and acutely can contribute to reversing current emerging planetary crisis, but also as valid artistic instruments to speak of our time for future generations.

List of contents

List of illustrations

List of tables

List of acronyms, siglas, abbreviations

0 – zero

0R – zero reality

0X – ox, or zero crossings, or hexadecimal notation prefix

3D, 2D, 1D, 0D – three, two, one, zero mathematical dimensions

AI – artificial intelligence

AL – artificial life

AR – augmented reality

ARD – arduino computer

ARTEX - artist's electronic exchange network

art-sci – art and science

ASCII – american standard code for information interchange

AT – ada-turing machines

BA – biologic art

BASIC - beginners' all-purpose symbolic instruction code

BCE – before common era

BCI – brain computer interface

BIND – binary drawings

BIOD – biological drawings

BIT – binary digit

BSD – berkeley software distribution

BYTE – unit of digital information, commonly 8-bits. kilo-bytes (kb), mega-bytes (mb), etc.

C64 – Commodore 64 computer

CA – cellular automata algorithms

CaiiA – center for advanced inquiry in the interactive arts

CIBIO – centro de investigação em biodiversidade e recursos genéticos

CE – common era

CLI – command line interface

CR – consciousness reframed

CRLI – centro de recuperação do lobo ibérico

DNA – deoxyribonucleic acid, or genetic algorithms

EA – electronic art

EEG – electroencephalography

FACTT – festival of art & science transdisciplinary and transnational

FFT – fast fourier transform

FLOSS – free libre open source software

FPS – frames per second, or first person shooter

GA – genetic algorithms, or generative art

GNU – gnu's not unix

GPS – global positioning system

HCI – human computer interface

I2C – inter-integrated circuit

IA – imaginary art

ICLI – international conference for live interfaces

IP – internet protocol

JAR – java archive

JPG – jpeg compression codec format image encoding

K,k,k.,k.~ - kilo-bits first two, or my (sonic) kafkian land-surveyors

kbps – kilo-bits per second

LACE – los angeles contemporary exhibitions

LAN – local area network

LEA – labyrinthine electronic arts

mA – milliampère, one thousandth ampère (1e-3a)

MACBA – museu d'art contemporani de barcelona

MEIAC - museo extremeño y iberoamericano de arte contemporáneo

MIDI – musical instrument digital interface

MetaPh – meta photography

MIT – massachusetts institute of technology

MNAC – museu nacional de arte contemporânea

MoMA – museum of modern art

MU.SA – museu das artes de sintra

NaN – not a number

nm – nanometer (1e-9m)

NN – neural networks algorithms

NASA – national aeronautics and space administration

OF – openframeworks

OGL – opengl graphics library khronos group

P5 – processing

PC – personal computer

PDE – processing development environment

PLY – polygon file format

PhD – philosophy doctorate

POV – point of view

RAM – random access memory

ROM – read only memory

RMS – root mean square

rPI – raspberry pi computer

RPG – role playing game

RX – receive serial protocol

sci-fi – science fiction

SNBA – sociedade nacional de belas artes

ST – stochastics, procedural generation (procgen), or a xenakian series of opus, or an atari computer model

TA – technoetic art

TAP – zx spectrum tape file format

TNAF – the new art fest

TTT – taboo, transgression, transformation in art & science

TX – transmit serial protocol

UEd – unreal editor version one

URL – uniform resource locator

V/DBAP – vector/distance based amplitude panning

VR – virtual reality

VRML – virtual reality modeling language

W0, W1 – wolfanddotcom outputs

WiFi – wireless fidelity

WWW – world wide web

XR – extended reality

ZG – zeno and/or zero games

ZhDK – zürcher hochschule der künste

ZR – zero reality

ZS – zenospace

ZX – codenames british zx spectrum machines

Thesis outline

This outline is structured to help traverse the reader through research topics by providing an overview of the thesis which is accompanied by video documentation. Firstly, the title of the thesis: in its architecture and wording, it pinpoints the research domain coupled to the overarching aim, it lays claims to return purpose to the arts as well as establishes views that these tools/experiences can become affective vehicles within immersed participants providing infrastructurally exemplary directions to tackle global socio-environmental crisis. Then, a first consideration to justify the fact that, after the preamble's tone frequency, as a tribute to computer languages and electronic pioneers, whom have crafted tools providing means for the construction of rule-based programs in more advanced Ada-Turing (AT) machines[1], this thesis structure numbering starts at 0. A second remark around 0, since it is the first mathematical number element to express a possible void, it assumes a fundamental linking concept steering this research, 0 (zero) is also anthropologically and philosophically observed (0, ZR, 0D) in order to establish reasoning leading to thoughts drawing concepts and artworks orbiting the quested framework for imaginary arts (IA), which summarily opens up speculative quasi-trails & skylines rooted on electronic arts (EA), biologic arts (BA), technoetic arts (TA), artificial life (AL), extended reality (XR), virtual reality (VR), zero reality (0R/ZR).

Chapter 0 deals with establishing a broad introduction to the research. Firstly by providing a condensed gist of the research scope on 0.1, which includes the investigations' context, organization and outcomes, as well as a summary of its methodology, key concepts and reference studied paths associated to the field where the research foundations are based. Key concepts like *play, cybernetic, non-human, technoetics, generative, spatium, myth, imaginary*, aiming towards the formulation of aesthetic experiential cybernetic laboratories. 0.2 formalizes the research's goal, its fundamental queries, aims and objectives. 0.3 delves in the methodological approach and branches out towards methods for created cybernetic environments (playful laboratories) and static generated artifacts. Ethical issues finalize the thesis initial chapter 0 under 0.4.

---

1   Lady Ada Lovelace and Alan Turing form the author's inspiration of where programmable machines were invented, following Indian dust-abacuses, as well as mythological ancient devices, of which the Antikythera mechanism is an example (see Angelakis 2006, Ifrah 1998). AT machines which Lovelace and Turing dreamt could sing, utterly describe, synthesize unknown incoming worlds of utmost beauty and complexity.

Chapter 1 provides lineage of the aesthetic regions of interest and a state of the art within the researched field, it encompasses a conceptual and practical context covering crucial aspects related to this investigation in the fields of arts, sciences and engineering. It also establishes key terms crafted to address conceptual aspects of the produced works, axial to a framework for immersive non-human human playable cyber-environments. The introduction of these notions (*panvision, zenospace, imaginary art, zero reality, gaian field, aspatiality, quantum-now*) consist of introductory aspects to areas of research whose unfolding, primarily of the first four concepts, lay beyond the scope of this document, and are left for future endeavors. They constitute however crafted words to delineate regions in order to engage in the charted here research space, within the landscape provided mainly by the mathematical theory of communication, differential philosophy, complex numbers, chaotic and fractal algorithms, self-recurrence and strange loops, electronic and natural cybernetic systems, "*the computational beauty of nature*" (paraphrasing Flake 1998), upon its applications en route to imaginary art (IA).

Chapter 2 engages with the description and evolution of the wolfanddotcom series of works, where the artistic practice-based PhD research is applied. The chapter is multiplied with two sub-sections, where 2.1 unfolds engendered cybernetic environments, 2.2 static art-sci constructs. 2.1 begins by providing an extended ligature of the concepts introduced chapter 1 into the practical creation of the first three mythological videogames of the series, Draco.Wolfanddotcom.Info, Wolfanddotcom and Phoenix.Wolfanddotcom.Info. 2.1.4 addresses works that have labyrinthine roots, 2.1.5 and 2.1.6 describe bio-electronic opus. 2.2 proceeds to describe the static art-sci constructs grouped under the ruling cybernetic-environments, sorted by ascending date of creation.

Chapter 3 establishes concluding remarks by summarizing contributions to new knowledge, addressing research boundaries and limitations, permeable porosities and unaddressed interesting intersections, crashing/error routes, ending with looping future directions.

Appendices are included to expose underlying programming aspects on making libraries of code and interfacing techniques which are quintessential throughout the wolfanddotcom series (appendix α) described at chapter 2. Appendix β.1 lists an electronic byte sequence both as an example of the gathered raw electronic materials, and as a functional saved game in Rogue (Toy et al 1980) you can run. B.2 lists a biologic byte sequence from Half-Plant's 2017 logs and derives example aesthetic outputs as in β.1. Research outputs advent of these investigations (publications, conference presentations, workshops, exhibitions) are documented at appendix γ, while appendix δ provides video documentation of a selection of running mythological videogames and bio-electronic aggregates.

The text of this thesis is informed extensively on previously published articles crafted while performing the research (2016 to August 2022, listed at appendix γ), however it was extensively re-written and clarified, with further situation and speculation surrounding the works & quested framework. Sometimes sections of text are present in its entirely within the listed publications, but mostly from prior written versions; sometimes further information is documented in the articles themselves, in order for this thesis to be able to provide a concise and precise object of the work and practice-based research undertaken thus far.

«*It is a world of plants and animals, of divine epiphanies within the mountains and among the flowers, of apparitions that come from the sky, that the Minoan artists transport us to. The man, in its historical magnificence or not, is not there at its center. But the proximity of the divinity is frankly required. Within this general framework, the divinity could also manifest in a man, not less than in a swarm of insects, in birds or sea animals, or in a bull, and fixate the gesture that answers it like a model to imitate exactly.*» (Kerényi 1963:35) [2]

---

[2] Translation note: from a 1963 text by Kerényi entitled "Holy Crete", within a 2008 Portuguese book by publisher Assírio & Alvim titled "Estudos do Labirinto" ("Studies of the Labyrinth"), translated from the following Portuguese original: «É um mundo de plantas e de animais, de epifanias divinas nas montanhas e entre as flores, de aparições que vêm do céu, a que os artistas Minóicos nos transportam. O homem, na sua magnificência histórica ou não, não está aí no seu centro. Mas a proximidade da divindade é francamente requerida. Neste quadro geral, a divindade poderia manifestar-se também num homem, não menos do que num enxame de insectos, em pássaros ou animais do mar, ou num touro, e fixar o gesto que lhe responde como um modelo a imitar exactamente.»

«I will argue that today's composer are more frequently 'gardeners' than 'architects' and, further, that the 'composer as architect' metaphor was a transitory historical blip.» (Eno 2011)

«But weeding fecundates the cultivated plants = functional (in contradiction with the point of view of the gardener)» (Kandinsky 2002:194) [3]

---

[3]   Translation note: from Kandinsky's 1975 book "Cours du Bauhaus", Editions Denöel Gonthier, Paris, published in Portuguese by Edições 70 in 2002, translated into English from the Portuguese original: "Mas as ervas daninhas fecundam as plantas cultivadas = funcional (em contradição com o ponto de vista do jardineiro)." (Kandinsky 2002:194).

0. Introduction and overview

0.1 Research gist - context, organization and outcomes

In the obscured exciting times we are going through, the arts can and must have a transformative role, either by reconnecting the human with a spiritual yearning, or by inducing a positive transformative cathartic state, self-operated by coming into contact and communication with artistic works. Thus, artworks having the power to change a person, can consequently transform society, through the transformation of individuals.

Brian Eno, the originator of ambient music puts forward stillness, ambience, a tendentiously zero discretely changing music of tiny variations over time:

> *Long cassettes of music chosen for its stillness, homogeneity, lack of surprises and, most of all, lack of variety. We wanted to use music in a different way - as part of the ambience of our lives - and we wanted it to be continuous, a surrounding. [...] And immersion was really the point: we were making music to swim in, to float in, to get lost inside.* (Eno 1996:293)

It is unquestionable that cultural and artistic products accompany history, inevitably reflecting societal problems from different perspectives and perceptions. This is what Wassily Kandinsky affirms when he says in his book "Concerning the Spiritual in Art" (1911:22): *Every work of art is the daughter of its time and, many times, the mother of our feelings.*

It is also undeniable that periods of crisis or major ruptures such as the ones we are experiencing end up inspiring artists to research and create artistic works that induce a practical positive catharsis, with the potential to help the human being to change the way of self-seeing and seeing the world, and to open space to take the transformative social role of art to the level of purpose.

For several years, the creative practice of the author of this thesis has been developed within a multidisciplinary and broad domain, including many arts (painting, sculpture, music, cinema, videogames, technoetics), sciences (philosophy, mathematics, biology,

ecology, mythology), and engineering (informatic computation, electronic circuitry, machinic fabrication, electro-technical and systems programming). Most of his research has been carried out within a nascent field (which combines the areas of aesthetic computing, interactive electronic arts, videogames, mythology, biology, human/non-human computer interfaces), essentially focusing on bio-electronic and imaginary arts alloyed with a non-human turn that marks out the global area of investigation.

The wolfanddotcom research also leads investigations within this field, establishing multiple lines of flight seeking novel, procedural, immersive, cathartic and bio-electronic methods designed as playful aesthetic cybernetic environments, generators of interactive time spaces that summon play, for human and non-human engagement, as grounds for establishing deeper humane spiritual connections.

The central postulate of this research practice is that aesthetic, interactive and immersive experiences in non-human cybernetic themes and environments go beyond of mere entertainment and can be a valid tool inducing the desired transformative positive catharsis that enhances a critically conscious cyber-humanity. Also central to the investigation is the conviction that investigating factors of innovation in the creative process of this broad area leads to the creation of poorly or not mapped artistic outcomes, which contribute to the advancement of knowledge in the area and, in this way, enhance the broadening of the base for the establishment of deeper humane spiritual connections.

The researcher's personal reflection on his and other authors relevant work reflected upon this thesis, as well as the basic assumptions for research in the context in which the investigation is developed, led the author to constitute the process of artistic creation in this area (namely the process assumptions, methods and outcomes) as the object of study. It encompasses creating practice-based artistic constructs in the form of interactive videogames and bio-electronic installations, as well as static art-sci artifacts related to the main cybernetic creations, shaped like 3D sculptures, drawings, photographs, videos, organic paintings, accompanied with theoretical epistemologically based investigations and delineating a broad research field. Altogether these are the components of the investigation in which most of the research work of this thesis was developed.

The creative practice research component focuses on developing cyber-environments as experienceable electronic arts twofold: on the one hand, mythological videogame spaces, where human users full body immerse as dragons, phoenixes, wolves, minotaurs (through computer vision, sound, networked or haptic sculptural interfaces); on the other hand, bio-electronic aggregates, lasers, visuals, sounds, electronic byte sequences, genetic and generative algorithms interwoven micro-granularly with biological byte streams, plants, ants, wolves, where devices forge tangible non-human biological and electronic apparatuses, spurring ongoing mutual hybridization.

Figures 1, 2, 3, 4: Examples of research produced mythological videogames & bio-electronic aggregates. Depicted: Draco.Wolfanddotcom.Info (2015) at O Espaço do Tempo; Wolfanddotcom (2017) at XXth Bienal Cerveira 2018; Half-Plant (2017) at Consciousness Reframed XXI 2019; Bioscope #1 (2020) at Intimate Observations, Ermida S. Roque.

Both cyber-environments' domains, mythological videogames and bio-electronic aggregates, are conceived on a speculative neon paleolitikos strata, a plateau depicting aesthetic archaeology from an imaginary geological age after the Anthropocene / Chthulucene[4], featuring operational bio-electronic symbioses as aggregates combined from ruins of silica, transistors, algorithms, cells, plants, animals, electricity.

---

4   The Anthropocene, man's planetary geological age, is augmented under the light of Haraways' Chthulucene (Haraway 2016), which was developed in order to urge for a multispecies contextual narrative in facing current times of severe biodiversity collapse. Neon paleolitikos refers to a dystopic post-humans speculative setting where the biological and the electronic domains find ways to hybridize into distinct species.

Within the scope of the encompassing theoretical investigations and the delineation of a research field, the inquiry builds grounds upon well rooted landmark concepts referenced throughout this document. Particularly *play* (Fuchs 2015, McGonigal 2011, Fullerton 2009, Flanagan 2009, Bogost 2007, Galloway 2006, Aarseth 2001, Sutton-Smith 1997, Huizinga 1980, Caillois 1958) and *cybernetics* (Ga 2018, Pickering 2010, Ascott 2003, Gianetti 1998, Langton 1989, Fuller 1981, Pask 1975, Beer 1959, Shannon 1948, Wiener 1948), which are axial touchstones to the foundations of the aesthetic experiential laboratories, within the field of electronic technological arts. They are applied in the creation of artistic installation spaces, drawn and constructed for *immersion* (Lanier 2017, Davies 2005, Grau 2003, Benedikt 1992, Xenakis 1992, Novak 1992, Krueger 1983, Engelbart 1968, Sutherland 1965) and experimentation, associated with their related artifacts.

Immersion herein defined as the technological facilitation towards emotional enveloping of (non-)human sense data and/or physical body amplification subsumed into other features exclusive to the *non-human* or to the *mythological*, or bothly immersing emotionally and physically towards the *non-human* (Tsing et al. 2017, Haraway 2016, 1989, Grusin 2015, Chamovitz 2012, Parikka 2010, Vesna 2007, Simondon 2004, Deleuze 2004, Wilson 1990, Uexküll 1939, Aristotle 1910) and the *mythological* (Kerényi 2015, 2008, 1963, 1956, Coomaraswamy & Nivedita 2002, Colli 2001, Eliade 2000, 1957, Borges 1998, 1974, Spence 1994, Grimal 1987), bathing fully the source aggregates' qualia sensorium onto a specific and distinct, simulated or tangible destination aggregate, or a particular aspect of its sensing quality/modality, dually filling the source aggregate's perceivable/perceived spectrum with similar data it is used to sense, but most pertinently, overflowing onto the novel perceptive and emotional filling experience. Immersion where a body, or an aggregate, is sense data transported towards becoming an otherness*:* a step further than Manovich's *illusion* (Manovich 2001) and a step closer to Deleuze's *becomings* (Deleuze & Guattari 1988), as is expanded at 1.1.1 & 2.1.1.

Immersion in spaces mainly consisting of user driven touchable audiovisual systems, also derivative aesthetic objects sprouting across media upon refinement of the numerous tasks involved in the edification of laboratorial cyber-environments. Immersion guided by an aim to ultimately adhere, increasingly osmotically, human (or non-human) users onto the *non-human*, towards the *mythological*. Inhuman aesthetic imaginaries, lenses into an

unknown. Experience spaces, immersive laboratories distinct from what can socially be established as a common reality, as it is grasped by our biological non-augmented human sense data.

In the ambit of the thesis' object of study, several (7) focuses north driving directions, charted reference paths studied for the synthesis of the quested framework, underlined into sub-areas of creative practice made to address and explore mapless aesthetic territories, involving playful cybernetic environments, mythological videogames, (non-)human immersion in non-human constructs, while also speculating, via cybernetic installations of electronic and biological systems, tangible bio-electronic aggregates. The seven internal directions the thesis will approach and produce new knowledge consist of:

1) Computation, *technoetic*[5] (Ascott 1997) and *generative*[6] (Eno 1996) approaches, where rule based creative man-machine processes implemented through algorithmic languages on cybernetic **assemblages** are favored to human only generated artifacts (Mignonneau & Sommerer 2009, Ascott 2003, 1997, 1989, Galanter 2003, Hofstadter 1999, Eno 1996, Xenakis 1992, Krueger 1983, Sutherland 1965, Wiener 1948);

2) Sculpting digitally spatial navigable architecture engendered by creator crafted algorithms for the users' avatars new virtual spaces, which tap onto novel spatial (in)habitability directions, in aesthetic regions which build upon work by Hofstadter 1999, Flake 1998, Serres 1997, Xenakis 1992, Alexander 1964. Artists like Davies, Shaw, Sims, Novak, Viola, Krueger, Xenakis, Kandinsky, Escher, Piranesi;

3) Spatialized generative musical compositions, unfolded by user interaction with the systems that follow programmed algorithmic instructions and set afoot interactive, continual and non repeating sonic landscapes (after references of similarities and work

---

5   Coined by Roy Ascott, "Technoetics is a convergent field of practice that seeks to explore consciousness and connectivity through digital, telematic, chemical or spiritual means, embracing both interactive and psychoactive technologies, and the creative use of moistmedia." (Ascott 1997).

6   Emergent, bottom-up creation techniques, usually following simple local rules between individual elements within a system that sprouts macroscopic patterns gifted with complexity and elevated output variety. Generative art (see Galanter's 2003 "What is Generative Art? ") has grown considerably during the XXth century across all art fields and was coined by Brian Eno as generative music (Eno 1996:332): "From now on there are three alternatives: live music, recorded music and generative music. [...] The idea of generative music is not original to me (though I think the name is)."

built upon by composers Eno, Cage, Xenakis, Pärt, Risset, Schaeffer, Stockhausen, Ussachevsky, Bach);

4) Boolean logic, fuzzy logic and game mechanics of interaction within the virtual space (virtual here being an imaginary tangible construct usually posited through technology) and within the real space (through human/non-human machine interfaces) unfolding a works' full *spatium*[7] of intensive and immersive crafted ambients, hovering users through *abstract*[8] spatial displacements or *concrète*[9] narrative interaction (Deleuze 2005, 2004, Hofstadter 1999, Borges 1974, Caillois 1958, Kerényi 1956, Huizinga 1944, Abbott 1884);

5) Human and non-human machine interface design, which bridges the physical bodies, their data, gestures and sounds becoming interpreted commands that can be used for spatial displacements or virtual interactions onto the new proposed spaces (after references of similarities with artists Shaw, Davies, Novak, Vesna, Sommerer & Mignonneau, Viola, Krueger, Sutherland, Snow, Ikeda, Jodi, Paik, Stelarc, Tanaka, Manabe, Howse, Sims, Eno, Wright);

6) *Granular* (Roads 2004, 1996, Proakis & Manolakis 1996) and magnified micro and macroscopic observations of raw biological electrical signals living matter emits while displacing through time; also from raw electronic processes, from their structure on hardware, as byte sequences on memory registers' media, to operating systems permitting programs executing on electronic substrates, their data flows taking place in machines and in communications protocols within networks;

7) Static art-sci constructs, as sculptures, drawings, slowly evolving organic paintings, and dynamic cybernetic laboratories for user entanglement with live bio-electronic systems with *mythological* and *non-human* baselines, resonating observations of kinship

---

[7] Spatium is Deleuze's *intensive space*, where his *virtual* merges completly with the *actual*, an ideal or metaphysical surface, a hyperspace, a *plane of immanence* where the being and its thinking expresses its full scope. See for example Burchill 2007:154-60.

[8] Abstract expressionism art was a major driving force establishing alternative directions other than popular realistic painting into expressing the spiritual of the self and of art at its fullest by "*renouncing the object altogether, throw it to the winds and instead lay bare the purely abstract*." (Kandinsky 1911:169)

[9] Concrete borrowed from the lineage founded by *musique concrète*, where portions of reality are sampled with devices and transposed to an artistic plane by composing music with recorded samples as raw materials (Schaeffer 1952).

and similarity between biological and electronic information, creatively exposing their structurally inherent rhythmic organization of data over time and space.

While the disciplines and internal driving research directions described here are not new to a reader familiarized with interactive electronic arts, nor the final outcomes (consisting of interactive spaces for aesthetic experimentation and fruition, or the static art-sci constructs, usually machine fabricated derivative artifacts that come into existence by walking the long path of conceiving, programming and composing the interactive cybernetic laboratories), new knowledge is sought technically and artistically by this research threefoldedly:

a) By devising new algorithmic strategies for opus composition, of interactive rules applied in space and time, and the programs' associated game logic coupled with interfaces for immersion within human and non-human users through natural and often invisible bridges, like sounds, computer vision body gestures, or mediating objects with full body physical computation or networking situations.

b) By restructuring and looking beyond the habitual sonic, visual and other human-centric rendering pipelines[10] (whose mainstream purpose is a creation of a fabricated, near photo-realistic entertaining reality, whose sense data and internal logic is akin to normal human sense data reality apprehension), with a final purpose of exploring new electronic arts' aesthetic regions, new non-human audiences and creative collaborators, and unexampled connections between generative technoetic art, videogames, and mythology, biology.

c) By creating cybernetic laboratorial constructs, the dynamic art-sci constructs, in the form of interactive videogames and bio-electronic installations, as well as new artistic static art-sci artifacts related to the main interactive creations (3D sculptures, drawings, photographs, videos, organic paintings, etc).

[10]   Rendering pipelines is an expression borrowed from the computer sciences' OGL of cybernetic implications which refers to a complex stack of algorithmic procedures that formalize the transformation of source data into output rendered images, an expression that could also be applied to sonic or other computational processes. "Most implementations of OpenGL have a similar order of operations, a series of processing stages called the OpenGL rendering pipeline. [...] Geometric data (vertices, lines, and polygons) follow the path through the row of boxes that includes evaluators and per-vertex operations, while pixel data (pixels, images, and bitmaps) are treated differently for part of the process. Both types of data undergo the same final steps (rasterization and per-fragment operations) before the final pixel data is written into the framebuffer." (Woo et al. 1997:10)

These kinds of research materialize what can be considered as the innovative strategic research axis that forms and contributes to shaping the global methodological approach further described at 0.3. As a catharsis inducing mechanism, promoting immersion through seemingly transparent interfaces onto experiences of emotional tension release, purgation or purification, like flying, fireball cusping, laser and sonic ant bathing, fostering adhesion to the research created cybernetic laboratorial constructs: by simulating the vivid experience by which users, human and non-human alike, are set as explorers in an imaginarium of a post-human world, set in a post-Anthropocene epoch, creatively coined as neon paleolitikos, dating since the decline of mankind until the apex of bio-electronic life forms.
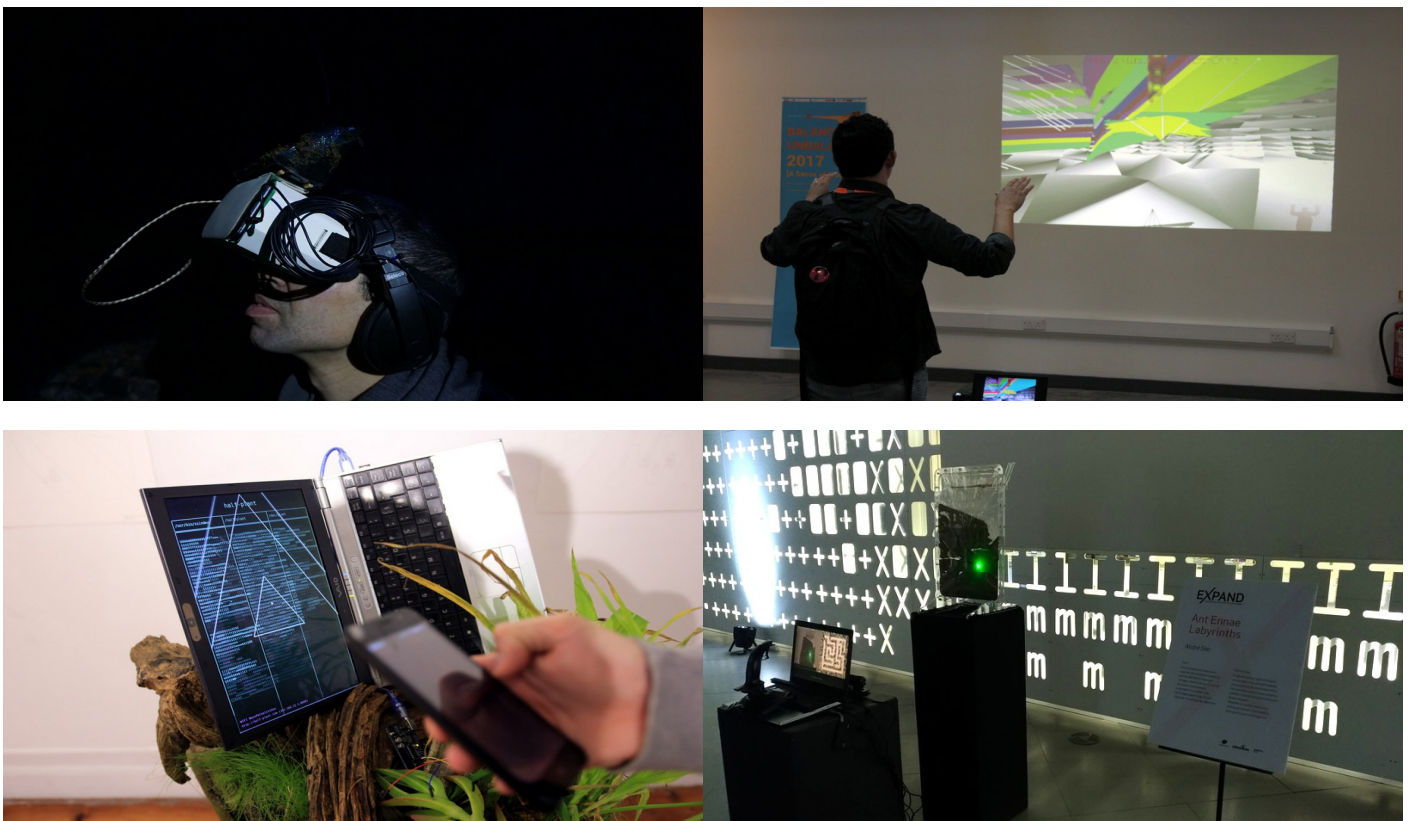
Figures 5, 6: Visual examples of research produced towards human immersion onto mythological videogames: sound input and gaze interaction in VR opus 0X Labyrinth at Lady of the Labyrinth's Honey, Zaratan, Lisboa, Jan-Mar 2020; Computer vision detecting flying gestures in Phoenix.Wolfanddotcom.Info at Balance/Unbalance 2017, Plymouth University.

Figures 7, 8: Examples of research of non-human immersion onto bio-electronic aggregates: sound and sensors linked to plants in Half-Plant at Neon Paleolitikos, Ocupart, Nov-Dec 2017; Laser beam rhythmically composed for ants in Ant Ennae Labyrinths (2019) at Expand, Centro Ciência Viva.

By focusing immersion onto a non-human reality, by departing from the anthropocentric model and leading humans towards inhuman realities, as was once the

established ideology by humans inhabiting our ancient planet, of which mythology, alternative anthropological models and other societies have once furthered (as demonstrated by Viveiros de Castro 2014, Deleuze 1980, 1969, Kerényi 1968, Artaud, Zeno), the immersion onto the non-human with mythological videogames and art-sci constructs of bio-electronic aggregates serves here as the means to promote cathartic immersion and to restore a longing, in a direction where artistic disciplines may shine light onto incoming obscured times, shadowed by the human hubris and its geological age overwhelmingly taking over all planetary resources, failing to attain a balance. Instead, we look for models that can be inspiring and shifted to practice, the natural, the biologic and electronic, non-human worlds. For art is a practice of essential role and can aspire to be a vehicle leading transformative outcomes.

Art is born and takes hold wherever there is a timeless and insatiable longing for the spiritual, for the ideal: that longing which draws people to art. Modern art has taken a wrong turn in abandoning the search for the meanings of existence in order to affirm the value of the individual for its own sake. (Tarkovsky 1998:38)

Figure 9: Still image from Andrei Tarkovsky's Stalker (1979), seen here as poetically alluding to themes from the wolfanddotcom research, like a roadside picnic on the collapse of the Anthropocene, embracing nigh 71% water, 29% human + non-human. Screenplay for this spiritual science fiction movie was based on Roadside Picnic by Arkady & Boris Strugatsky (1972). Image © Andrei Tarkovsky 1979.

Instead of a common enterprise ruled by commercial and capitalistic market ideas, the arts can and must have a transformative role. On the one hand, art reconnects the human with its spiritual longing, this timeless and insatiable yearning Tarkovsky alludes to, which

will be reprised when analyzing labyrinths, zero, and wolfanddotcom's labyrinthine opus (sections 1.2, 1.3, 2.1.4) and upon the concluding remarks (chapter 3). On the other hand, some of it leads an internal transformative cathartic role, self operated, by coming into contact and communication[11] with such artifacts, experiences or devices. The essential role art elevates the human spirit to, answering to a timeless insatiable longing for the spiritual, for the ideal. As Tarkovsky poignantly places it, art engages the very core of the meanings of human existence, art involves a practice reconnecting humans with deeper spiritual communications, provides ilinxian[12] (Caillois 1958), dishorienting, life changing experiences.

This practice-based creation of new knowledge areas, by ways of making new works, appealing immersion, framed with theoretical considerations, allows for both deep inquiring and the creation of tangible prototypes that research a broad latitude of aspects upon the investigation's theme. These outcomes establish grounds for deeper human spiritual connections, according to the belief that the speculative objective of a practical positive immersive catharsis is stepped through. These aspects will be expanded and combined in upcoming works, informed on the research undertaken as well as critical appreciation on the reception of the works themselves. Many of these outcomes were presented as research updates, published papers, exhibited artworks, workshops tutoring, artist talks, conference presentations, referenced at appendix γ research outputs.

Technoetic Arts (TA), inaugurated by Roy Ascott's technoetics, holistically merges arts, sciences, technology and consciousness research. It can provide cybernetic cultural helmsmen means and tools, essential in steering mankind. Just like culture and its artifacts have been doing for the human throughout his existence. Artistic constructs condense in a single stroke the knowledge of sciences, the technology of machines, processes, fauna and flora, steer and feedback, provide mechanisms for deeper artistic visions answering seemingly unquenchable human longings, of contemplating and/or inhabiting the artifact, the experience, the bridge that allows these emotions and understandings to come full circle.

---

11 "The word *communication* will be used here in a very broad sense to include all of the procedures by which one mind may affect another." (Weaver 1963:3)

12 Ilinx is a category of games and a kind of play Roger Caillois ascribes in his seminal 1958 book *Les jeaux et les hommes* to a temporary disruption of perception capable of inducing alter perceptive experiences, like vertigo, dizziness, brief acute disorientation. This playful outer body experience resembles key elements of knowledge incorporation, change, Deleuze's (1968) foundation of differential ontology.

Furthermore, being influenced by innovative technoetic arts and its intertwined methodologies, in order to explore "consciousness and connectivity through digital, telematic, chemical or spiritual means" (Ascott 1997), not only in the human, but to investigate further alter consciousnesses and incorporate the non-human back into the human, both as "a model to imitate exactly" (Kerényi 1963), "deterritorializing" [13](Deleuze & Guattari 1988) from the human (or another non-human element) into the non-human, or into the imaginary, the mythological, and twain, as an audience member, or collaborating performative partner, where ants or plants, wolves, dragons or biological materials and electronics with their digitized data become central helmsmen, cybernetically steering purpose on the works.
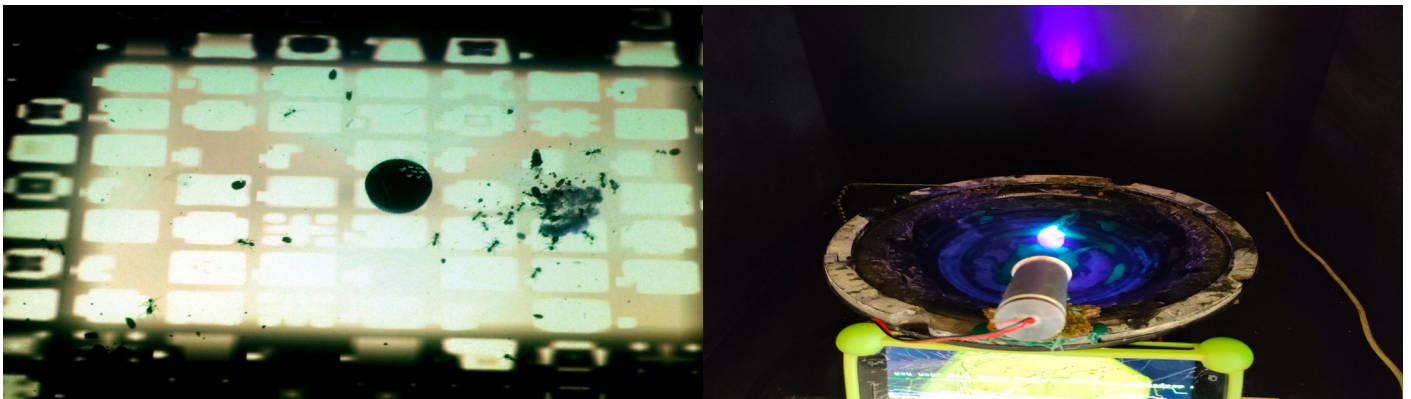
Figures 10, 11: Two examples of non-human communication, immersion and moistmedia installations. Immersing ants in an rPI audiovisual cellular automata ecosystem in *Half-Ant* (2020), at Lady of the Labyrinth's Honey solo exhibition, Zaratan, Jan-Mar 2020, Lisboa; Biological material growing with water, honey, sound, electronic divinations and laser interaction in *Honey Krater* (2019) at International Conference for Live Interfaces ICLI 2022, Universidade Lusófona, Lisboa.

Within these opus ecosystems, meaning is experimentally sought, similar to bottom-up electronic generative algorithms (GA), whereabouts the macro-structure is unknown and emergent, since it is derived from local rules situated at an elemental level, sourced here either from the biological sphere or from the electronic one. TA methodologies juxtaposing isolated fields onto moistmedia[14] (Ascott 2007), where the "dry" digital world intertwines with the "wet" biological sphere, giving rise to interdisciplinary fluid frontiers - neither dry nor wet but moist -, where the creative tools are amplified with features

---

13 Deleuze's (1988) concept of territory automatically includes deterritorialization within, for he builds territory as a delineated yet porous region traversed by turbulent lines of flight, of becomings, incessantly moving within and which can reform frontiers.

14 Ascott's moistmedia, the "moist domain" combines virtuality's "dry world" and biology's "wet world". Moistmedia is a concept made by Roy Ascott (1998) ascribing the creation pallete to be fluid and interdisciplinary, with a heightened scope, like Deleuzes territories with vibrant lines of flight in between regions, hybridizing new practices, new interdisciplinary spaces.

typically ascribed to either one of the fields, a strict inquiring amalgam of bioelectronics, where the final outcomes assert fundamental lines of flight "(det)territorializing" from either field.

Figures 12, 13: Electronic + non-human communication field work. Laser-ants communication documented in series of photographs *Eusocial* (2018); Portable robotic laser beams built for non-human ecosystem communication in *Wolfmachine* (2020-22), depicted in installation *Wolfmachine Cerveira* at Espaço/Programa April-June 2022, Fundação Bienal de Cerveira.

Figures 14, 15, 16, 17: Examples of research produced static art-sci works. Depicted *Neon Paleolitikos Drawings* (2017-) at Uivo, Casa de Cultura Nov-Dec 2021 Ericeira; *Universal Automata* (2011-), *Binary* and *Biological Sculptures* (2017-) at Boundless Objects, Fundação Eugénio de Almeida, Évora Oct19-Mar20. *8-bit Maze Gardens* (2018-) at Cantina Lx Factory 2018-20, Lisboa; *Totem-Lobo #1* (2021) at Iberian Wolf Recovery Center (CRLI), 2021-, Mafra.

In the wolfanddotcom investigation, the contribution to the advancement of knowledge in the field in which the research is inserted constitutes the central element of the thesis, being materialized and expressed in a threefolded way:

a) dynamic art-sci constructs, in the form of interactive videogames and bio-electronic installations, as well as new artistic static art-sci artifacts related to the main interactive creations (3D sculptures, drawings, photographs, videos, organic paintings, etc.);

b) technoetic arts, created not only using moistmedia techniques, to enhance a critically conscious cyber-humanity, but also proposing interactive constructions that could be considered as change-inducing tools;

c) pinpointing of new areas of knowledge in electronic arts, which involves flowering / expanding artistic, theoretical and engineering knowledge, in non-realistic / imaginary representations of cyberspace.

0.2 Goal, research questions, aims and objectives

As an artist seriously committed to contributing to the high purpose of positive social transformation through art, this thesis is developed from a compelling desire to achieve the goal of gathering and advancing knowledge embodied in practice within a field combining areas such as aesthetic computing, interactive electronic arts, videogames, mythology, biology, and (non-)human-computer interfaces. Doing so, we will challenge in this research area the prevalent lack of artworks with the power of inducing positive cathartic states to transform society through the individual's transformation, a lack that reveals an apparent inattention in the area regarding the purpose of the art's transformative social role.

Inherent to the author's great aspirations are problems or difficulties of concretization, which led to identify and propose solutions based both on previous knowledge on the subject and on his creative imagination, thus with potential viability in aesthetic and conceptual practices. These likely solutions, so-called research questions, are central to the creative research process, and may, in the case of this thesis, be formulated as follows:

- Can human or non-human interaction with immersive cyber-environments consisting of mythological videogames and bio-electronic aggregates promote experiences of going beyond / beneath (non-)human condition through sense-altering perception-disrupting (ilinx)?

- Can the interaction with art games and bio-electronic systems induce new knowledge, new experiential territories, new perceptive experiences of mythological or non-human spaces?

- Can human consciousness, self-awareness, through videogame technology and bio-electronification, programming, interaction and immersion lead to transformative outcomes of the ways by which (non-)humans experience / inhabit reality?

This thesis' aims, the specific actions to be developed within the research scope, are comparable to guiding processes to respond, more or less closely, to the research goal, being therefore categorized as primary and secondary. They are presented below and, whenever relevant, accompanied by the associated applied methods. As shall be seen on the methodological approach (0.3), one particularity of this research is that primacy is attributed to practice. Probing, testing, prototyping new ideas: the emergence of practice, following a resonating theme, is implemented across multi-media, leads the theory through multiple lines of flight, returning aspects that are later reflected upon, refined and conceptualized.

The primary aims (A1-A3) are: (A1) to contribute new knowledge to the making of aesthetic experiences, through videogames/interactive installations, and novel artistic objects related to the main interactive creations (3D sculptures, drawings, photographs, videos, organic paintings, etc); (A2) to create TA & IA, using moistmedia techniques to enhance a critically-aware cyber-mankind, and proposing interactive constructs that go beyond mere entertainment, and that might be regarded as change inducing tools; (A3) to pinpoint new areas of knowledge in interactive arts, which involves flourishing/expanding artistic, theoretical and engineering know how into non-realistic/imaginary depictions of cyberspaces.

The secondary aims (A4-A6) include: (A4) to build tools and experiences capable of inducing change at an individual level, fostering deeper and more engaging cathartic / educational / ilinxian experiences, while proposing immersion in new virtual bodies / experiences / cyberspaces; (A5) to speculate in the now about how a humanless future might look like, emerging from the debris of our current technological and biological peaks; (A6) to create playful laboratories of human intervention, self inquiry and modification through interaction, catharsis and non-human embodiment of the users experiencing the interactive artworks, as well as non-human immersions that also lead towards the creation of bio-electronic aggregates machines, where the electronical and the biological combination is expanded upon further.

In addition to these main objectives, with a broader, more panoramic scope, there are still others to consider, at a more detailed level, which are briefly presented below, categorized as general and specific.

General objectives (G1-G6) are to:

G1. Theorize and conceptualize about immersive interactive videogame otherness experiences and bio-electronic constructs.

G2. Identify raw, low-level, non-human life forms and electronic rules, behaviors, at individual and community levels.

G3. Identify life forms cognitive systems suitable to be used in ilinxian game experiences. Identify electronic data from programs' structure and execution suitable to engage bio-electronic experiences.

G4. Develop principles for distinct categories of ilinxian games and bio-electronic systems, including novel human-computer interfaces, ilinxian game categories, non-human methods, programming and interactive paradigms.

G5. Identify theoretical and technical frameworks of imaginary art, ilinxian, non-human videogames and bio-electronic experiences, developing practical applications as static art-sci constructs or dynamic art-sci experiences.

G6. Document reactions and immersion to mythological videogame and bio-electronic interactive environments through participants' observation and subjective interviews.

Specific objectives (S1-S4) are to:

S1. Outline modes of mythological videogames and bio-electronic devices based on ilinx and moistmedia, developing prototypes of experiences that promote disruption of the human perception into non-human forms.

S2. Identify sub-categories of immersive ilinx in games in the prototypes to develop.

S3. Prototype innovative aesthetic experiences using videogames, immersive technologies, bio-electronic media, procedural algorithms and non-human methods.

S4. Assess immersion and disruption of perception relative to exposure to prototypes through observations, interviews, analysis of biological indicators acquired during exposure.

As already expanded (0.1), by setting forward this serial practice-based work related to the researched series of artifacts within the wolfanddotcom series (which is set around this idea of raw animality combined with electronics, interfaces, cyber-environments, grounded in the experience of interactive playful laboratories), it is expected that the inquiry research questions alongside the associated aims and objectives lay the foundations of a possible framework, where immersive experiences in non-human subjects and themes might be a valid, deeper and more engaging artistic tool, to speak of our time to future generations, and to help gather knowledge, through immersive catharsis on logic spaces, about deeper educational tools/experiences, which subtly and sharply attempt to reverse the current planetary crisis, derived from the plundering of the planet for profits, evident during the Anthropocene/Chthulucene.

0.3 Methodological approach

The electronic artistic work the author has been producing since the mid 1990's is serialized, for it reverberates core ideas within a series, by establishing multiple lines of flight actualized in distinct pieces belonging to the same series. The practice based artistic research undertaken since 2016 until August 2022, upon joining Roy Ascott's Planetary Collegium PhD program on its CaiiA hub based at Plymouth University, in intense sessions among inspiring international conferences and colleagues, set at Shanghai, Corfu, Athens, Plymouth, Porto, is rooted and inspired in previous artistic practice as electronic artist since 1997[15]. The research is grouped and serialized under a far-reaching inquiry titled "Building Immersive Environments Towards Non-Human Models of Organizing Against Global Crisis". The immersive environments are based solely on the artist's wolfanddotcom series and quest an imaginary arts' framework (IA) axialized with mythological videogames and bio-electronic aggregates for immersive non-human human playable cyber-environments.

Besides the *wolfanddotcom* series, the *struct*, *uunniivveerrssee*, and *piantadelmondo* series are also worthy of mention for their precursor role in the making of this research (Sier 2018, 2017, 2011), strange field attractors (Casti 2000) contributing fractal meanings and refined new techniques in the making of immersive environments.

Figures 18, 19, 20: Screenshots of online portfolio documentation (https://andre-sier.com) from the previously developed major series of works struct (1999-), uunniivveerrssee (2007-), piantadelmondo (1999-).

15   An online catalog of selected artistic work is documented at https://andre-sier.com.

The work within the PhD program consists on several artworks attempting to address a new research field which is informed by the artist's previous aesthetic practice, where each artifact focuses a specific query actualized as an artistic object or interactive installation. The series conceptual basin sets the leitmotif landscape of experimentation. Here, each of the series' works approach and draw regions within it, expanding its scope while bringing forward a distilled essence in a nutshell. The core overarching methodological approach on this PhD inquiry consists thus in establishing multiple lines of flight which seek novel immersion and cathartic methods of non-human and mythological embodiment, as well as new aesthetic outcomes, while engaging interactive, videogame, mythical and non-human themes, mediated through custom computational methods made apparent in the works themselves, whether they are interactive installations, videogames, bio-electronic devices or static art-science constructs.

This methodological approach reflects and is grounded on the above expansion of the thesis title, which carves an expression that condenses the core aspects investigated by this research: building immersive environments towards non-human models of organizing against global crisis by questing an imaginary art's framework for immersive non-human human playable cyber-environments; which, overarchingly, while highlighting new aesthetic grounds, contributes to infrastractural changes seeking better models to tackle global socio-environmental crisis. The serie's title *wolfanddotcom* provides this conundrum in a word. It alludes to a juxtaposed and poetic single word combination made out of animality and cyberspace (wolf and dotcom), and it names the series of aesthetic works brought forward by this research. Wolfanddotcom series' name is intertwined by two apparently antagonistic case examples from distinct fields which are brought together in the making of this research: wolves and their packs inhabiting territories, delineating a non-human space; human activities in cyberspace (capitalism, knowledge, art, etc.) scattered among computers and communicated electronically in the dot com era; both aspects looked at equally from within the Anthropocene, as if two faces from the same coin, as two kinds of animals sharing the same world (see also figure 9).

Questing is a word reminiscent of pioneer computer adventure videogames which tend to put forward interactive ludic works with goal oriented behavior, whereas its logic is driven by puzzle solving and narrative unfolding operated by the player throughout the often large game intensive space. And we quest a *framework* for *imaginary art (IA)*, where the proposed tangible constructs address a combination of imaginary *aspaces* built by the human mind, i.e., the omni-present "virtual" plane in the "actuality" of the human (Deleuze 1969), or the complex plane in mathematics – the "imaginary plane" –, made by a conjugation of real and imaginary numbers to form a special plane quite helpful to solve everyday physical problems (Struik 1989, Hofstadter 1979), or even yet, compounding syncretically mythology, non-human, differential philosophy and complex mathematics with a reading of imaginary art brought forward from previous and precursor aesthetic movements.

A wider aesthetic output variety scope is addressed by combining *imaginary art* with a *non-human* field coupled with the tools to reach it (mythology, biology, electronics, combined with generative, technoetic art, videogames). The *non-human* field focuses on inhabiting further than (human) reality spaces, inhuman shapes with their own methods of formation, also techniques of sensing, displacing, bottom-up emergent motion dynamics and even societies, which usually do not belong to a human sphere. *Immersive playable cyber-environments* describe cybernetic electronic arts (EA) / new media technologies capable of immersing (non-)human spectators and participative users as explorers in seamless constructed spaces other than what a human biased reality engenders, where they can play, under custom algorithmic rules, play/simulate in their new bodies or new spaces.

In summary and as previously mentioned, the wolfanddotcom series of artworks created and explored during this thesis seeks to establish new knowledge embedded in the practice within a nascent field combining the areas of interactive electronic arts, videogames, mythology, biology, human/non-human computer interfaces. This research aims to create playful laboratories of human self inquiry, of human modification through catharsis and non-human embodiment of the users experiencing the interactive artworks, thus engaging behaviour modifications through ilinxian becomings. Another relevant aim is to spawn a number of aesthetic objects in a novel and authorial artistic language,

ranging from interactive immersive installations, 3D printed sculptures, organic paintings, machinic drawings, photographs and videos: static works that address the core mythology and philosophical considerations underlining and leading to the more complex interactive dynamic works' creation while proposing new aesthetic glades.

The series of works establishing mythological videogames, bio-electronic communication and interaction follow a speculative methodological approach (Ross 2017, Bryant et al 2010) combined with artistic practice-based research (Candy 2006, Scrivener 2002): a research which assumes, speculates, explores the existence of a post-human non-anthropocentric model, in which, besides sourcing aspects from the mythological, from the non-human biological and electronic realms, puts them in communication, hybridizes their structure, where each field incorporates new traits coming from its sibling (combines it stochastically and genetically at raw levels and observes the outcomes produced by these processes); a research which is practical, which emerges from the continuous process associated to artistic creation, in which constructs are posited as views and as functional cyber-environments that anchor the conceptual and practical creation, where it is initiatically explored a positive affirmation of mythological videogames and bio-electronic aggregates.

The serial works mingle videogames, animality, cybernetic space; they take a close look at raw biological and at raw electronic processes; they look at the operating system that executes programs on electronic substrates as living entities. They also observe, with the same low level tools created for this research, at the raw biological information, at the electrical flows discharging on plants, animals, logging their activity and transforming it into bytes from biologic aggregates. The bytes from files, programs and processes, the bytes from plants and animals are transformed into fractal binarized visual patterns, they become lines that are organic, unpredictable, musical. The electronic substract spawns drawings and three-dimensional landscapes, becomes terrain inhabited by bio-electronic beings resembling wolves, dragons, phoenixes into a vibrant, luminous, neon paleolithic age. A terrain where you can be immersed and experience a perception disruptive ilinxian view of a change inducing cathartic future.
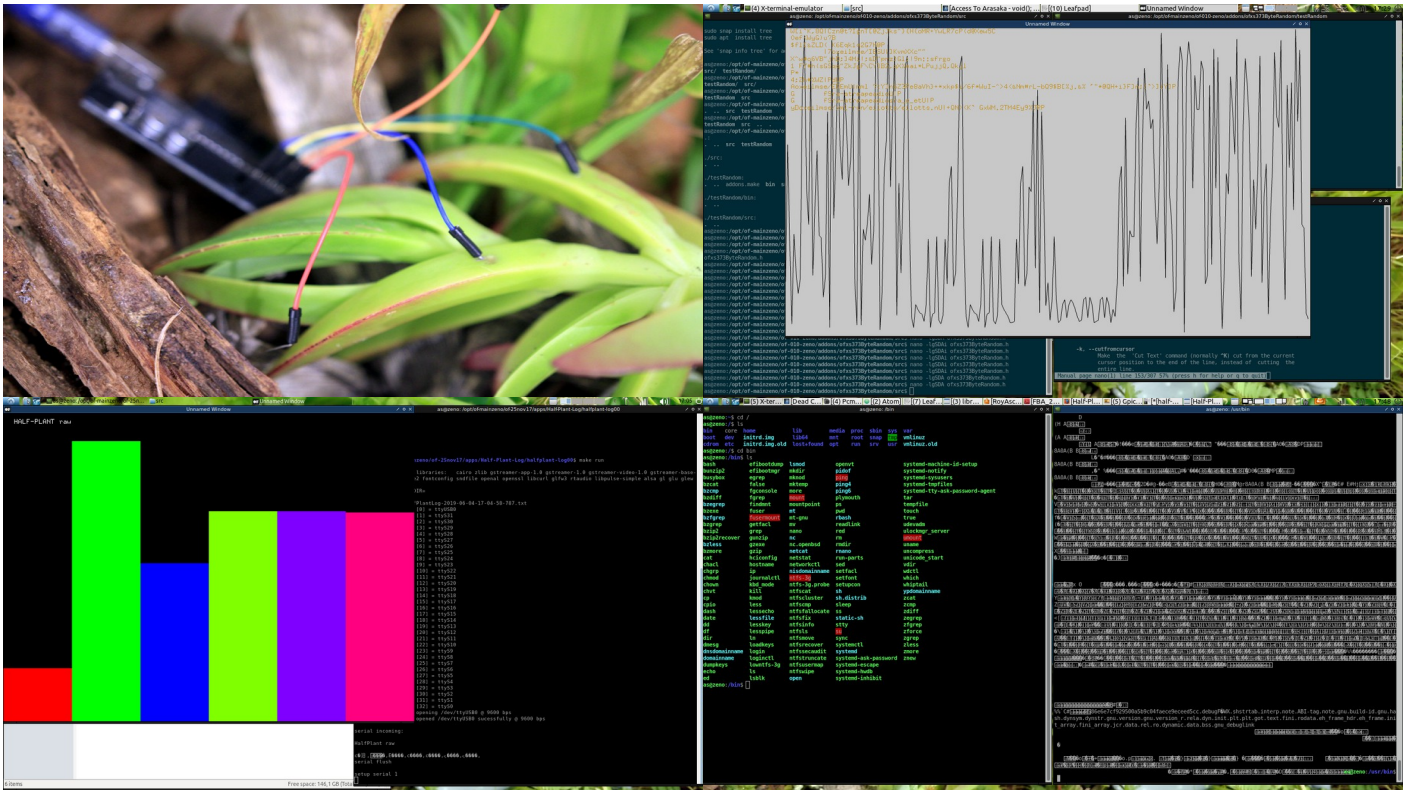
Figures 21, 22, 23, 24: Sampling and logging biological (21,23) and electronic (22,24) data. Sourcing biological data from plants (21) and electronic data (24) through ofxs373ByteRandom (22). Direct, special random and accumulated data history observations in custom developed OF based C++ programs.
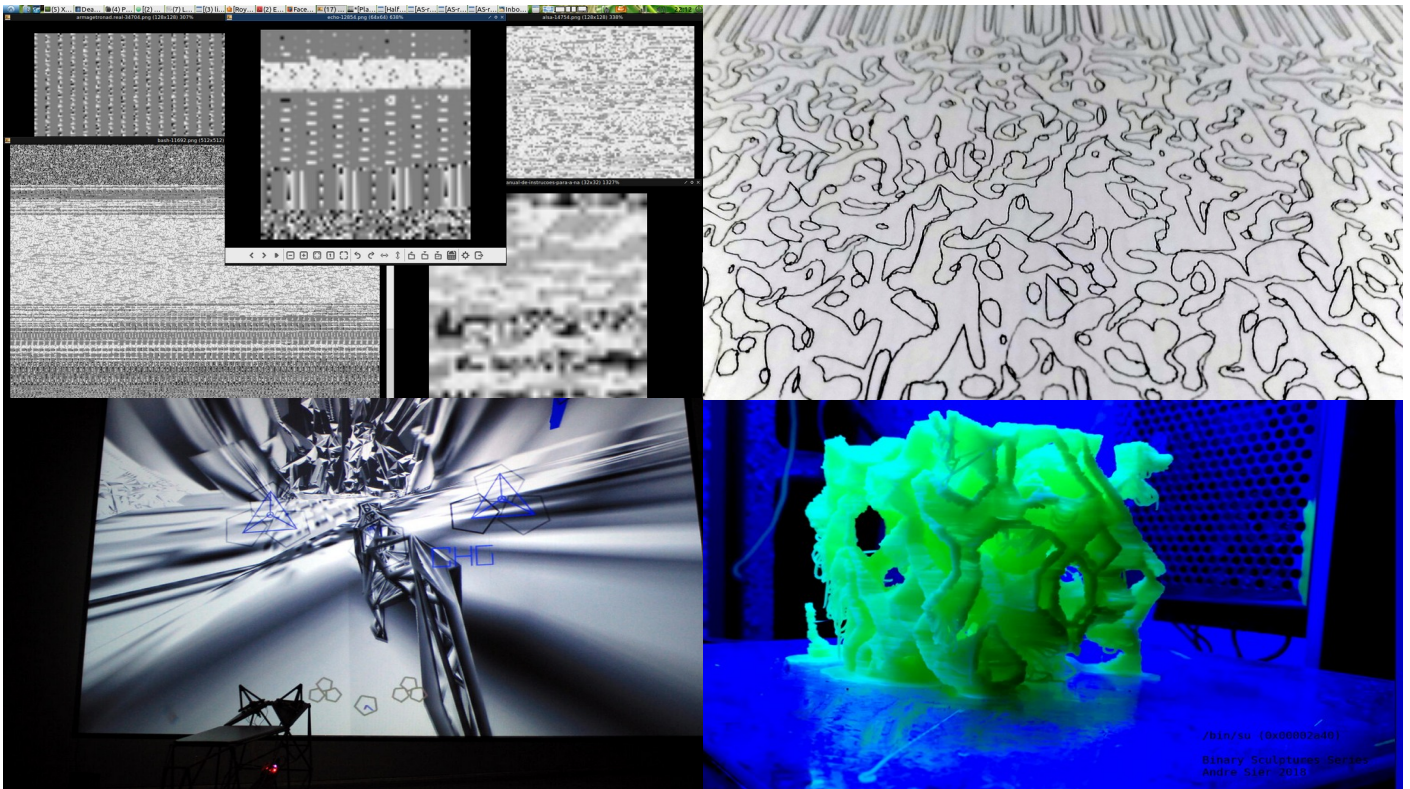
Figures 25, 26, 27, 28: Analyzing, drawing, painting and sculpting with electronic data. Data from programs and their processes as 2D images from byte sequences. *Binary Drawings* (2019-) plotter drawing detail. *Wolfanddotcom*'s 3D terrain heights and textures electronic data derived, here shown at National Museum of Contemporary Art (MNAC Lisboa Nov17-Apr18). *Binary Sculpture* /bin/su (0x00002a40) (2018) fabrication ending at s373.net/x studios.

In order to fulfill the research's aims and produce new knowledge, following speculative and practice based methodologies, the initial focus set on creating a collection of ilinxian (Caillois 1958) otherness interactive experiences, videogames, static artworks, field work, bio-electronic work, and critically assess their outcomes, while innovating computational code based techniques, which allow the creation and refinement of such outcomes. An action-research qualitative approach applying the principles of grounded theory (Strauss & Corbin 1998) was also utilized in some of the early PhD research artworks, namely the Wolfanddotcom videogame (2017), in order to refine later works of the series. Test-retest field-experiments were continuously documented and studied regarding user feedback from multiple audience exposed artifacts, complemented with selective user interviews, and form the basis of shifts in the production of the works addressing raised issues, as well as the initial introduction of the aesthetic results to larger audiences.

Following the general and specific objectives, four methodological approaches are considered: M1) narrative/scoping literature reviews; M2) artistic practice based methodology, in which a collection of ilinxian technoetic otherness interactive experiences, videogames, static artworks, field work, are generated; M3) action-research qualitative approach, applying grounded theory principles; M4) test-retest field-experiment, addressing immersion, reactions and raised issues to the interactive videogames laboratorial environments when audience exposed. The M1 approach "narrative/scoping literature reviews" (Baumeister & Leary 1997, Center for Reviews and Dissemination 2009) [addressing general objectives G1-G5 from thesis aims 0.2] focuses on core game theory concepts (with a special interest in Caillois' concept of ilinx), social videogames, related gamification principles and their utility to improve self-awareness, development and transformation of self-perceptions, ethical, cultural / social impact of non-human experiential perceptions promoted by non-human cyber-environments exposure. Search focuses broadly on the literature, on articles and other documents in scientific and humanistic areas (e.g., through Leonardo, Pubmed, Scielo, JSTOR, PsycINFO, Perseus), artistic areas (e.g., visiting and presenting works at relevant artistic events and related documentation), and philosophical literature. Reviews are organized by specific questions, keywords, aiming to be as systematic and inclusive as possible. Addressing general objective G4, the M2 "artistic practice based methodology" (Candy 2006, Scrivener 2002)

is applied in order to create the actual prototypes and generate culturally novel artifacts, engaging artistic practice based regular activities. The interactive experience prototyping includes tasks of interface design, computer engineering, drawing, sculpting, sampling, digitizing actors, bio-electronic sampling, music creation, 3D modeling, 3D animating, electronic circuit design, synthesis, programming, etc. The activities are focused on building ilinxian thematic otherness interactive experiences, multitasking on a case by case basis. Non-human immersive target cases were selected in order to answer creatively the inquiry questions set afoot by the research. Each target case involves a number of artistic creation tasks. By walking through the entire build process of the interactive experience, since it utilizes novel custom technological programming techniques fine tuned over the years by the author, a selected number of creative outcomes are to be expected (3D sculptures, photographs, videos, drawings, interactive immersive environments).

For the definition of key framework elements of the electronic-artistic environments [general objectives G4-G6], the M3 "action-research qualitative approach" is followed, applying grounded theory principles (Strauss & Corbin 1998). The initial idea involved conducting four focus-groups with youngsters (8 boys/girls, 8-12 years old) and adults (8 men/women, 18-64 years old), to use a participatory action-research approach, with data collection through multistage focus-group (Hummelvoll 2008). This would involve the development of the prototyping videogames to be done in a collaborative way with these participants. This would include three sets of focus-groups, in different stages of videogame development: a) pre-conceptual stage focus-groups (discussing: which non-human lifeforms would be most appealing to get immersed? Which sensorial modes would be of major interest to interface? Which game objectives would facilitate interest and immersion into the environment?); b) rough videogame prototype stimulus-oriented focus-groups (where some key-elements are presented to the same groups of participants); c) participants who are presented with the first version of a playable-work, with user-experiences shared-together and used for improving the interaction-experience. Sampling is intentional, criteria oriented, with both intra-group homogeneity criteria (e.g., similar age, experience with videogames) and inter-group heterogeneity criteria (e.g., youngsters or adults, one group having expertise in videogames development, another group with players of videogames without expertise in videogames development).

In a way, this grounded action-research methodological approach was implemented over informed and informal settings, but within a more restrictive group of users. In particular, besides empirically evaluating and documenting audience immersiveness during the presentations of the works within exhibition settings, there were numerous interviews conducted about the imaginary of the Wolfanddotcom videogame in 2017 and in 2018, when it was exhibited for five months at MNAC Contemporary Art Museum of Lisbon and for two months at XXth Bienal de Cerveira. The interviews involved recorded conversations ranging from Wolfanddotcom's interface adhesion to conceptual, mythological and non-human aspects of the theoretical structuring research foundations. The interviews were conducted with fellow artist practitioners, also with non technological artists, random audience members, as well as with Dr. Rui Esteves, the mayor of a Portuguese municipality nearby to wolf regions acutely aware of the Iberian wolf problematic[16]. Following the interview we shared an immersive experience in the Wolfanddotcom space.

Figures 29, 30, 31, 32: Interviewing and sharing Wolfanddotcom experience during XXth Bienal de Cerveira 2018 with Dr. Rui Esteves, mayor of Covas municipality, Professor Rui Torres and Luis Aly. Photos © s373.net/x.

16   On one hand the *Canis lupus signatus* (iberian wolf) is the first protected endangered species in Portugal and insufficient measures are in place to attempt to preserve them, on the other hand, rural workers, cattle farmers with traditionally difficult living conditions sometimes get deprived of their own nourishment, since sporadic wolf attacks occasionally target their livestock (See Álvares 2015, Petrucci-Fonseca 1990).

While an interesting vehicle to access others views and immersing sensibility, in addition to producing outcomes that provided insights and changed posterior building directions, the fact remains that the main focus of the research is about creating the non-human human playable cyber-environments, and of initially developing the conceptual framework which embraces it. In this manner, a somewhat thorough scientific qualification, involving numerous individuals and accessing immersiveness or other technological aspect, hinders succession in the long run in this particular research project, and thwarts progression on other areas of higher importance, like advancing the framework and the technological architecture of creation (as seen on M2), which in the end is the mechanism through which the outputs scope variety enlarges, deterritorializes, reaches important new areas of study worthy of deeper research, as is demonstrated within this thesis and its cyber-environments.

Urged by the broad latitude of the research and subsequent vast amount of ideas yet to prototype during the creation stages spurred by the initial works, also failing to see the aesthetic relevance of what a thorough scientific assessment might add, having arrived at the conclusion that these interviews or even case studies we might perform with the works cannot validate the framework being proposed as well as the practical research inquiry taking place. The author often regards the outcomes of such case studies as superficial and non-engaging the core aspects of the artistic depths the works aim at. It would be like trying to analyze thought meanings from EEG signal streams, like others have dedicated their entire research to (Pickering 2010:39), like others are in this present day building companies to implement brain computer interface (BCI) communication, i.e., an uncommensurable amount of work which would deviate attention from the research involved in art making and framework developing, in the cycle addressed by the M2+M4 approaches, the practice based creation and the test re-test field-experiment practice. It would become another research of its own, analyzing case studies and deriving eventually false or superficial conclusions.

Even experts agree there are no effective unquestionable methods to assess immersion in interactive works, and the best ones would involve electro-dermal and EEG analysis, eye-tracking analysis (Jennett et al 2008), which somewhat escapes the research's aim. It requires scientific equipment and computing analysis usually out of reach of artists,

becoming a research field by its own right, distinct from the one being addressed here, which is one of creation, of identifying and laying grounds to a framework, of positing practical objects and even cyber-environments to targeted raised research questions. Additionally, brain-computer interfaces (BCI) are yet missing sturdiness, they are presently at an initial state where they can replace mouse interaction in regular desktop environments, although BCI seems like the most promising step for invisible interfacing technologies with machines: *Despite this promise, there are no current serious BCI technologies in widespread use, due to the lack of robustness in BCI technologies* (Lance et al 2016).

Thus research time was invested with a strong focus on the making, on the reflecting and on the reading, predominantly on the aesthetic and conceptual cycles, applying experimental science instead of just using it for validation, while still being highly receptive to insightful witnessing of encounters of familiar people and total strangers with the experiences offered through the artworks, as well as with the interviews, and the more subjective insights gathered from sharing with others the installation space.

The author also thinks that attempts to scientifically validate an artwork, through ranking statistics from sets of analyzed parameters, contribute to the formation of mainstream homogenized cultures at all levels of human society (hollywood, aaa games, popular and institutional artists for example), which are tendentiously oblivious of promoting diversity in order to affirm their stance. They confirm and lead to increasingly acute pyramidical score boards, shape mainstream currents instead of fostering diversity, related to what can be seen in the likes culture emanating from social media (see also Lanier 2018). They are oblivious of plurality, and even obfuscate it, they are forgetful of specificities which could be related, for instance, and at a macro level, to how the viral proliferation of human space promotes the extinction status of too many species. Even within human space itself this behavior is replicated. Cultures, languages, intonations, chantings few remember, harder to come by, decimated by human hubris's wars.

We also looked at other artists and how they addressed these issues of artistic and/or scientific validation on their PhD thesis, and some important pioneers in the field of

technological and moistmedia arts we are querying, like Char Davies, there is a statement she produces summarizes well our concerns. "I have focused my discussion on artistic Intent, rather than on whether I have been successful, for this can only be evaluated with the passing of time."[17] And somehow these ideas keep making sense.

As shown in the following sections, the M4 approach "test-retest field experiment" is central for the research involved in art making, in the cycle also addressed by the M2 "artistic practice based methodology".

17   From Char Davies's 2005 PhD thesis titled "Landscapes of Ephemeral Embrace: A Painters Exploration of Immersive Virtual Space as a Medium for Transforming Perception",
https://pearl.plymouth.ac.uk/handle/10026.1/353.

0.3.1 Dynamic art-sci constructs: playful laboratories

Within the core methodological approach, a particular dynamic sort of cybernetic mechanisms are devised as playful laboratories, aesthetic laboratorial environments, spaces that summon play (Fuchs 2015, McGonigal 2011, Fullerton 2009, Flanagan 2009, Bogost 2007, Galloway 2006, Aarseth 2001, Sutton-Smith 1997, Caillois 1958, Huizinga 1944), spaces that call for user interaction, spaces that invoke a region for playful experimentation with the technological apparatuses, which in this research usually consist of computational derived ambiances, interlinking human, biological and electronic realms, providing an infra-structural plateau to engage in electronic plus non-human communication. Electronic derived and augmented spaces, that besides addressing humans and their immersion in devices on some of the series' works, other works also communicate with plants, ants, or wolves, engaging biological non-human computation and immersion environments (communication which is bio-electronic bidirectional and/or unidirectional, as shall be described on the bio-electronic artworks sections 2.1.5, 2.1.6, on chapter 1.1's aesthetic regions of interest, particularly 1.1.3 and 1.1.4). On the other hand, they are also dynamic spaces that source non-human electronic information, the very substrate which allows them to operate: byte sequences of programs running in operating systems, electronic traces and flows of data of their execution. Or biological voltages sourced from organisms like plants, animals, humans. The electrical currents discharged and flowing within their organs and inner structure.
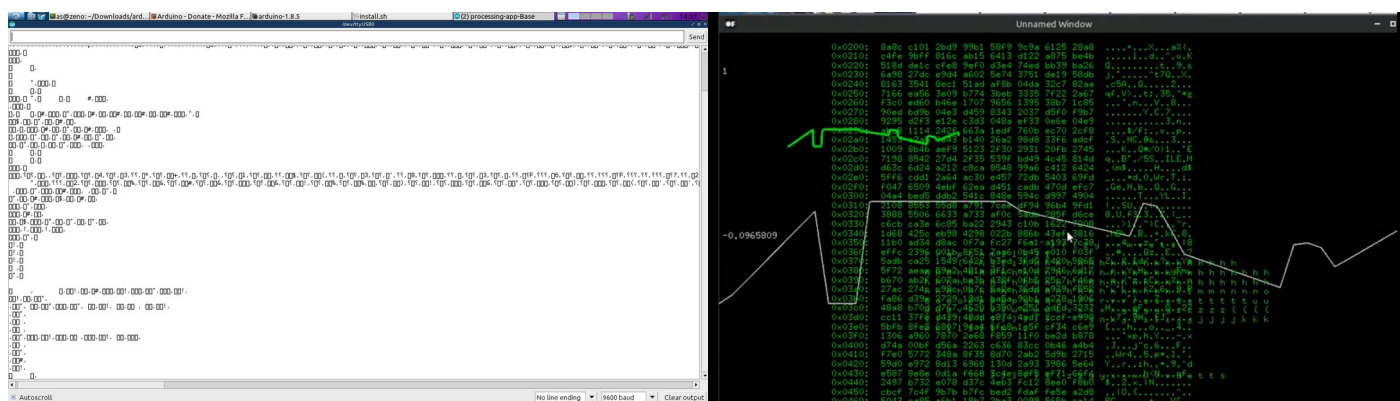
Figures 33, 34: Incoming raw 6 channel interleaved 8-bit sensor data displayed on Arduino's serial monitor program. Machine networking logging and direct data sonification with s373.net/x studio's audio library s373A~ (appendix α.1).

Spaces that become playful scientific laboratories, as complex procedures take place, as raw biological data is algorithmically genetically combined with the raw electronic data

in the development of bio-electronic aggregates. Bio-electronic data becomes sounds, virtual terrains, or tangible sculptures, architectural models of spaces, drawings, or as it becomes time events, or spatial partitions imprinting dynamics in the composition and autonomous movements in the works. As with what happens in cybernetics, these audiovisual systems feedback to their sources, for instance, by emitting continuous sounds to plants, generated by raw plant and electronic data while it is sampling voltages from it to generate the sounds (Half-Plant 2017); or by casting laser beams onto an ant colony making mazes with electronic formation (Ant Ennae Labyrinths 2019), or casting generative cellular automata[18] visuals derived from rule based slow visual transitions also to an ant colony with its ecosystem consisting of food, water, electronics and generative audiovisual patterns (Half-Ant 2020).

Figures 35, 36, 37, 38: Examples of dynamic art-sci constructs:. Depicted: *Half-Plant* (2017) at FACTT Toronto 2019, *Ant Ennae Labyrinths* (2019) at Expand exhibition, *Half-Ant* (2020) at solo exhibition Lady of the Labyrinth's Honey. Photo 35 © Cultivamos Cultura.

Like a scientist in a lab, so does the artist experiment, catalog, produces outcomes, collects and analyzes source data, or by synthesizing it, further manipulating it through

18 Cellular automata (CA) consist of precursor AI (artificial intelligence) techniques, where a vast variety of screen outputs with observed macroscopic behavior is obtained by simple local pixel/cell rules. It is researched in depth chiefly by Stephen Wolfram (2002), incurring a tremendously deep scientific analysis and addressing a field where even autonomous computational machines with cellular automata operating principles are foreseeable in the future.

various procedures into hybrid outcomes, the artistic line of flight traversed throughout this research consists of establishing outputs derived from the production and creation of several target lines of reasoning where the conceptual considerations of deriving bio-electronic beings are put in place and set in motion. Merging interactive electronic arts with scientific laboratorial spaces and practices, whereas aspects of both fields are brought into art exhibition experimentation contexts.
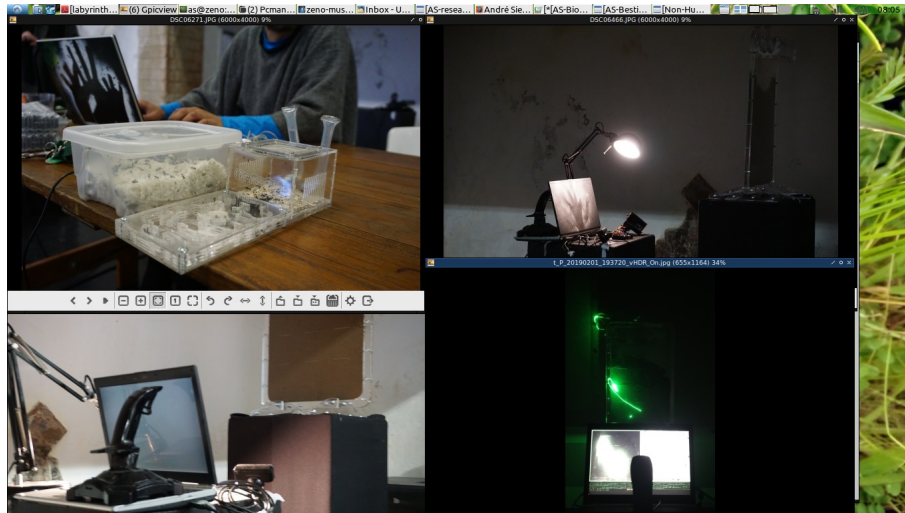
Figure 39: Screenshot of pictures prototyping *Ant Ennae Labyrinths* (2019) in the Expand residency at O Espaço do Tempo, Montemor-O-Novo December 2018. Photos © André Sier and Eduardo Sequeira.

Most dynamic art-sci works produced within the series (Draco.Wolfanddotcom.info 2015, Phoenix.Wolfanddotcom.info 2017, Wolfanddotcom 2017, Half-Plant 2017, Ant Ennae Labyrinths 2019, Wolfspace 2019, 0X Labyrinth 2018-22) appeal for some sort of user interaction, propose interface techniques ranging from interaction with physical computation objects, to computer vision or sound based navigation and network interactions: the wolf-sculpture-joysticks in Wolfanddotcom, computer vision tracking flying gestures (Draco, Phoenix), smart device joystick app (Half-Plant, Wolfanddotcom, Wolfspace), sound and VR gaze (0X Labyrinth, Babylon[19]). Other dynamic works address non-human bio-electronic apparatus or devices, and engage in bidirectional and/or unidirectional non-human communication. Works like Half-Plant (2017), Ant Ennae Labyrinths (2019), Half-Ant (2020), Bioscope #1 (2020), Wolfmachine (2020-22) seek to establish different sorts of electronic, electrical, algorithmical channels of communication

---

19 Since Babylon (2018) originates from the same period as the research, and it utilizes sound and virtual reality gaze as interface, abstract motion mechanics, it is mentioned here. However since it is not part of the wolfanddotcom series, but from the piantadelmondo imaginary abstract city series, it is only technically addressed in this thesis due to the sound and VR gaze interface. The piantadelmondo series is showcased at https://andre-sier.com/piantadelmondo/.

and experimentation, in the biological and electronic domains, in the creation of seed structures coupled to ecosystems that showcase and are evidence of several lattices into new bio-electronic worlds.

These playful laboratories can then be considered of as targeting: a) human intervention, or b) non-human machine interaction. They are drawn and designed as engaging means, as ludic constructs, often focusing on spaces that evoke play, experience, adhesion by its users. They summon immersion by shifting users as explorers of pseudo-infinite stochastic spaces and bio-electronically based new worlds, and also designed as means of engaging, through the experience, self-inquiry and self-modification by exposure, experimentation and immersion within the cyber-environments.

a) Playful laboratories of human intervention

Playful laboratories of human intervention are dynamic art-sci constructs developed to deepen the orbital trajectories around the framework concepts' of illusion, immersion, mythology, ilinx, non-human otherness. Usually consisting of human scale interactive spaces augmented with visual and sonic projections, these devices are responsible for emitting access bridges to the electronic-computing inventions, interfaces either set forth on videogames with spatialized compositions that are unraveled by user interactions, or interfaces to observe and interact with bio-electronic aggregates. Those developed in the Wolfanddotcom series consist of installation spaces where electronic or bio-electronic mechanisms provide communication between human users and the cyber-environments put forth by devices. Some playful laboratories of human intervention were designed as videogames, others were targeting bio-electronic systems.

The cyber-environments of human intervention designed as videogames are focused on establishing means for a mythological immersion targeted at human users of the interactive work into accessing, through near invisible interfaces (like the computer vision flying gestures in Draco and Phoenix.Wolfanddotcom.Info, like the smartphone network joystick of Wolfanddotcom and of Half-Plant, like the gaze and sonic gestures in 0X

Labyrinth), or through physical computation situations (like the wolf-joystick-sculptures in Wolfanddotcom), human interfaces towards electronic mythological videogame spaces. Those targeting bio-electronic systems are focused on establishing means for a human interaction with bio-electronic systems combinations through near invisible interfaces (like the smartphone network joystick on Half-Plant), or through physical computation situations (like the joystick connected to the laser in Ant Ennae Labyrinths, the tablet touch interface on Wolfspace), human interfaces towards intervention on bio-electronic aggregates.
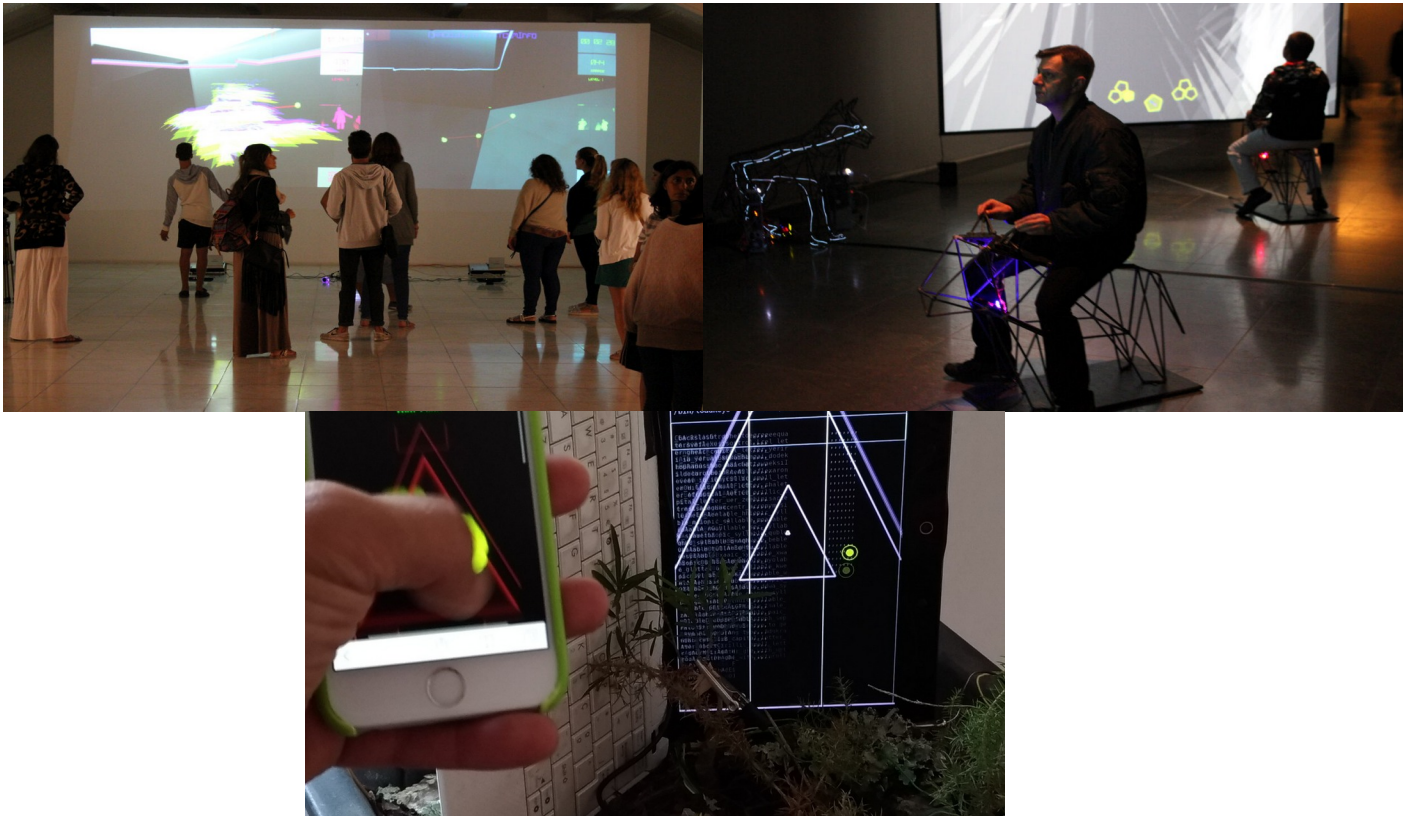
Figures 40, 41, 42: Examples of playful laboratories of human intervention. Depicted: *Draco.Wolfanddotcom.Info* at Aura Festival, MU.SA Sintra Arts Museum Aug2015; *Wolfanddotcom* wolf-joystick-sculptures at MNAC2017-18; *Half-Plant* network joystick at Festival Art & Science FACTT18, Livraria Ler Devagar, Lisboa.

b) Playful laboratories of non-human machine interaction

The generated cyber-environments of non-human machine interaction are focused on establishing means for an hybridization of the non-human biologic and electronic domains into cybernetic bio-electronic aggregates, through physical computation situations, like piezo-electric sensors and sound speakers attached to plants in Half-Plant, laser beam(s)

rhythmically composed for ants in Ant Ennae Labyrinths, for biological material in Honey Krater and Bioscope #1, for wolves in Wolfmachine, set through hemispherical laser lighthouse beacons placed in landscapes surrounding wolves, broadcasting synchronized beams of light in the landscape. Also generative audiovisuals, cellular automata based, displayed on a screen on top of which an ant colony thrives in Half-Ant.

Figures 43, 44, 45, 46: Examples of non-human machine interaction. Depicted: *Half-Plant* (2017) at CRXXI, Universidade Católica do Porto 2019; *Ant Ennae Labyrinths* (2019) at Água Terra Ar, Palácio Landal, Santarém 2019; *Half-Ant* (2020) at Zaratan, Lisboa 2020; *Wolfmachine* (2020-22) recordings for Wolfmachine Cerveira.

0.3.2 Static art-sci constructs: generated artifacts

In order to apply and test ideas in the practical research, some aesthetic objects are constructed with combinations of biological living aggregates and electronic operating cybernetic systems, which are frequently combined in non-invasive ways. Constructs where sensors sample and digitize from either biological data, or from electronic data. The data then begins the process of traversing the programmed rules in the cybernetic device, and is usually fed back to the ecosystem generating the data, assuring the required standards for the existence of one or several communication channels between raw elements of each data stream. They are put into an environment where they can either derive directly an output channel, e.g. by transcoding a plants voltage data channel as direct raw audio samples, or for instance, combining genetically a new channel from strands of raw electronic information coupled with biological one.
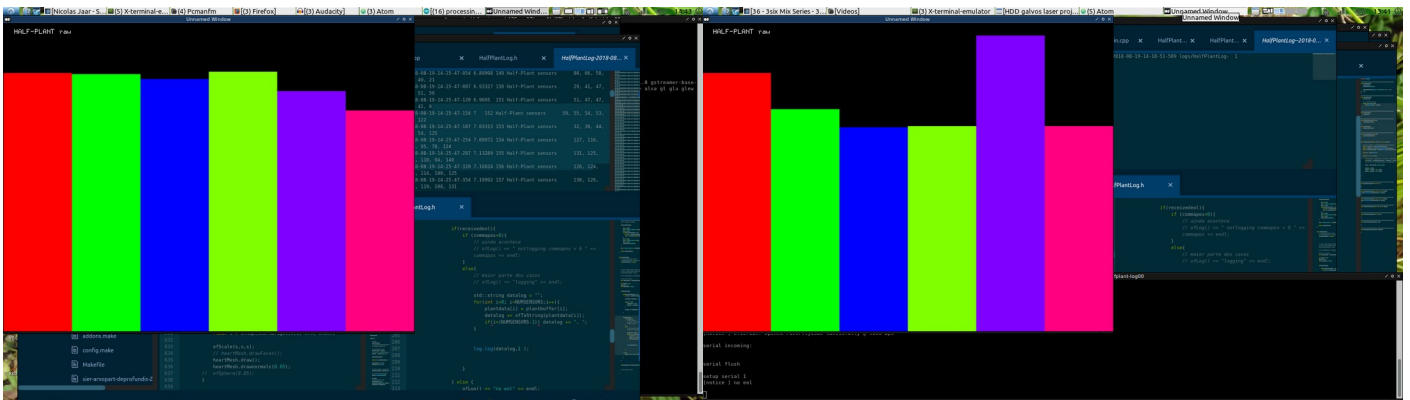
Figures 47, 48: *Half-Plant Raw*: a research built program digitizing and logging plants voltages into unsigned char 8-bit precision values (0-255) while prototyping *Half-Plant* (2017).

Seconding the creation of playful laboratories, the static art-sci constructs (generated artifacts ranging from 3D printed fabricated sculptures, organic paintings, machinic drawings, photographs and videos) are built both for the refinement of techniques involved in the creation of cyber-environments, as well as to return tangible constructs, to bring back to non-technological reality generated artifacts from these bio-electronic worlds that poetically address and underline the mythos and the ethos, surrounding and embracing the methods of artistic exploration and creation.

Their appearance within the research is tightly coupled to the creation periods of the cybernetic environments, or immediately after, as the result of insights, as attempts to capture the essence of the ideas into forms and to produce unique insightful artifacts. After using the initial electronic data in the microscopic and macroscopic scales of observation to generate the entire virtual landscape and sonic composition of the videogame Wolfanddotcom, alongside with its textures and terrains topologies, firstly the author began with Neon Paleolitikos Drawings (2017) and Wolf-Totems (2017), a series of plotter based drawings with source data excerpts and some drawn wolf totemic game characters, as well as several of the digital wolf totemic aggregates printed as 3D sculptures, both wolf characters and totemic sculptures from the Wolfanddotcom videogame.

Figures 49, 50: *Neon Paleolitikos Drawings* and *Wolf-Totems* in solo exhibition Neon Paleolitikos at Ocupart Camões, November-December 2017, Lisboa.

Then proceeded an ongoing extensive period of field data collecting, both bio and electronic data, leading to the bio-electronic dynamic opus Half-Plant (2017). From this basis the creation of 3D fabricated sculpture series followed, firstly developing the Binary Sculptures (2018) series, and a month or two later the Biological Sculptures (2018).
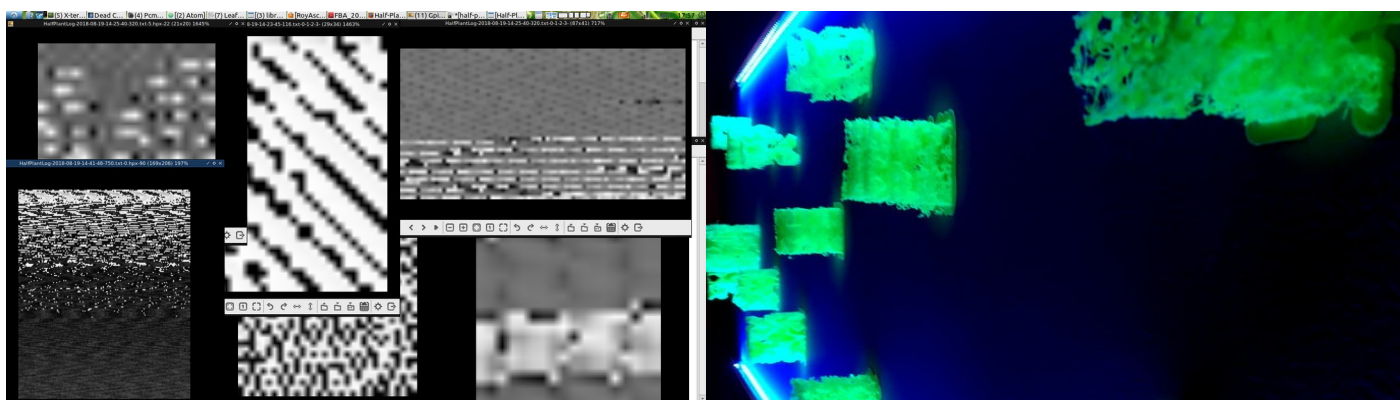
Figures 51, 52: Source visualization images from collected bio data; *Biological Sculptures* at Boundless Objects, Fundação Eugénio de Almeida 2018-19, Évora.

The bio-electronic data was field collected before the Wolfanddotcom videogame (2017) and also in between these aftermath periods. In both sculpture series, the data is source to custom generated voxelizing algorithms in order to construct polygons and sculpt material artifacts fabricated on 3D printers by transposing the gathered data into a spatial domain. The data is also source to the generation of vector drawings which are later machine fabricated through custom plotter machines, by undergoing a series of graphic procedures leading the data to become rhythmic lines of intensity registered in unique two dimensional drawings. The BIND and BIOD drawing series (BINary Drawings and BIOlogic Drawings 2018, 2019) put forth such data similarities and resonating frequencies between biologic and electronic sourced raw data by establishing lattices as black lines of data intensity drawn over white paper.
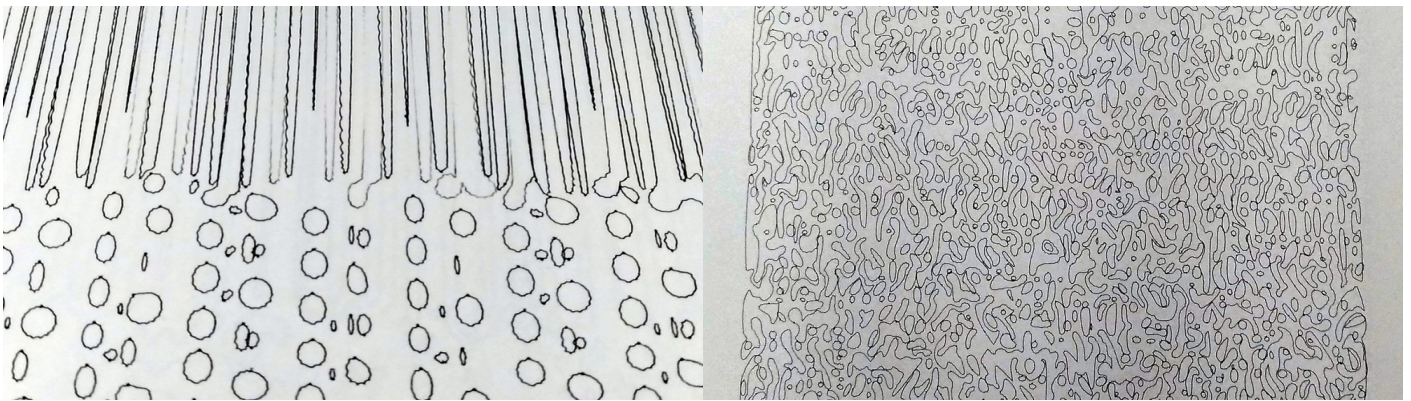
Figures 53, 54: *BIND* and *BIOD* details (Binary Drawings, Biological Drawings, 2018-).

While trying to research the non-human and the mythological on the real world, the inquiry was led to focus on real wolves, plants, and ants. Since this also involves working with animals, these considerations are further expanded under 0.4 ethical issues. While working on and with wolves, historic and GPS data of wolf presence in Portugal were utilized to create the Wolfspace project (2019-22). Information consists of scientific numbers of wolf presence from the XXth century (researched by Grupo Lobo) and GPS data from wolf collar devices in the period spanning from 2012-14 (researched by CIBIO). In Wolfspace code was constructed to fabricate sculptures and for interactive tablet data visualization consisting of ambients derived from the evolution of wolf presence on the region of the Portuguese map and the wolves continuous redefinition of territories throughout these time periods.

Before starting to work with ants on the projects Ant Ennae Labyrinths and Half-Ant, in order to research real live non-human biological and millennial creatures, the author started documenting field experiments consisting of interactions with ants electronically stimulated through low powered laser lights. From these empirical field work experiments emerged a series of photographs (Eusocial 2018) and videos composed with selected photographs (Ant Ennae Videos 2019), as well as important considerations that would be exploited in the living bio-electronic installations Ant Ennae Labyrinths (2019) and Half-Ant (2020). As research deepens, the need arose to seek out new methods for creating paintings that might address the research issues of creation associated with bio-electronic aggregates. Paintings that are alive, made out of slowly moving or decaying organic plant based inks, that explore the creation of non-human space (particularly labyrinthine spaces on 8-bit Maze Gardens 2018, virtual wolf landscapes on Biowolf218 2021, discussed further at 2.1.4.b.2).
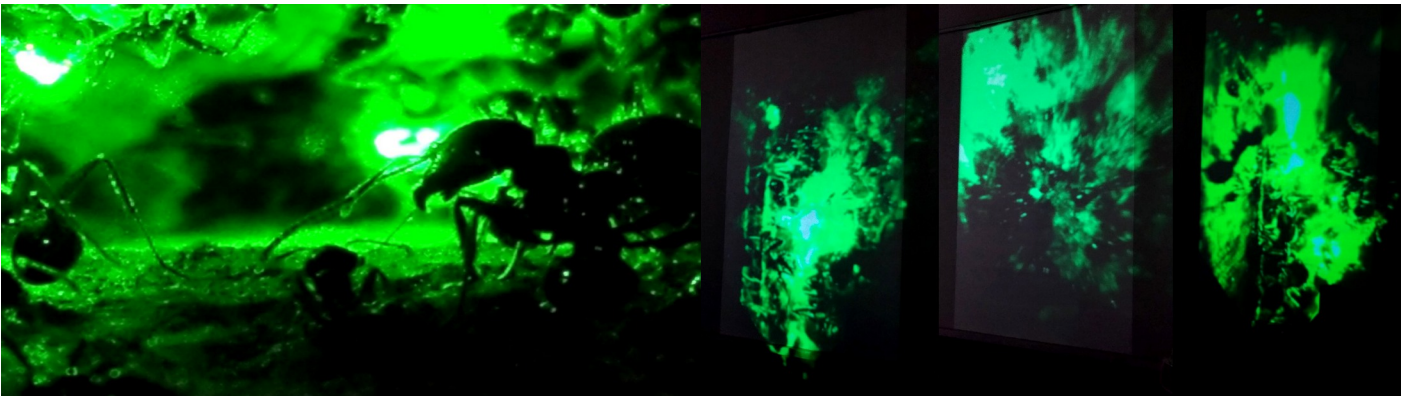
Figures 55, 56: *Eusocial + Ant Ennae Videos* at Festival Art & Science FACTT19, P28 Hospital Júlio de Matos, October – November 2019, Lisboa.

Figures 57, 58: *8-bit Maze Gardens* (2018-) wall sized vegetal labyrinthine paintings featuring created 'mathematical flower' non-human method of labyrinths at Festival Spray for Us, July 2018, Ericeira.

Figures 59, 60: *Biowolf218*, circa 5x4m structural moss based painting evolving since August 2021 at headquarters of Cultivamos Cultura, S. Luis, Odemira.

Working on the successor mythological videogame to trio Draco, Wolfanddotcom, Phoenix (2015, 2017, 2017), 0X Labyrinth (2018-22) is a work that has been on conceptualizing stages since the beginning of the wolfanddotcom series, for it combines braided research aspects in the areas of mythology, labyrinths, non-human and human gladiating for spaces. A series of 3D sculptures of the main characters of the game were sculpted by voxelizing live-action point data obtained from human actors captured by a depth camera, to create the videogame concrète PLY 3D animations. This series of sculptures, named Labyrinth Players (Eu Abstracto) (2019-20), emerged in a process similar to the Eu-Abstracto sculpture series from 2014[20].

Figures 61, 62: *Labyrinth Players (Eu Abstracto)* at Lady of the Labyrinth's Honey, Zaratan, Jan-Mar 2020, Lisboa.

---

[20] Eu-Abstracto (Sier 2014) is a series of fabricated sculptures where portraits made from actors are transformed into digitized sequences, facilitated by 3d cameras sampling three-dimensional point clouds of people in motion and spatially accumulating digital moments of time in the same digital sculptural space. Each sculpture is composed of unique frames or several temporal with or without spacial offsets. See https://www.andre-sier.com/projects/eu-abstracto/

Figures 63, 64: Images from *oX Labyrinth* 3D recording sessions at Ericeira and Plymouth 2018 towards game character PLY point cloud animations as well as static 3D sculptures,

Figures 65, 66: Images from research produced workshop '8-bit Maze Gardens', labyrinthine vegetable paintings workshop at Água, Terra, Ar, Palácio Landal, March 2019, Santarém.

Figures 67, 68: Images from research produced workshop 'Esculturas Generativas / Generative Sculptures: Modeling and 3D Fabrication', at Faculdade de Belas Artes da Universidade de Lisboa, April 2016. This workshop is published by ArteCódigo at https://artecodigo.pt/w. Photo 68 © Mónica Mendes.

0.4 Ethical issues

This research inquiry adheres to Plymouth University's Principles for Research Involving Human Participants, as well as biological or animal subjects. Namely, it follows the guidelines present in: 'Research Ethics Policy', 'Code of Good Research Practice', and 'Research Data Policy' (University of Plymouth 2018).

Some of the practical works are subject of research study with external human participants. Other works are constructed involving plants, ants, wolves or bacteria. All human participants within this research are informed in writing, through the information sheet, about the aim and procedure of the research and, in person, before the research activity starts. None of the animals participating in the research were subjected to activities that might be considered offensive or even dangerous to their existence, and focus was set for situations close to their regular activities, in no manner intended as disrespectful, but rather, insightful research, intended as a practical source of the creation of procedures associated to departing from anthropocentric models towards non-human worlds, towards sampling the non-human, analyzing its data, combine it in further procedures. As briefly shown in the following, the activities with animals were all discussed and monitored by biological scientists with specific expertise of renowned scientific institutions.

For the work with wolves, the first scientific group involved was Grupo Lobo, a scientific wolf research non-profit group, headquartered at the Faculty of Sciences of the University of Lisbon and leading the Recovery Center for the Iberian Wolf (CRLI), a near extinct wolf species. Over the last 50 years, their numbers have plummeted, promoting them to be recognized with an endangered species status, for merely circa 300 Iberian wolves are present and, significantly, only in a small country region, to the north of Portugal (Petrucci-Fonseca 1990). With Grupo Lobo the collaboration involved: learning about historical wolf distribution in Portuguese regions since 1900's until 1990's; studying wolf behavioral models, and matching these behaviors with the ones programmed in the videogame Wolfanddotcom. Physical traits and wolf pack mechanics, as well as sense data and communication strategies were also approached. A second practical collaboration with Grupo Lobo included the production of two artistic works, in conception and discussion since 2018, premiered October 2021: a totemic, 2.5m tall wireframe bio-electronic

sculpture of a wolf (Totem-Lobo #1 2021) and the production of a bio-electronic work drawn and designed for wolves, which involves interaction among living wolves, non-human ecosystems and electronic installations (Wolfmachine 2020-22).

Figures 69, 70: *Totem-Lobo#1* & *Wolfmachine* at Iberian Wolf Recovery Center CRLI, October 2021, Mafra.

A second scientific wolf research group involved was CIBIO-UP (Centro de Investigação em Biodiversidade e Recursos Genéticos da Universidade do Porto), a northern Portuguese biological research institute with scientists actively monitoring wolves in the wild (Álvares 2015). The collaboration with CIBIO involved scientific expertise consulting and permission rights to use the GPS data from their own research. This valuable information allowed to artistically construct a visualization of how wolves occupy and travel through space, how these animals construct their usage of space, how they territorialize. That information also grounded real wolves' dynamics matching with the motion patterns of the virtual wolves in the Wolfanddotcom videogame (2017) as well as the construction of a 3D visualization and sculpture making app, designed for interaction with smart devices (Wolfspace 2019, 2022).
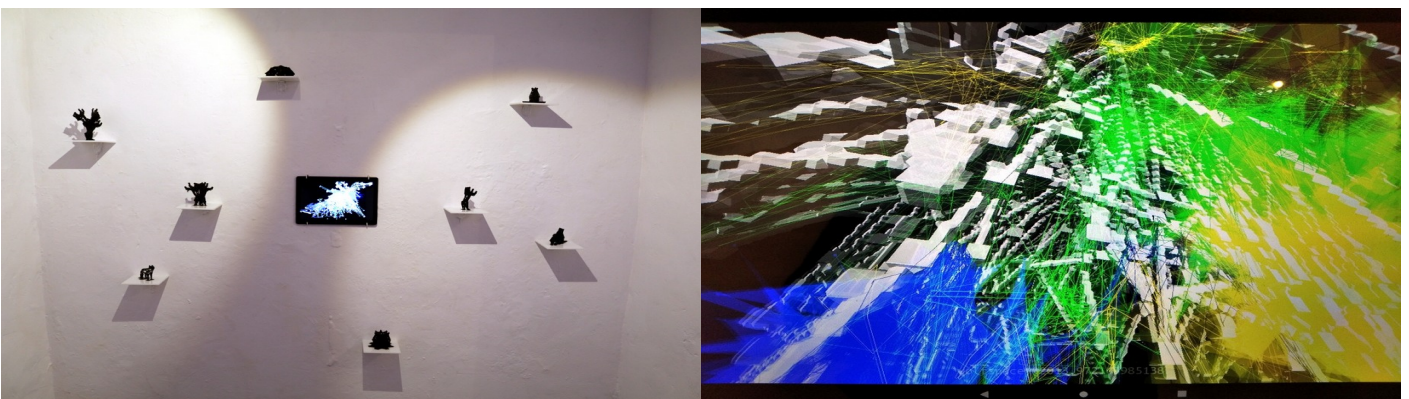
Figures 71, 72: *Wolfspace* app at Lady of the Labyrinth's Honey, Zaratan, Jan-Mar 2020, Lisboa, and at Uivo, Casa de Cultura Jaime Lobo e Silva, Nov–Dec 2021, Ericeira. *Wolfspace* is published online 23rd July at https://artecodigo.pt/pub.

Another professional whom collaborated, Eduardo Sequeira, an ants' specialist graduated in biology and is a passionate expert on ants, has since started a small company (named Mirmex) to sell portable anthills as pets. He has been the right person to assist the author design a bio-electronic work involving ants, in a construction where ants are even living in spaces ten times larger than the hand sized spaces common for small ant populations destined to be families' pets. The work with ants involved analyzing and artistically documenting their behavior when experimenting laser interaction situations. By means of low powered laser light sources, ants are stimulated being hit by the radiation, which is considered safe for these animals, for it consists of a low power green laser (532nm, circa 5mA). This behavior was used artistically in research, to try to derive a non-human spatial structure model intended for non-human labyrinth formation techniques, which were used in the immersive virtual reality videogame work 0X Labyrinth, alongside with other non-human labyrinth formation, as furthered discussed in the article published during research "Non-human labyrinths: Roots and additional other than human formation methods" (Sier 2019).

The research involving other biologic non-human entities addressed bio-electronic work, where a small computer-plant ecosystem open to networked smart device app human interaction, has an Arduino[21] firmware that is sensing electrical flows of voltages in six distinct sampling channels and points of contact with the plant through piezo-electric sensors, and sending this raw sensor data flow, now digitized, to be further combined in the computer with electronic microscopic readings of the electronic self-information present in the computer machine that is acquiring the data. Several aspects of the ambients in the videogames Wolfanddotcom (2017) and 0X Labyrinth (2020); the sculptures series (Binary Sculptures 2017, Biological Sculptures 2018), and the drawing series (Neon Paleolitikos Drawings 2017, BIND and BIOD 2018) are derived from this data.

---

21 The Arduino platform (ARD) is an ambitious open source electronic computation project seeking to universalize and simplify the creation of electronic systems that can read and write from the digital to the exterior analogue world (TX/RX/I2C). It was brought forward in the veins of Processing (P5), a precursor program written by artists, for artists, which has come to simplify across platforms the expression and creation of coding artifacts which make full use of a computing machine potential.

Half-Plant (2017), 8-bit Maze Gardens (2018), Ant Ennae Labyrinth (2019), Half-Ant (2020), Bioscope #1 (2020), Wolfmachine (2020-22), Biowolf (2021), documented at chapter 2, are works which combine creative aesthetic research onto primer bio-electronic aggregates research, with laboratorial situations where biological living systems communicate with electronic systems, ranging from the usage of plants in Half-Plant, 8-bit Maze Gardens and Biowolf; the usage of ant colonies, in Ant Ennae Labyrinth and Half-Ant; the usage of bacteria and/or other biological materials in Honey Krater and Bioscope #1; and the usage of wolves in Wolfmachine, in Wolfspace.

1. *Arts, sciences, engineering – conceptual & practical context*

As already expanded in chapter 0, the overarching research aims go through the creation of playful laboratories of human otherness, as well as a number of aesthetic artifact objects in a novel and authorial artistic language. Interactive immersive installations, machinic fabricated sculptures and drawings, organic evolving paintings, photographs and videos: aesthetic artifacts which address the core mythology underlining and leading to the more complex interactive works research and creation. The series of artifacts and experiences seek to establish new knowledge rooted and embedded in the practice within a nascent field that addresses the areas of interactive electronic arts, videogames, mythology, human / non-human computer interfaces. The research presented in this document produces theoretical considerations which accompany the driving practice-based research in the field of interactive aesthetic arts and sciences domains of fabrication of immersive experiences, otherness playful laboratorial devices, and of fabrication of artifacts, deriving from the wolfanddotcom series of artworks.

Chapter 1 is firstly oriented towards relevant aesthetic regions of interest (games & interactive arts and experiences; immersive playable cyber-environments; generative or moving / inhabited paintings; sculptures and void space sculpting; interfaces, augmentations, bridges; codex and strata), providing theoretical considerations addressed by this inquiry, elucidating paths of research rooted here on the works of other artists and scientists, thinkers and engineers. Presenting the edified theoretical considerations, an expanded theoretical context is engaged within this chapter. It also introduces a practical state of the art, with the selection of a number of aesthetic objects, games and interactive arts by artists whose work resonates with similar work this research addresses. Additionally, following 1.2, a table succinctly summarizes a reading of electronic arts labyrinthine works, adding up to present an overall state of the arts (1.1.x) and specifically labyrinthine (table LEA). Overall, the context covers a broad subjective introduction to the world of new videogame based technological artistic tools, seen as technological apex, and programming languages, generative, interactive, technoetic, imaginary arts, as they were being made.

Sections 1.3 & 1.4 will ground philosophical concerns by means of contextualizing and speculating new concepts, while aggregating imaginary art's (IA) framework. Section 1.5 complements with a practical description of scientific collaboration engaged in selected bio-electronic works.

The topics covered in chapter 1, addressed by the undertaken research, will discourse concisely thematic, theoretical, and practical areas surrounding the creation of the interactive cathartic artistic laboratories, its background, motifs, interfaces, philosophical concerns, as well as seeking to establish each topic's state of the art related to the inquiry.

1.1 Aesthetic regions of interest

1.1.1 Games & interactive arts: immersive playable cyber-environments

Games here seen as interactive logical ludic constructs targeting alternative directions other than mainstream triple a gaming, or even indie gaming tends to focus on. Art Games, Proto Games, Zeno/Zero Games (0G/ZG), Ambient Videogames, Not Games[22], Immersive Cyber-Environments.

Beginning here at 1.1.1 with games, interactive arts and immersive experiences, these sections (1.1.x) contain a reference path of relevant pioneers who have upgraded and even shifted from the ground up an enormous amount of technological and aesthetic advances. In order to add to this relevant state of the art, though biased in direction of the research and missing out on other relevant paths, following the more labyrinthine detailed analysis (section 1.2 Daedalus and Zeno), a table is provided within chapter 1 featuring a selection of pioneer and precursor labyrinthine usage in electronic arts (table LEA - notable examples of labyrinthine usage in electronic arts).

Moreover, games and technological art are tightly related. Stated on a May 2016 article at Cibertextualidades, the author's main fascination with videogames lays in their technical apex of computation, by running interactive immersive audiovisual programs on computers, as well as its integration of multiple artistic disciplines: *Videogames merge sciences, arts, engineering and logic to provide a virtual time-space continuum, closer to the experience of alternative experienceable realities* (Sier 2017). Games' intersection with the art sphere of creation overlaps several areas in this research, both conceptually with the creation of new concepts to describe further areas of framework development, as well as practice-based new aesthetic outcomes, concurrently focusing on themes such as interactive, videogames, mythical, non-human, and applying custom computational methods. In this way, the research aims to establish pathways where certain types of videogames could be regarded as consciousness research tools.

---

22   While most expressions are derived and constructed from the research and/or historical/contextual framing attempts, "notgames" in particular is an expression made by the Belgium duo Tale of Tales (Auriea Harvey & Michaël Samyn) which addresses some of our concerns when thinking about these open experiences often falling back to a videogames category. See http://notgames.org/blog/2010/03/19/not-a-manifesto. Zeno/Zero games (0G/ZG), protogeometrical games (2.1.1) on the other hand, have been lurking around in playable binaries, since 2013 on Temporary-Babel 2D on its title screen, since 2007 on k., with earlier appearances circa 2000-1 on 747, 1998-99 on 0 0 255 (see figures 80, 81).

Videogames as consciousness research can be traced to the germinal Homo Ludens (Huizinga 1944), where Johan Huizinga applied game theory to different aspects of human life. An innovative concept since games have been assigned almost exclusively to the ludic sphere, and not as tools to everyday aspects of human life. Though Huizinga tended to theorize about games looking too often at competition. While it is a major game category, there are and were other uses and categories for games. For instance, McGonigal, citing Herodotus, remarks an ancient episode where intensive game playing and inventing by the Lydians performed a life-saving role: *The plan adopted against the famine was to engage in games one day so entirely as not to feel any craving for food* (McGonigal 2011). Also, most relevantly, Roger Caillois built upon and disputed Huizinga's emphasis on competition in play, devising four separate categories of gameplay: Agon, Alea, Mimecry/Mimesis, Ilinx (Caillois 1990, 1961, 1958). Ilinx focuses on using perception disruption, engendering on the player a vertigo-like sensation. It is this latter game category of ilinx that Caillois exemplifies with daring physical games of feats capable of disrupting normal perception, where players experience strong perceptive changing emotions, from dancing to dizziness to drunkness, starting from the comprehensive Mexican *volador,* where after offering ritualistic dances, singly waist tied, braves cast themselves flying/spinning into the void. Huizinga (1980) also remarks about dancing:

> *In short, feast and play have their main characteristics in common. The two seem most intimately related in dancing. According to Kerenyi, the Cora Indians inhabiting the Pacific coast of Mexico call their sacred feast of the young corn-cobs and the corn-roasting the "play" of their highest god.* (Huizinga 1980:22)

It is around ilinxian ambient flying and gestural flying interfaces that the gameplay in Draco.Wolfanddotcom.Info (2015) is concerned with, as well as other modeled wolfanddotcom mythological videogames, whose purpose is to bridge, to serve as gateways facilitating otherness intensification into non-human immersion and embodiment.

Videogames are among the most elaborated software programs, which house a significant number of procedures in every displayed frame. Running in logical machine-like substrates, which control flow electricity as data information at dazzling speeds

through labyrinthine electronic circuitry, following rules of complex algorithms, which combine almost all computer's abilities at circa 30/60/120+ frames per second, near instantly, providing at a human scale and directed at its predominant senses a feasible replica of reality, or engaging other realities. They are also a most effective mean by which, through simple interactive experiences (key stroking, mouse moving, sonic, visual, physical, bio or etc input interfaces), it is possible to engage in first-person played experiences, storytelling and even to achieve immersive otherness. *They feedback from life and have the potential to modify the self* (Sier 2017).

Video games holistically merge numerous sciences, arts, engineering and logic to provide a virtual time-space continuum closer to the experience of reality or of experienceable alternative realities: breadboards[23] of reality that feedback from the real, stimulating and modifying the human virtual, which leads the actual and the virtual on the human person; they are playable interactive experiences, safe spaces for experimentation, that convey meanings, knowledge and experiences, in ludical, performative, first-person ways.

The experiences they provide are directly related to the players dexterity in unraveling the complete game space. They are also a plateau which often combines mini-games within the game, or structure one or many playable experiences through a sequence of goals: objects the player must pick up, keys to unlock game regions, puzzles that hinder and block game progression, physical dexterity demanding faster reflexes in evading obstacles at constantly higher speeds, but most relevantly tools for knowledge incorporation and test beds, they can also convey otherness experiences.

Interactive electronic new media arts (EA), through technologies, place the viewer as an active observer-participant, while freeing artistic and technological works from the time and space domain, since the work does not repeat, it is, it executes, as you witness or

---

[23] Breadboards consist of prototyping boards for electronics, and the expression is utilized in this context to symbolize videogames as tools for easier alternative realities experimentation, like a bicycle with training wheels for reality. Breadboard also derives from the electronic language of physical computation, that is usually responsible for the bridge between the analog/real world and electronic/digital sampled world. "The breadboard is the primary place you will be building circuits. The one that comes in your kit is solderless, so named because you don't have to solder anything together, sort of like LEGO in electronic form." (Fitzgerald & Shiloh & Igoe 2012)

participate, and its scope can be near infinite, while remaining interactive to the player's decisions. Unlike time-based works of exact duration, spatial based works of fixed dimensions, user actions are fundamental in unveiling the scope proposed in the work. More and more interest is being given to videogames as tools able to foster experiences in the first-person by interacting with the programmed machines. They can act as privileged means to study and even enhance consciousness. Shifting the human from passive viewer to active participant in the work facilitates the processes that leads to immersion as well as becoming a mean of knowledge and experience incorporation, based on the videogame's proposed experience.

A good example of this perspective is the work *The Night Journey* (2007-2018) by Bill Viola and the University of Southern California's Game Innovation Lab. Viola, besides being a personal landmark inspiration for his breathtaking spiritual video work, as well as sublime to many other artists and scholars alike (Townsend 2004), is a well known pioneer of video art who manifested interest in making videogames, and together with the Game Innovation Lab spearheaded by Tracy Fullerton they developed an interactive experience depicting a metaphysical voyage which seeks to unravel an individual's quest towards enlightenment, dynamically defined by the player's decisions (Fullerton 2009).

Figure 73: *The Night Journey* (2007-18), by Bill Viola and the Game Innovation Lab, portrays an interactive metaphysical voyage inquiring apropos the "mechanics of enlightenment". Photo © USC Game Innovation Lab.

Immersive games provide virtual environments where usual rules can be changed and explored, even immersed into creating distinct modes of being, alternate modes of experiencing, beyond reality. This is what happens within *The Night Journey* (Viola & Game Innovation Lab 2007-18), as you start your quest upon a structured dreamlike virtual space which nears photo realism graphics with poetic transitions in overlapping experiences, ultimately, a surrounding enveloping immersive experience endowed by the videogame.

Humans, animals, plants, lifeforms in general, experience reality through their limited, enclosed, machine-like, bio-mechanic, operative but permeable bodies (Ga 2018, Haraway 2016, 2004, 1989, Deleuze & Guattari 1980). Seen from a philosophical perspective, these bodies drive and redefine their actuality in reality through their unique breaching desires and goals (virtual plane) (Deleuze 1969)[24]. Empirically researching, questing, it may be possible to devise experiences which expand human body perception and consciousness by inducing a shift onto other species or other bodies. One of the quested ways to achieve such states is by playfully immersing the participant's body, bathing his senses and composing situations capable of inciting ilinx (Caillois 1958), via exploiting the perception in the self, altering and disrupting it, mediated through a) technology, b) automata (CA), evolutionary (DNA), generative algorithms (GA), contributing to artificial life (AL) (Wolfram 2002, Flake 1998, Sims 1991, Langton 1989, Krueger 1983) and c) custom human computer interface (HCI) research. The purpose is to forge a sense of otherness in the self, deepened into almost inhabiting other species, on structured and stochastically synthesized pseudo infinite virtual spaces, overall aiming at making human users more aware of their environment, and of enhancing an active listening of their surroundings, of other lifeforms.

By sharing a common field, as transformed explorers of gigantic architected spaces they are unable to enumerate, touching upon a kantian notion of "sublime", overflowing aesthetic and pure logic sensitivities (Kant's critiques of judgement and pure reason), overwhelmed by the ungraspability of the full spatium involved, inducing an endless play game kantian mind faculties are subsumed to by constantly forking their infinitude

---

[24] The internal movements of these complex philosophical ideas are further discussed below within this section, also upon presenting an introductory ligature between the conceptual and practical state of the art as well as a connection to the proposed cyber-environments on section let there be dragons at 2.1.1.

apprehension-seizing attempts and waiving control between one another in awe (Freeland 2004, Kant 2001, 1998), gifted with new senses that computer game technology provides and with the algorithms engineered by the programmer, the user now player, brave enough to engage the challenge of the game, oblivious of his human body through the immersive apparatus entwined to the cathartic and emotional transformation, is now extended in direction of a becoming, transported inside the experience.

Similar to interactive windows into an existing imaginary virtual game logical-space, the immersive game, played in the first person by its user, through its mediating bridges, invisible or haptic interfaces, sonifies and visualizes the experience of inhabiting an otherness, including other non-human species and mythological realities.

Consciousness, or a sense of self, can thus shift from a human reality to a virtual inhuman animality. A seed onto new laboratorial ontological playgrounds, inserting the human in non-human points of view, facilitated through interactive immersive art. We've already observed how Deleuze and Guattari ground identity to that which breaches *it*. Poetically, perhaps *it* could be set in an image of a floor perpetually subsuming and collapsing on itself, while still holding ground to whatever perceiving mechanism constitutes *it*. Deleuze and Guattari on *Mille Plateaux* (Deleuze & Guattari 1980) refer an extreme non-linear internal circulation of energetic flows, beyond infra-structural limits, happening in key states like in their construction of the "body without organs" concept: an otherness intensification so profound, an advent of turbulent pre-consciousness virtual flows taking place in the actuality of the individual – better renamed as aggregate – such that the amplitudes these energetic forces reach reveals the selves innermost defining states as porous bodies of becomings, diluting the source identity borders towards ruling and attractor engulfing becomable destinations. Applying forces, bending frontiers and re-tracing identity lines. Neuroscientist António Damásio also attempts to describe and define similar pre-conscious states as the "protoself", in *The Feeling of What Happens* (Damásio 1999); fulcral states lingering before "core consciousness", and next, "extended consciousness".

Hence, beyond the self there is also a projection of a "field" where these aggregate becomings are inserted at, where they engage in communication with one another, and where they feed, mutate, react, actuate, sleep, hybridize, mate. A landscape background which becomes the foreground, where aggregates linger, persist and insist, and withal are re-shaped by the field whereabouts they have a sense of self, where they have perceptive feelings, where they are capable of thoughts, of actuating. Where they have a will, where they are awake and aware of their surroundings and where simultaneously they shape themselves according to their turbulent becomings. Perhaps this is why Roy Ascott went further along this reasoning and sharply speculates that there is no such thing as an individual consciousness. Instead of *it* solely located at an individual level, *it* becomes an epiphenomenon of the ecosystemic "field" where *it* is embedded in. *It* arises from all levels of intercommunication by which all procedures affecting within temporary borders contact more or less with the field. Equally, *it* grows as a varying encircling mind field at an aggregate individual level, and a field of multiple minds where aggregate ensembles of selves are a part of, constituents and citizens, and where they contribute to its continual formation, where they cannot be individualized, where background and foreground under this speculative light becomes now indistinguishable. Like Ascott critically synthesized:

> *We should perhaps be open to the idea that "individual consciousness" may be an oxymoron. While individual self–awareness is a prerequisite of living beings, consciousness is more likely to be the attribute of a field than of the individual organism.* (Ascott 2006:70)

Relevant points of intersection from these thought lines can also be most pertinently crisscrossed by combining the above introduced "field" (Deleuze & Guattari 1980, Ascott 2006) with Lovelock and Margulis's Gaia theories (Lovelock 2009, 1979, 1972, Lovelock & Margulis 1974), with Haraway's aforementioned Chthulucene (Haraway 2016, 1989), and with Capra's interconnection of quantum physics with eastern mysticism (Capra 1975), views that substantiate deeply, urgently, non-anthropomorphized theories by urging standpoints regarding the Earth[25] as a giant organism, an enormous "gaian field", capable

---

25   Earth, or as in the Old English wording Eorthe, which is referred to in Greek antiquity as Gaia/Γαῖα, compounding Γε/Ge (land) bound with Αῖα/Aia (grandmother), the Mother Earth, also impersonated through the mythical Gaia, a key Greek goddess symbolizing her, it, our planet, third rock from a sun. The oldest known form to this day, Μā Γā/ma-ka, arrives from the Mycenaean Greek circa XIIth century BCE, discovered through Linear B decipherment (Chadwick 1990). Earth as a theme is developed further in this thesis upon section 1.2 dealing with labyrinths, caves, masks and human communication with the earth-mother.

of regulating itself throughout the entirety of its parts, including its weathering, through the usage of sensing, actuating and feedback between the planetary biological life and its engulfing infrastructure which supports it, that is its ground and atmosphere and nucleus.

> *The most important characteristic of the Eastern world view - one could almost say the essence of it – is the awareness of the unity and mutual interrelation of all things and events, the experience of all phenomena in the world as manifestations of a basic oneness. All things are seen as interdependent and inseparable parts of this cosmic whole; as different manifestations of the same ultimate reality.* (Capra 1975:130)

As we have just identified a particular reading of consciousness research towards otherness intensification and technoetic ilinxian based methodologies, concluding in a most relevant "gaian field", whereas minds and matter blend in a living planetary field, extendable towards a *tao of physics* (paraphrasing Capra 1975), unto a human ungraspable cosmic interconnectedness unison, we now propose to follow along the reasoning that ascribes video game technologies as a possible pathway of research into these meanders. As is described below, while hosting a personal, subjective accounting of how videogame related tools and programming personally changed radically the way the thesis author has since approached art making, this section walks with the reader through a subjective history relating advances in computation and algorithms to the pioneers and the birth of interactive immersive experiences, and why they matter in this context.

In short and speaking about the author's arts practice, after studying music, painting, sculpture and philosophy it has mutated into exploring computation and its intersections with the arts since. Inspired by early contact with videogames and audiovisual synthesis, fascinated with its immersive capabilities, he started to delve into computation, exploring *τέχνη/techné* and media to create, synthesize, host and navigate cyber-virtual-environments. Programs, ethereal objects that summon your actions to unfold their *spatium*. Cathartic otherness artistic laboratories. Human interfaces towards non-human worlds to feedback onto the human. Artistic constructs refocusing mythological ideas, actualized in the self that experiences and perhaps merges with the proposed ambiance.

Back in the nineteen eighties, with the introduction of consumer-level micro-computers with very limited capabilities (Atari, Commodore, Spectrum), even as a youngling, fascinated and engaged at the rudimentary logical constructs, graphics and sounds early game programmers set afoot: by interacting with physical devices one could role play and control on-screen characters with simple graphics, unfold absurd or fantastic story lines, train faster responses to stimulus and increase my dexterity navigating the logical space within a game, while arousing the illusion of actively participating in endless parallel worlds that quickly changed the space around one's body by immersing it in the videogames being played.

Although his first gaming and programming experiences were on a ZX Spectrum clone with the BASIC programming language, from which a fond memory of being able to program by example a simple snake game with custom rainbow colored blocks as time progressed and as it grew larger, it was not until the nineties, with the appearance of more powerful commercial personal computers (PC), and of games such as *Wolfenstein 3D, Doom, Quake* (iD Software 1992, 1993, 1996), *Unreal* shipping with its editor *UnrealEd* (Epic Games 1998), that have heightened the experience of the immersive capabilities of videogaming.
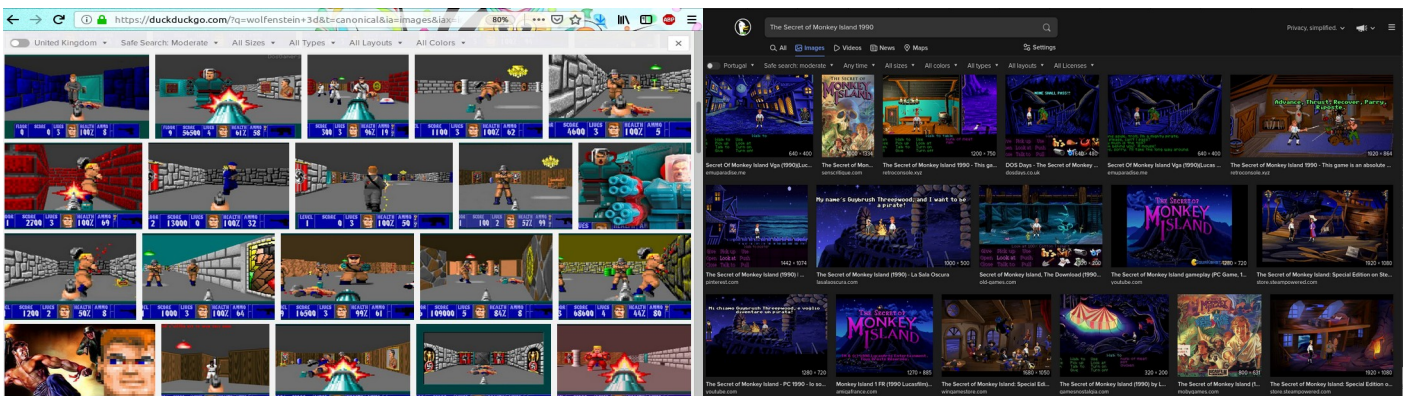
Figures 74, 75: Screenshot of duckduckgo image search for Wolfenstein 3D (id Software 1992) and The Secret of Monkey Island (Lucasfilm Games 1990).

Playing these games was like an introduction into nearing seamless plateaus of roaming imaginary and tangible 3D spaces as well as interactively delving upon luring emotional narrative lines. Here finding the tools to start experimenting immersion and crafting of virtual spaces and experiences. Within these emotionally immersive games, immersiveness refers not to the modality of HCI adhesion, nor to the already mentioned

immersion onto the mythological or upon the non-human (like is fulcral and defined in this inquiry at 0.1), but immersiveness as a strong engagement from the user with the programs' simulation, either deeply enveloped in its labyrinthine narrative, or dazzled through the possibility of becoming a new body through the game's avatar, inhabitting an emotionally compelling and interactive story line, where we *get lost inside* (Eno 2006). A user, when transported and submerged, becomes responsible for deeply emotional decisions throughout the gaming narrative, as experienced firsthand as a teenager, firstly through adventure gamebooks like *Starship Traveller* (Jackson 1986, 1983), later as Guybrush Threepwood seeking to unravel *The Secret of Monkey Island* (Lucasarts 1990), and as Roger Wilco, traveling through galaxies and time with a broom (Space Quest series, Sierra On-Line 1986-95).
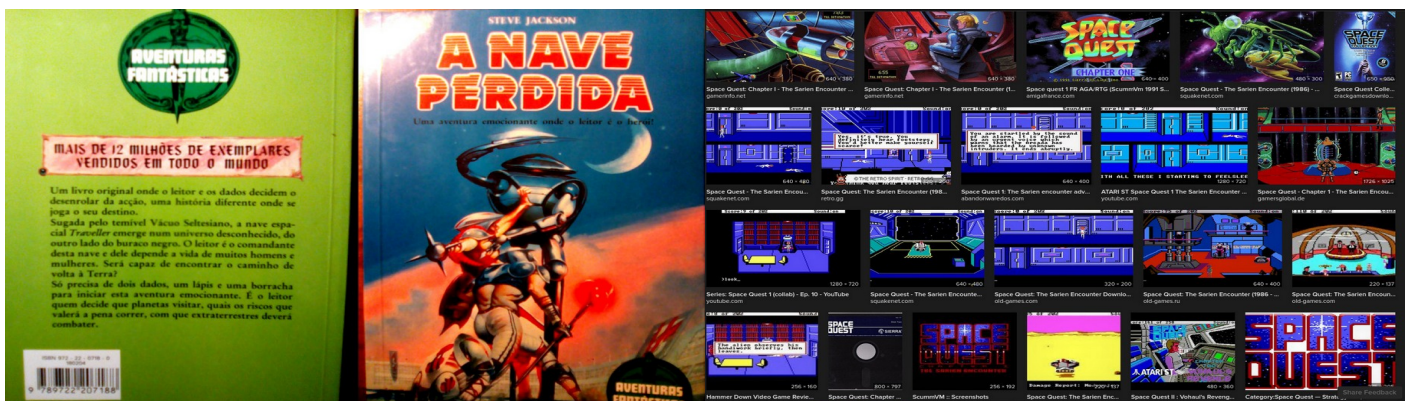
Figures 76, 77: Photo of author's Portuguese edition of sci-fi adventure gamebook Starship Traveller (Jackson 1983); Space Quest I: The Sarien Encounter (Sierra On-Line 1986) random images through duckduckgo image search.

However, perceptive immersion on top of a technical feat of fast enough moving images depicting rudimentary first person 3D perspective graphics, often coupled with sounds, immersion in a real-time interactive and vast cartesian simulated virtual space, made by computer graphics and sounds that are interactive to player control (iD/Carmack 1992, Benedikt 1991, Baudrillard 1981, Colley et al 1973, Sutherland 1965), where there's an intensification of a lingering persisting feeling of being there, tendentiously forgetful of the aggregate departing body and sensing abilities since he is now intensifying his illusion towards becoming (Manovich 2001, Deleuze 1969), provided by the immersive gaming experience. These other types of immersive games are played in the first person where the player experiences the action through the eyes of the protagonist. Although the FPS videogame genre debuted nearly 20 years earlier[26] than the author's first experiences, it

---

26   In 1973 Steve Colley, Greg Thompson et al programmed Maze War on a Imlac PDS-1 at the NASA Ames Research Center in California. The program depicted mazes on a 16x16 bit resolution that could be navigated from a first-person perspective and shared on a network setting amongst similar machines.

was usually implemented in non-standard and cutting edge computational research platforms, only available at research institutions like NASA or MIT, not to a standard consumer. Affordable personal computers bridged this gap and massified access to games and tools, even though they were written in cryptic logical programming languages with steep learning curves.
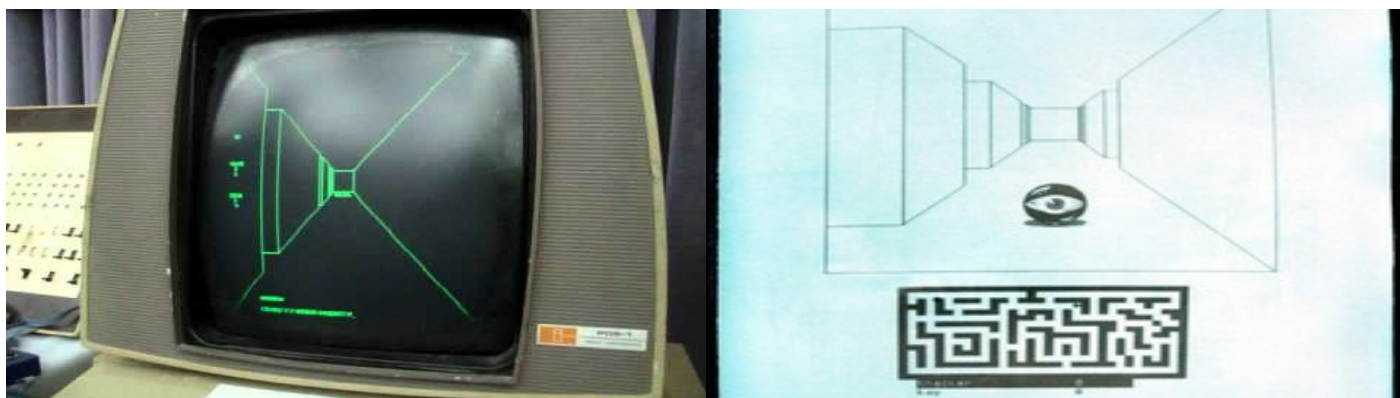
Figures 78, 79: Steve Colley, Greg Thompson et al programmed Maze War in 1973-74 making it the first example of interactive first person navigation, precursor to the FPS gaming genre. Photos © Bruce Damer 2011, Bill Verplanck 1977.

First-person 3D perspective computer graphics have since layered the computational foundations for the recreation of a playable virtual space inside the memory of computers, exposed through a variety of computer peripherals that target the human senses. Videogame users saw the playing field as if they themselves were walking on it, with the virtual game space being rendered in one point perspective as if seen from the users' point of view. These types of early kinds of graphics and immersion could also be considered a very early virtual reality system. But it could also do more. Ivan Sutherland, one of the forerunner fathers of virtual reality (alongside with Engelbart, Krueger, Lanier, Carmack) has stated:

A display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world. It is a looking glass into a mathematical wonderland. (Sutherland 1965:507)

Combining these gaming experiences with artistic research in painting, sculpture, music and installation already undertaking since the beginning of the nineties was an obvious natural step. These early immersive gaming experiences on computers, that

[https://digibarn.com/history/04-VCF7-MazeWar/stories/colley.html, accessed 21 October 2018].

initiated first person navigation on vast three dimensional spaces, by using the keyboard and mouse and joystick as interfaces on the PC between the author's body and the virtual constructs, have since transformed his views on what art could be: as an arts student, he quickly extrapolated this immersive quality on computerized ludical constructs to being transported into a traditional art piece's objective space. Moreover, led him to craft feasible immersive pseudo-infinite stochastic audio-visual worlds.

Instead of experiencing traditional static works of art, by mind playing/wandering with the sense data paintings or sculptures offer, where the eyes and the imagination move according to what some masterpiece is inscribed and composed with, returning a sense of beyondness, awe, terror or delight (to name a few), what if we could merge art experiencing with videogame interacting? What if we could enter a painting and browse through it, touch it, play with it, dive within it and immerse in the artists piece conception scattered over an interactive virtual space and time? What if we could *become* the painting, traveling seamlessly within the fabricated imaginarium, dilute and transform our normal body towards instances scattered throughout the prompted constructs held together by a sense of self? How would we conceive different spaces and mechanics where a concept of a cybernetic, interconnected and limitless body augments the real one and overflows itself in a cyber-realm? Could these new technologies promote a heightened deeper engaging with themes unheard of in reality? Not that the mere experience of static art masterpieces does not carry along already this game within – of which numerous philosophers and artists have tried and continue to tackle –, that countless human made artifacts through the course of millennia within each epoch's technologies are proof of. But through these new computerized techniques we could almost physically venture into artistic realms, themes, interact and play with them, as no other technique has managed to actualize before, engaging deeper illusions with almost concrete tangibility into navigable interactive experience spaces, which are distinct from what the body knew so far from its experience in a non-computerized non-augmented reality. New bodies could be forged, with distinct motion characteristics. New virtual cybernetic spaces could be built. Spaces that have their own set of rules, spaces that could be shared, communicated through networks, bodies that could blend into other lifeforms sharing same cyberspaces.

This idea of a cyberspace, rooted in Norbert Wiener's cybernetics, where in 1948 he defined the cybernetic discipline as "the scientific study of control and communication in the animal and the machine", provides the infra-structural plateau on top of which such phenomena of shared topological thinking for human augmentation gain concreteness. It comes as no surprise that an artist pioneering artworks and first embracing these cybernetic grounds tackles the seemingly endless possibilities of these new media as a major leap, both for our understanding of the world and for its impact into forging new arts that could embrace this unbefore seen potential, reviving the ideas of a "Gesamtkunstwerk" as conceived by Trahndorff in 1827 and Wagner in 1849[27], although now set and framed within a cybernetic context. Roy Ascott, in his 1989 text Gesamtdatenwerk shares with us both of these groundbreaking topics foreseen in their full applicability:

Increasingly, as artists, we are impatient with single modes of operation in data space. We search for synthesis of image, sound, text. We wish to incorporate human and artificial movements, environmental dynamics, and ambient transformations all together into a more seamless whole. We search, in short, for what I call, in German, Gesamtdatenwerk, or "integrated data work," echoing the Gesamtkunstwerk, or "total artwork," conceived by Richard Wagner. (Ascott 1989:227)

Ascott continues to underline the philosophical implications of what such a cyberspace could be, firmly entwined in a reality:

[…] computer networking provides for a field of interaction between human and artificial intelligence, involving symbiosis and integration of modes of thinking, imagining and creating, which, from the point of view of art, can lead to an immense diversity of cultural transformations, and which, in science and philosophy, can yield enriched definitions of the human condition. Computer networking, in short, responds to our deep psychological desire for transcendence— to reach the immaterial, the spiritual—the wish to be out of body, out of mind, to exceed the limitations of time and space, a kind of biotechnological theology.

27 The term Gesamtkunstwerk first appears in Trahndorff (1827), Ästhetik oder Lehre von Weltanschauung und Kunst, although is more attributed to Richard Wagner of which he uses this same word-concept in his book "The Art-Work of the Future" from 1849. (Wagner 1993).

[...] Our perception of space and time is not the frame of reality but an aspect of an undivided whole within which an infinity of separate realities, parallel universes, can endlessly be constructed. How quickly this science moves into metaphysics and brings us back to theology, mysticism, and mythology! It is in this richness of value systems, world models, cultural constructs, and virtual realities that the networking artist operates. (Ascott 1989:223)

Ascott's visionary cyber-transcendence of networked humans and machines establishes a plateau for the emergence of a field blent through collective electronic machines and hive minds communicating in Wiener's sense, where all the procedures by which one mind-machine affects another are to be considered. We can expand this reasoning to accommodate for non-human communication, where entities that possess distinct individual and social levels of existence amongst the biological and electronic kingdoms are to be considered. They operate at other than human physiological and behaviorally infrastructures, and can contribute with features out of reach for humans. Cyber-networking coupled with and to non-human mechanics, in order to foster prolific constructions of inhuman *gesamkunstdatenwerks*, which can propose other than human field modes of being. This thought process is expanded on 1.1.4 by analyzing cybernetic electronic biologification and electronic consciousness research, providing an infra-structural plateau from where zenospace (1.4) sprouted, while 1.1.3 investigates non-human and mythological linkage.

Another aspect worth highlighting from early encounters with new technologies and programmed virtual realities is that it also seemed these deeper experiences could change reality rules under new technological strata, by proposing new ones, or attempting to emulate and play with known ones. It could educate and foster life changing experiences in the virtual that would feedback in the user towards a better real. At the time of the first young encounters with these technologies the author knew of no traditional arts artists working on such "fields". The possibilities percolating mesmerized his senses since.

At the dawn of commercial internet during the early nineties the author was able to research and experience VRML spaces[28], ahead of time mathematical and software art, tutorials, and most importantly, coding tools which allowed him to learn the initial principles of programming languages, refining them over the years. In the gaussian bell peak curve of these first technological encounters with multimedia programming environments, with early game engine tools and visual programming environments, they have since shifted interests as an artist from static traditional art experiences towards interactive processes and devices, then game spaces. Before approaching virtual space interactivity, and already with keen interests in video manufacturing, electronic sonic processes and music composition coupled to synaesthetic and cymatic water/lights interactivity, yet in art school, the author began experimenting with real-time sound and light and water installations, which led him to develop since 1998 and ongoing the struct series of artworks[29]. It was yet in 1998 that he jumped into the virtual and initiated building a first interactive experience space for the final work of sculpture at art school, an interactive, navigable abstract space with spatialized sounds. *0 0 255*[30] was a first practical entry point into the arts the author has studied, researched, presented works on, ever since.
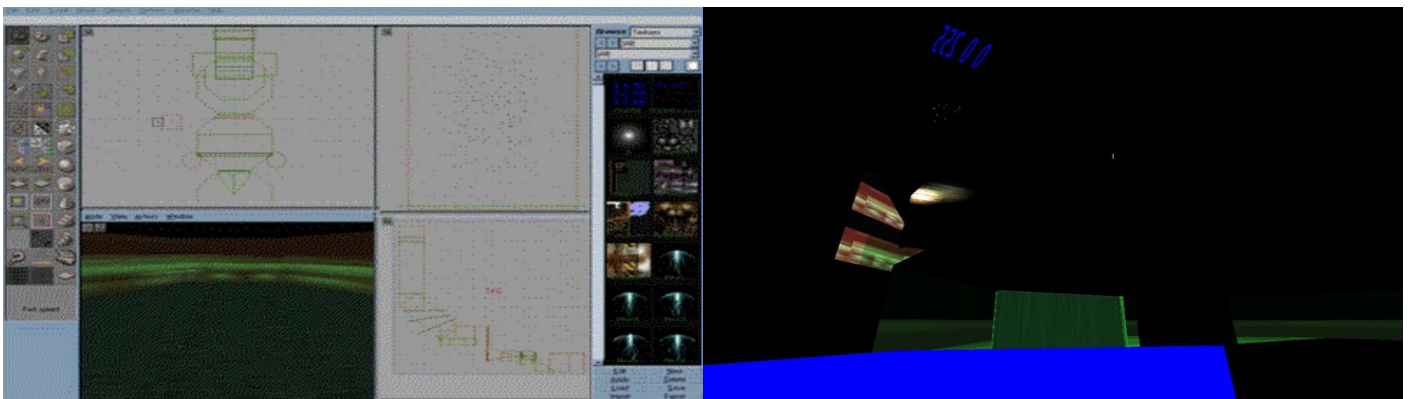
Figures 80, 81: Construction and example images from *0 0 255* (André Sier 1998-99), author's first interactive immersive gaming experience sculpted in UEd (Epic Games 1998).

28 VRML stands for Virtual Reality Modeling Language, a precursor attempt to create a standard file format for representing 3 dimensional interactive graphics, designed in 1994 as a runner up to extending the World Wide Web to support virtual reality (Raggett, 1994, https://w3.org/People/Raggett/vrml/vrml.html accessed 10 October 2018).

29 For a research article about the struct series of artworks see Sier, A. (2017), 'Structs for an aspatial quantum-now', Taboo – Transgression – Transcendence in Art & Science, Honorato, D., Giannakoulopoulos, A., (Eds), Corfu: Ionian University.

30 0 255 was an interactive audio-visual browsable game space constructed with UnrealEd in 1998-9. The 3D environment offered the player navigation through a joystick in a constructed imaginary space with spatialized sounds and events. A precursor work into the many interactive 3D environments the author has constructed; some images can be consulted at https://andre-sier.com/piantadelmondo/0-0-255/

Each artistic videogame/(bio-)electronic based installation merges many simultaneous areas within its design as well as on its physical implementation to be audience engaged. When designing an interactive experience of electronic arts (EA) as complex as a videogame, without resorting to external game engines and designing the full experience from scratch, the structure and full implementation of the program must be machine coded by compilers through source code instructions fully programmed by the author in order for it to operate, and to run smoothly many times per second (circa 30/60 fps, even higher on most recent 2022 hardwares trying to set 120+fps standard). Besides the programming involved in each works' main audio-visual program/composition, the creation of interfaces on sculptural hardware as well as the programming of its custom firmware is also involved. It is achieved using open source artistic toolkits like Arduino (ARD), Processing (P5), Openframeworks (OF), which facilitate hardware and software programming, combined with the author's open source code libraries of generative processes used throughout his works (see https://s373.net/code, https://github.com/s373 for a collection of published libraries of code, addons and examples throughout the years). Additionally, specific coded tools are programmed for these environments in order to generate its unique main visual and sonic characteristics: to create textures and landscapes, sounds and music, character design, virtual environment design, game logic rules, landscape traveling testing, animation and lightning rigs, networking prototypes, interface interacting, generative spatial and musical composition, system interaction, among many others.

As an example of the complexity and the means to reach an authorial aesthetic language usually involved in one program (the videogame Wolfanddotcom), herein follows a selection of sequential listing of procedures grouped in high order operations, some logically taking place every single visual frame, others which control flow more rarely at two three times per second: read sensors; update player position; send network player pos; receive network data; update game logic; update dynamic objects; background; draw a texture; cam.begin(); enable lights & depth test & cull face; bind another texture; draw pseudo-infinite terrain with frustum visibility; unbind texture; disable lights; calc frustum visibility; draw many 3d objects with 1st texture; enable lights; draw assimp animated meshes; upload a texture; disable lights; draw 3d graphics (lines, circles); end cam; draw hud; draw panel; draw text; fbo1 begin; ofClear; draw 1sttex; fbo1end; fbo2 begin; ofClear; draw 2nd tex; fbo2 end; disable lights, enable blending; draw fbo1 & fbo2.
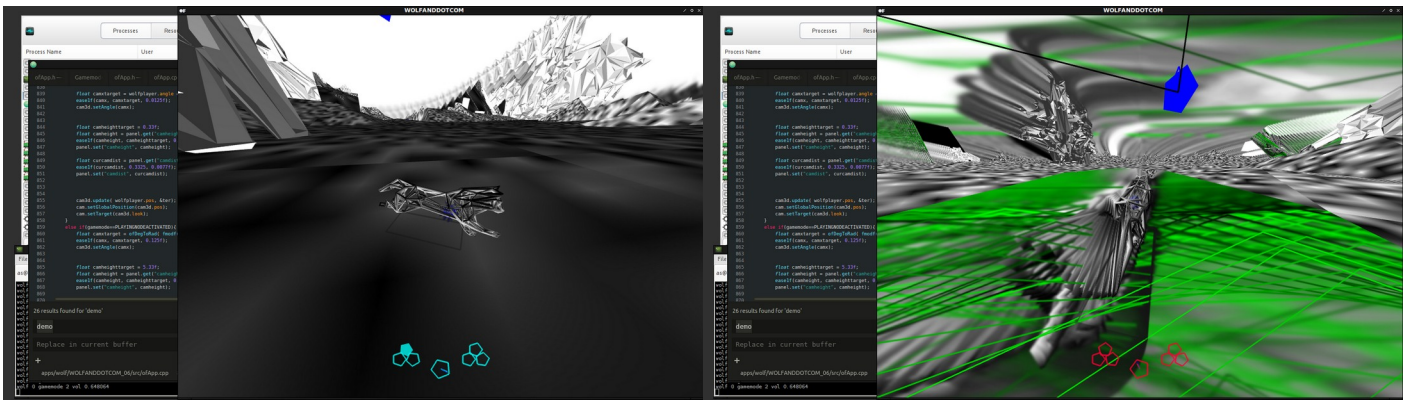
Figures 82, 83: *Wolfanddotcom* videogame graphics pipeline visual examples with source code snippets.

By taking low level control of what happens every frame, as well as a tight grip on the structure of the internal game engine programmed in its entirety by the artist, specific and interchangeable for every designed experience, by painting what the author is seeing and experiencing, with his own brushes and inks, and by refraining to delegate on others implementations of ideas he wishes to communicate, one can reach a specific authorial artistic new media electronic language which tends to focus upon distinct directions current mainstream gaming experiences are usually involved with, fixation with realism, i.e., emulating visual and auditory graphics similar to what our senses capture from the external world versus using the tools to visualize unheard spaces, topologies, modes of being. The author is deeply interested artistically in another view of virtuality, cyberspace, immersive alter visions, cybernetic new worlds. In order to walk towards this clearing, one must find or build the right tools, and be able to implement the visions, resorting to simple or elaborate and intricate aesthetic and technological expertise.

As non-human models provide an inspiring departure point with different physiological, behavioral and perceptive apparatuses (for example, Fuller 1981 remarks: "*Since the initial publication of the chart of the electromagnetic spectrum, humans have learned that what they can touch, smell, see, and hear is less than one-millionth of reality*"), through the research and in order to reach these new grounds of immersive alter visions and cybernetic new worlds, inspired by groundbreaking research such as Ken Perlin's Hypertexture (Perlin 1989), the author had to rethink about how to encode and program the visual, the sonic, the logic and interactive pipelines, and through the coding tools available and through the ones he could build (see appendix α), looking for new ways to visualize and interact with representations of virtual 3D imaginary spaces.

From the above, it becomes quite clear that videogames are one of the most complex types of software programs, combining visual, aural, interactive, logic, narrative and high end computational engineering. They can assume forms of interactive books, entangled meanders with labyrinthine logic, cinema where we play any role, a concert we interact with or even play with musicians, ultimately, videogames can be experience spaces where we can sense what videogames architects can imagine. Games, or the ludic sphere, are inherently present in many aspects of human activity. It is also a powerful tool to convey stories and other experiences which are usually outside a humans' normal life. As with what was already introduced at the beginning of 1.1.1, Huizinga applied game theory and devised a "magic circle" zone to different aspects of human life, outside of the ludic sphere (Huizinga 1980), and Caillois, in his 1958 grand opus *Les jeaux et les hommes* (Caillois 1990, 1961, 1958), introduced and deepened game categories other than competition. The research the author is undertaking focuses on electronic arts constructs and games fostering the disrupting of the human sense of self, thus fitting on Caillois' *ilinxian* game category, while trying to expand it to accommodate other distinct subcategories. This vertigo like game state of ilixian category might be achieved via altering and disrupting the perception of self while engaging the user on a ludical construct, mediated through technology, algorithms, and custom human-computer interfaces.

Videogames, by combining interactive content, become different from other media. Within this medium, like Espen Aarseth alleges, "nontrivial effort is required to allow the reader to traverse the text" (Aarseth 1997). He also highlights games' main contribution:

> *Games are both object and process; they can't be read as texts or listened to as music, they must be played. Playing is integral, not coincidental like the appreciative reader or listener. The creative involvement is a necessary ingredient in the uses of games.* (Aarseth 2001)

The interactive activeness remains an essential touchstone in the processes these new media allows: players dive in the imaginary yet tangible virtual worlds, and it is solely through their interaction with the world they progress or incorporate new knowledge. As Aarseth states, the playing action is integral to the object/process (game). There is no other

access to this world other than to play the game, or to see someone else playing, though playing is always involved and each playing act is unique. This essential new quality of videogames or deep interactive experiences is refered by Ian Bogost in his book *Persuasive Games* by equating videogames as a tool towards a new form of education through experimentation on the first person:

> *I call this new form procedural rhetoric, the art of persuasion through rule-based representations and interactions rather than the spoken word, writing, images, or moving picture. [...] In addition to becoming instrumental tools for institutional goals, videogames can also disrupt and change fundamental attitudes and beliefs about the world, leading to potentially significant long-term social change. I believe that this power is not equivalent to the content of videogames, as the serious games community claims. Rather, this power lies in the very way videogames mount claims through procedural rhetorics.* (Bogost 2007:10)

Learn by doing, learn through otherness near embodiment, or by experiencing the actions in our own flesh and field, virtualized or augmented, establishes a powerful and deeper mechanism by which experiences can be shared and actualized in a more acute way.

In order to finalize section 1.1.1 dedicated to videogames as consciousness research, and for a moment setting aside the aesthetic experiences described at 1.1.2, 1.1.3 & 1.1.4, also mechanisms to achieve equal purposes next described, focusing on games as the means to merge this reasoning with the aforementioned produced concept of "gaian field", blending Deleuze and Ascott's ideas with Lovelock, Margullis, Haraway, Capra, among others, ideas which reverberate a process of diluting anthropocentric and egoic views by thinning or even rapturing identity's borders towards a cosmic harmonic unison, and since besides the research crafted projects as well as the already presented videogame *The Night Journey* (2007-18) by Bill Viola and USC Game Innovation Lab bring forth emblematic examples that address immersive playable cyber-environments, we present two frequently unnoticed eminent games that lean towards the core of the research's overarching ambition, and condense in a nutshell the edified line of reasoning with a gaian outlook.
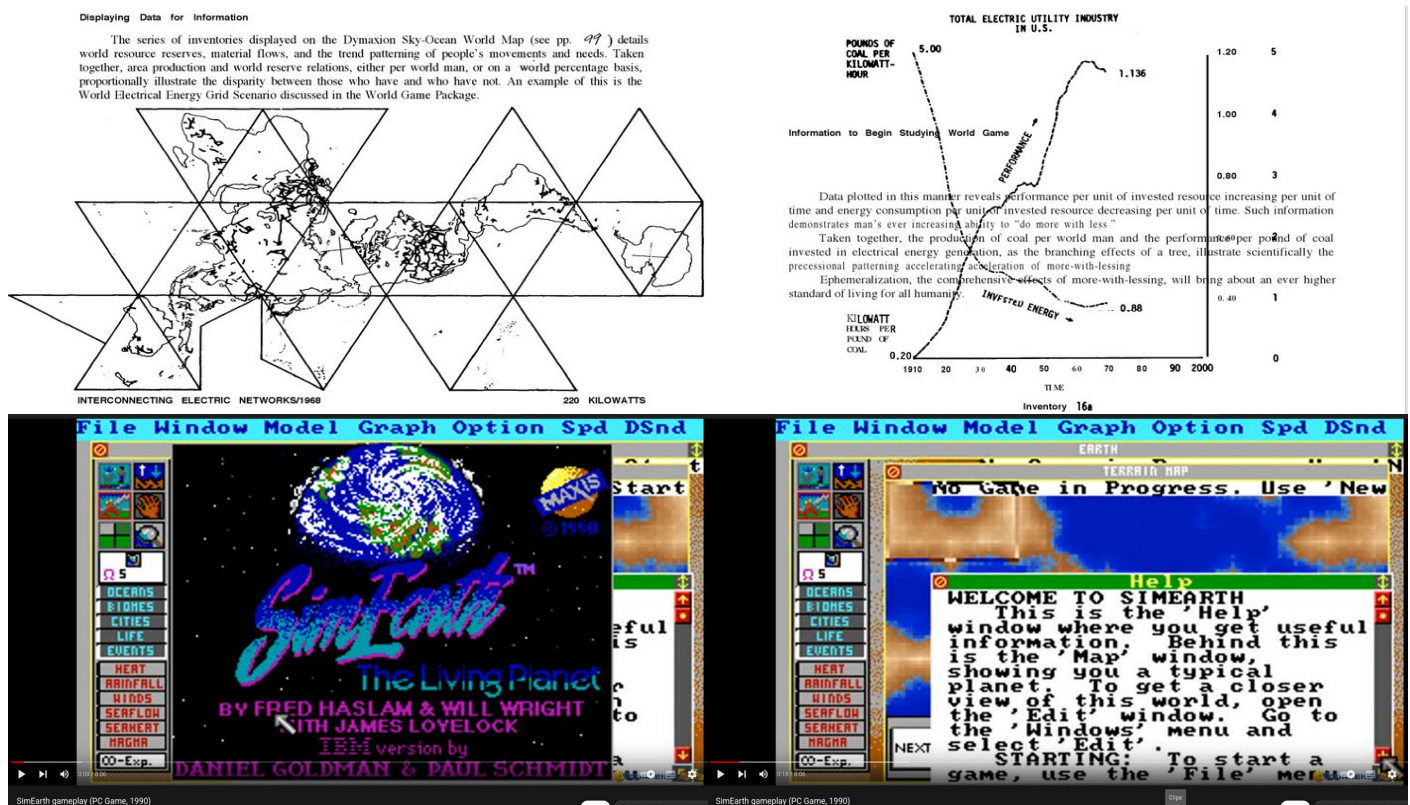
Figures 84, 85, 86, 87: Examples of harbinger games towards a "gaian field" management. Portrayed *World Game* by Buckminster Fuller, images composited from World Game Series: Document 1 (Fuller 1961); *SimEarth* by Fred Haslam & Will Wright with James Lovelock (Maxis 1990).

    One is the iconic *World Game* (Fuller 1961), in opposite directions of popular war games like *Risk* (Lamorisse 1957) that grounds almost all strategy games, where the unrivaled energy of Buckminster Fuller constructs as early as 1961 a game whose purpose is to look at Gaia and statistically tend to her, ever according to most recent scientific charts. An ecological simulation game where you prune and graft Eorthe's offsprings, fertilize and nurture her property, competing or cooperating among gardener teams whose purpose is to strategically manage her resources in order to attain gaian equilibrium and attempt to salvage *spaceship earth* and mankind along the way.

    The other is another oft unnoticed in the videogame literature yet briefly popular mainstream videogame from 1990, whose purpose is similar to *World Game,* yet addressed as an interactive computer game simulation. In *SimEarth* by Will Wright and Fred Haslam with James Lovelock himself consulting for the game, we play a real-time evolutionary simulation of managing an entire planet through control of its biomes, cities and resources. It is a game pioneer of the strategy godlike videogames genre, built on top

of Will Wright's infamous usage of CA algorithms for highly elaborate and open ended generative systems (Johnson 2004, Wolfram 2002, Flake 1998, Gleick 1994), whereas following logics related to what Wright devised and crafted for his more popular *SimCity* series (Maxis/Wright 1989), instead of mayor of the cellular automata based generative city, we play as a "gaian player" tending to a living planet emerging from parametrized CA coupled to architectural stratification of their degrees of freedom in the evolution of the logic space of the game.

Related to the "gardening" in art (Eno 2006, Kandinsky 1975), as exemplified in the above description of Fuller's fulcral game and throughout many portions of this thesis, as brought forth by Brian Eno married to cellular automata and other relevant generative algorithms, besides Eno's overview talk "Composers as Gardeners" (Eno 2011), there is an illuminating talk among Brian Eno and Will Wright "Playing with Time" (The Long Now Foundation 02006, see https://longnow.org/seminars/02006/jun/26/playing-with-time/) where Eno showcases the generative power of cellular automata algorithms by offering compositions built just a couple of hours prior due to having lost his computer, intertwined with Wright's insights and comprehensive overview of his usage of generative algorithms throughout his videogames, many of which inaugurated genres, as with Eno's ambient music. Wright's generative algorithms include stochastics (ST), though most pertinently CA and DNA based processes which exponentially heighten the scope field provided by the interactive gaming experience, fostering seminal steps in artificial life (AL), algorithms which are used throughout the entirety of the author's computational artworks described across this thesis and referenced under the appendices α.9 and α.11.

1.1.2 Interfaces, bridges, generative systems

This section, addressing interfaces, augmentations, bridges, interactive electronic arts and generative systems, is a topic that seeks to establish the relevance and history of the interface towards the digital work of art, as well as lay the ground basis aspects of artist thought usually attached to the creation of endless stochastic generative interactive environments.

Human computer interaction research (HCI) has been developed in parity with advances in computational technology. Scientists and artists have been among the forerunners in a long lasting quest towards seeking better adhesion and transparency with the least possible overhaul in the man machine symbiosis agenda. It is a fundamental area of research in the creation of immersive playable cyber-environments, since it becomes the bridge through which humans can interact and immerse in the programmed constructs, or proposed cyberspaces. See also Igoe 2011, Fitzgerald & Shiloh & Igoe 2012, Halfacree 2021.
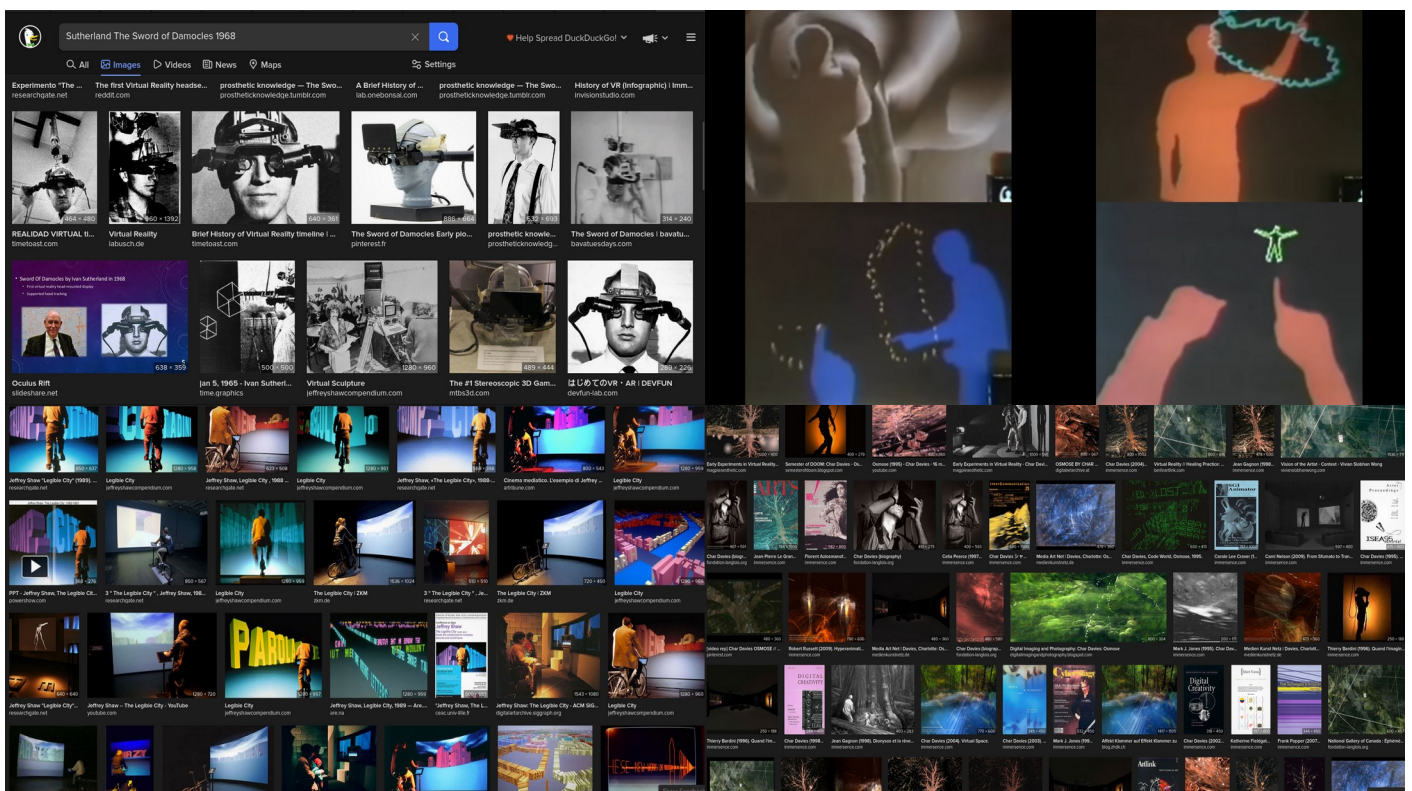
Figures 88, 89, 90, 91: Groundbreaking aesthetic human computer interaction (HCI): Ivan Sutherland's *The Sword of Damocles* (1968); Myron Krueger's *Videoplace* (1972); Jeffrey Shaw's *The Legible City* (1989); Char Davies' *Osmose* (1995).

Douglas Engelbart creates the mouse interactive device in the early sixties. Ivan Sutherland the first virtual/augmented device (VR/AR/XR), a head mounted display which merges virtual computer images onto observed reality, *The Sword of Damocles* (1968). Myron Krueger is a pathfinder in applying immersive computer vision interaction to artworks (*Videoplace* featuring dozens of different video interactive scenes, including full body, hand and tele-video-interaction, began in 1972). Since 1989, Jeffrey Shaw modified a bicycle to be the physical traveling interface of a 3D virtual space made from poem wor(l)ds as actual city buildings inside his *Legible City* installation. Char Davies devised a vest for users to wear, to be able to track their breathing patterns and balance, serving as the interface, alongside with a head mounted display virtual reality interface (VR), which immersed users within her onyric cyber-environments *Osmose* (1995) and *Ephemère* (1998), quite similar in purpose and with a more interesting immersive link to the virtual world, also probably an influence to already introduced spiritual videogame *The Night Journey* (Viola & Game Innovation Lab 2007-18).

The quality, transparency, feedback and modality of the interface remains a touchstone in interactive electronic arts and videogame research. Like our body interfaces with the world, HCI posits constructs through which we can interact in cyber-environments. Hardware makes porous borders that infiltrate algorithmical space, assigning them to different states when interacted upon by external user stimuli, unfolding each inherent programmed virtuality in the actualization of the running now under the software infra-structure's execution.

Performance art has also informed this personal inquiry and practice. Though looking at it from a computational point of view, the performative aspects are researched in terms of being conceived for the user and his subsequent immersion into algorithmical space. The quest of interface technologies to better delve the user in an artworks' spatium, with more adhesion, tendentiously osmotically (as discussed at 0.1), better than the keyboard or the mouse. When looking at performance art by artists like Nam June Paik, Chris Burden, Joseph Beuys, Ulay and Marina Abramović, he often wondered on the subtlety or expressiveness some actions of the human body might have as well as possible mechanics to apprehend them in a digital and later interactively sort of way. Even seemingly disparate humane actions, like artists are capable of. For example, by executing near shamanic

experiences, role playing through their practice, leading spectators to imaginatively immerse in situations, and to being able to experiencing them, mediated, as they perform the actions, whether you are playing with an anthropomorphic robot, or driving around town crucified to the top of a car, or communicating and inhabiting the same gallery space with a coyote for a week without leaving the premises, or in a delicate deadly equilibrium where your partner holds an arrow ready to fire at any instant[31]. If performance art has informed the author's practice regarding an artistic self's refined construction of human actions and procedures, its branching form of participatory art, as shall be seen below, has educated him into enveloping the exterior observer as an active participant within the work, and videogames, vividly as a player.
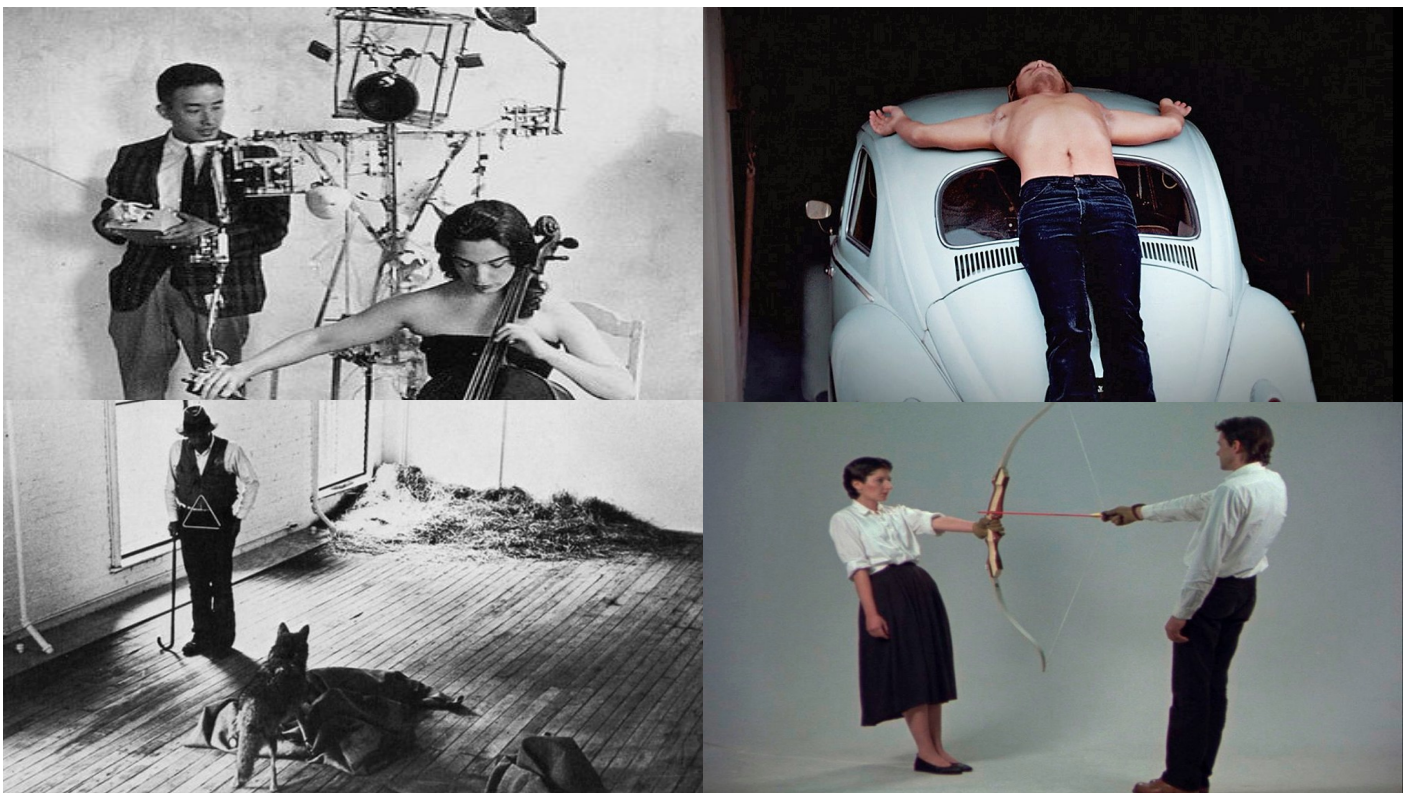
Figures 92, 93, 94, 95: Nam June Paik & Robot K-456 & Charlotte Moorman's *Robot Opera* (1965), Chris Burden's *Trans-Fixed* (1974), Joseph Beuys's *I like America and America likes me* (1974), Marina Abramović & Ulay's *Rest Energy* (1980). Photos © (92) Estate of Nam June Paik, (93) Chris Burden, (94) Joseph Beuys & Caroline Tisdall, (95) Marina Abramović Archives.

Innovative HCI techniques are also researched and implemented throughout the author's works, and they also become an axial technical aspect of this research, alongside

---

31   The text glimpses details from the following performances: Nam June Paik & Robot K-456 & Charlotte Moorman's *Robot Opera* (1965), Chris Burden's *Trans-Fixed* (1974), Joseph Beuys's *I like America and America likes me* (1974), Marina Abramović & Ulay's *Rest Energy* (1980). Paik & Moorman's work features *K-456* (1964), by Paik and Shuya Abe, a groundbreaking aesthetic electronic anthropomorphic robot capable of 20 actions such as head nod, raise arm, eye motion through motors, urinating, defecating white beans, play tape recorder, etc.

with the electronic work architecture and composition. Interfaces are drawn from the analysis of a specific (non-)human player's performative action. Interfaces operate as bridges between the action to be sampled and digitized, and its related causality event in the opus world. In order for these (non-)human actions to serve as input parameters to the artistic interactive systems created, for all of the custom interfaces developed until now, the author had to write its code, the firmware, and make the necessary hardware circuitry where applicable[32].

Underlining some interface achievements realized so far, for example, in the struct series (Sier 2000-) generated sound through incoming sound synaesthetically pulse lights and water surfaces; in *747.3* (2006) designing a computer vision algorithm to insert users flying gestures as game inputs; in *k.~* (2010) programmed a 0X input sound based joystick, where incoming audio is triggered into actions; *Temporary-Babel2D* (2013) features a sonic joystick which controls the game's time, suspended atop an antique cabinet with metallic arcade-like touch buttons; *Skate.Exe* (2014) uses a fixed skateboard with triangular wheels players must ride as the pieces' bridge into a fast paced infinite skating based game; in *Atlantis (Sólon Interface)* (2016), interaction with a suspended tetrahedron, operating it like a rotatable geometrics primer provides gamespace navigation; in *Wolfanddotcom* (2017) the game is controlled by sitting on a metallic wolf and moving its ears, as well as with possible multiple users connected with smartdevices to the wifi server, which can interfere with the main users playing, the ones riding along with metallic abstract wolves via joystick-sculptural interfaces.
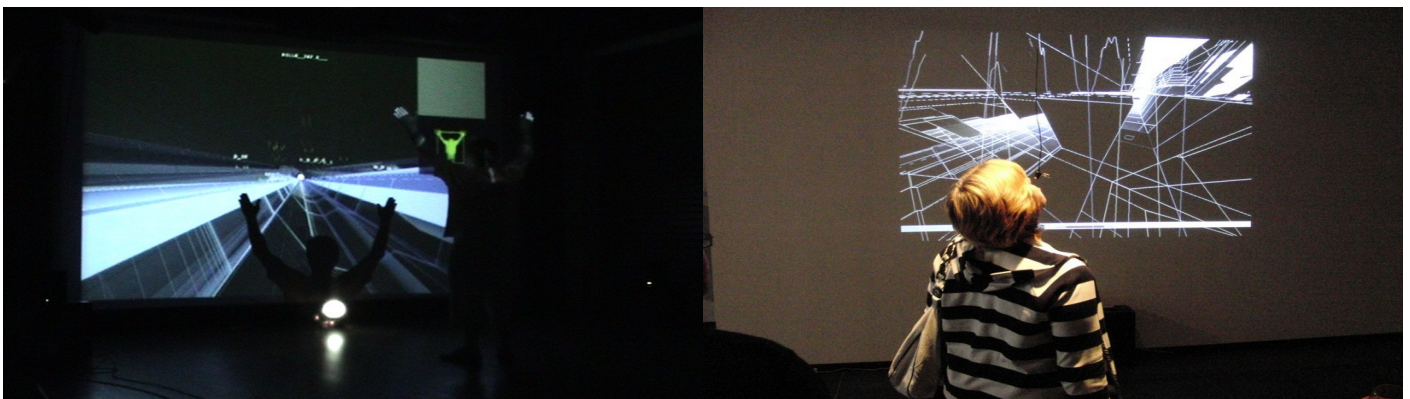
Figures 96, 97: Precursor usage of some fine-tuned research technologies: computer vision tracking flying gestures in *747.3* (2006); sonic 0X audio based 3D navigation in the pseudo-infinite virtual world of *k.~* (2010).

---

32   Using open source artistic toolkits like ARD, P5, OF, which skeleton-facilitate hardware and software programming – however all the built mechanisms were self coded on these platforms. See also https://s373.net/code and https://github.com/s373 for a collection of published libraries and addons of code.
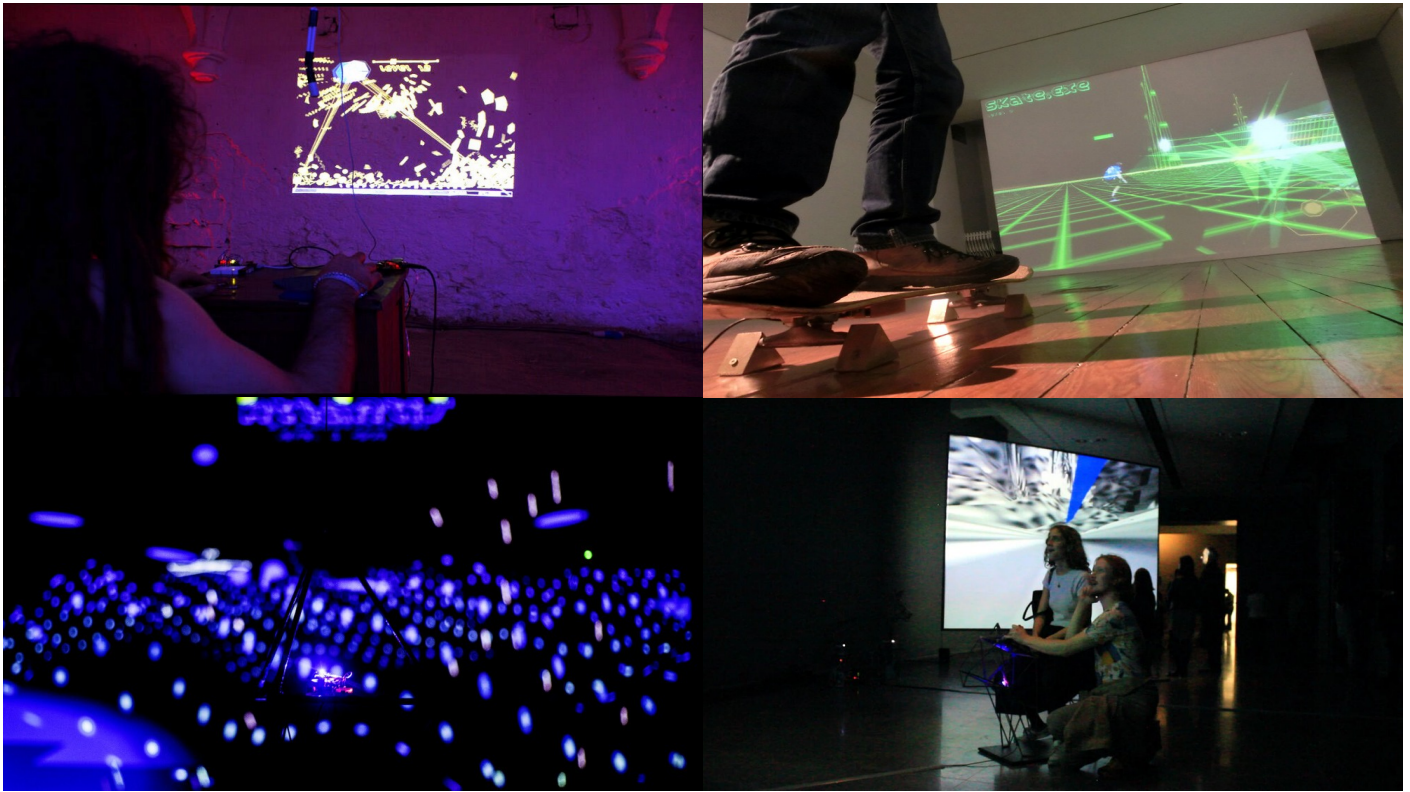
Figures 98, 99, 100, 101: Additional examples of researched interface technologies: sound input and physical computing touch interfaces in *Temporary-Babel2D* (2013); skate-joystick in *Skate.Exe* (2014); suspended tetrahedron-jostick in *Atlantis (Sólon Interface)* (2016); wolf-joystick in *Wolfanddotcom* (2017).

In the context of the wolfanddotcom PhD research at the Planetary Collegium program, the interface research up to date mainly consists of a refined blend of the techniques described above, alongside with other low-fi innovative technologies, like the virtual reality (VR/0R) research and conceptual framework created during this investigation. In *Draco.Wolfanddotcom.Info* (2015) as well as in *Phoenix.Wolfanddotcom.Info* (2017), two works within the wolfanddotcom series, an invisible computer vision technique is used in order to immerse the users as flying mythological beasts: a self-programmed custom skeleton tracker allows to pinpoint the hands and arms positions in a camera sensitive active space, which in turn allows simple gestures to operate as flying mechanics within the cyber-environments[33]. While tracked by the camera, the flying operations within the cybernetic space are triggered by the distance between the arms, which provides the speed parameter, and the angle between both hands when frontal facing the camera provides the turning amount of each players' avatar within the game spaces.

---

33   A more detailed analysis of the crafted computer vision algorithm was written in the author's 2017 article 'Human dragons playing in cyberspace', published at Technoetic Arts Journal. The algorithm is yet further discussed at 2.1.1 and appendix α.8.

Distributed social joysticks are also implemented in pieces like *Wolfanddotcom* (2017) and *Half-Plant* (2017). Here users, through their smart devices, can connect to a wireless local website each work broadcasts that allows them to interconnect at the same time within the artworks virtual space and play with it. *Wolfandotcom* also features a predominant physical interface, where users move the ears of metallic wolves in order to perform actions. Each articulated ears positions is sampled with three touch buttons, and pressing the buttons, by fondling the ears, allows for game actions like going forward, turning, jumping, braking, activating a network node, changing to a different wolf within the virtual pack. As a technological example representative of physical computation techniques involved in the projects, the source code of the firmware implementing the wolf-joystick-sculpture and its communication with the videogame server is listed at appendix α.12.
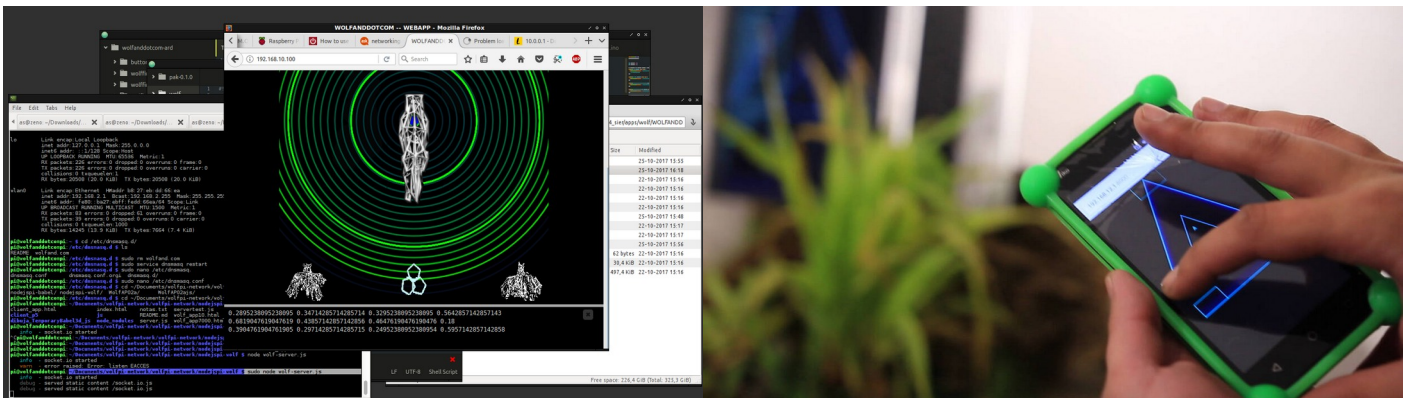
Figures 102, 103: Screenshot and photo of *Wolfanddotcom* and *Half-Plant* smart device joysticks using Node.js and Processing.js applets running in each works' WiFi server, allowing for simultaneous multi-user input.

Another relevant kind of interface consists of sound based interaction technologies, in development throughout a latitude of works, precursory utilized most relevantly in previous projects like *struct_0* (2001), *struct_1* (2001), struct_4 (2006), *k.~* (2010), *Temporary-Babel 2D* (2013), *Skate.Exe Portraits* (2014), *Babylon* (2018), *0X Labyrinth* (2020). While on the struct series simple RMS with lowpass filtering is applied on responsive audio interaction, on *k.~*, a zero crossings sound analysis (0X) operates as the piece's joystick: silence, or captured sound levels below a low defined threshold induce the player's avatar to continuously pivot standing still, while sonic content above it boosts the player forward, or upwards, according to the captured sonic frequency information of the sound, executing thus an engaging invisible interface, operated through spoken or singing noises emitted by the player that become actions in the virtual ambiance.

Figures 104, 105, 106, 107: Precursor examples of sonic interfaces depicted in the images from the works *k.~* (2010) at solo exhibition Ape-x, NT Gallery, Lodz; *Temporary-Babel 2D* screenshot (2013), *Skate.Exe Portraits* (2014) screenshot, *Babylon* (2018) at The New Art Fest TNAF18, SNBA Lisboa.

This sound technique is also utilized predominantly as the movement mechanics on wolfanddotcom's labyrinthine inspired opus *oX Labyrinth* (2018-22), coupled with researched, programmed and field-tested virtual reality gaze interaction, firstly on a linux system with barely supported Oculus Rift DK2 drivers, ofxIrrlicht, movement and sonic libraries based work *Babylon* (2018), then here on the wolfanddotcom research, with *oX Labyrinth* (2018-22), resorting to a custom VR sculptural mask joystick and immersive apparatus based on standard OF/C++ for Android devices adjoined with custom programmed interface technologies. On both these works, yet with distinct modalities, the player moves or jumps in the direction of his gaze according to his sonic interactions coupled to the works' movement compositions. The zero crossings (0X) sound interface technique is also further discussed at appendix α.7, the virtual reality (VR) library at appendix α.10.

Figures 108, 109, 110, 111: Developing, field-testing and exhibiting custom virtual reality technologies in sculptural immersive masks designed for works *Babylon* (2018), *oX Labyrinth* (2018-22). Photo 108 Babylon residency at Espaço do Tempo 2018; (109, 110) Babylon at XXth Bienal Cerveira. (111) 0X Labyrinth 2020 version 2 VR mask.

Early generative works also bring along sublimity of endless variations of a work's core rules, either using or not using computers. Artists focus on rules which expand into an object depicting a multitudes of states with seemingly endless variations (John Cage, Jean Tinguely, Roy Ascott, Georg Nees, Frieder Nake, Manfred Mohr, Vera Molnar, Sol LeWitt, Hans Haacke, to name a few early artists that have produced striking generative works). Generative artists usually construct autonomous systems which are endowed with rules that produce a near infinitude of artistic outputs (Galanter 2003, Eno 1996). Early generative artists have furthered ideas forerunners to the advent of computers, implemented throughout their works as interactive or evolutionary systems, or sets of rules set in motion upon the works execution, even as games that can be played between two conductors, aesthetically exploring a broad latitude of possible musical outcomes inscribed in the conception of the work, like in Xenakis' *Stratégie* (1962).
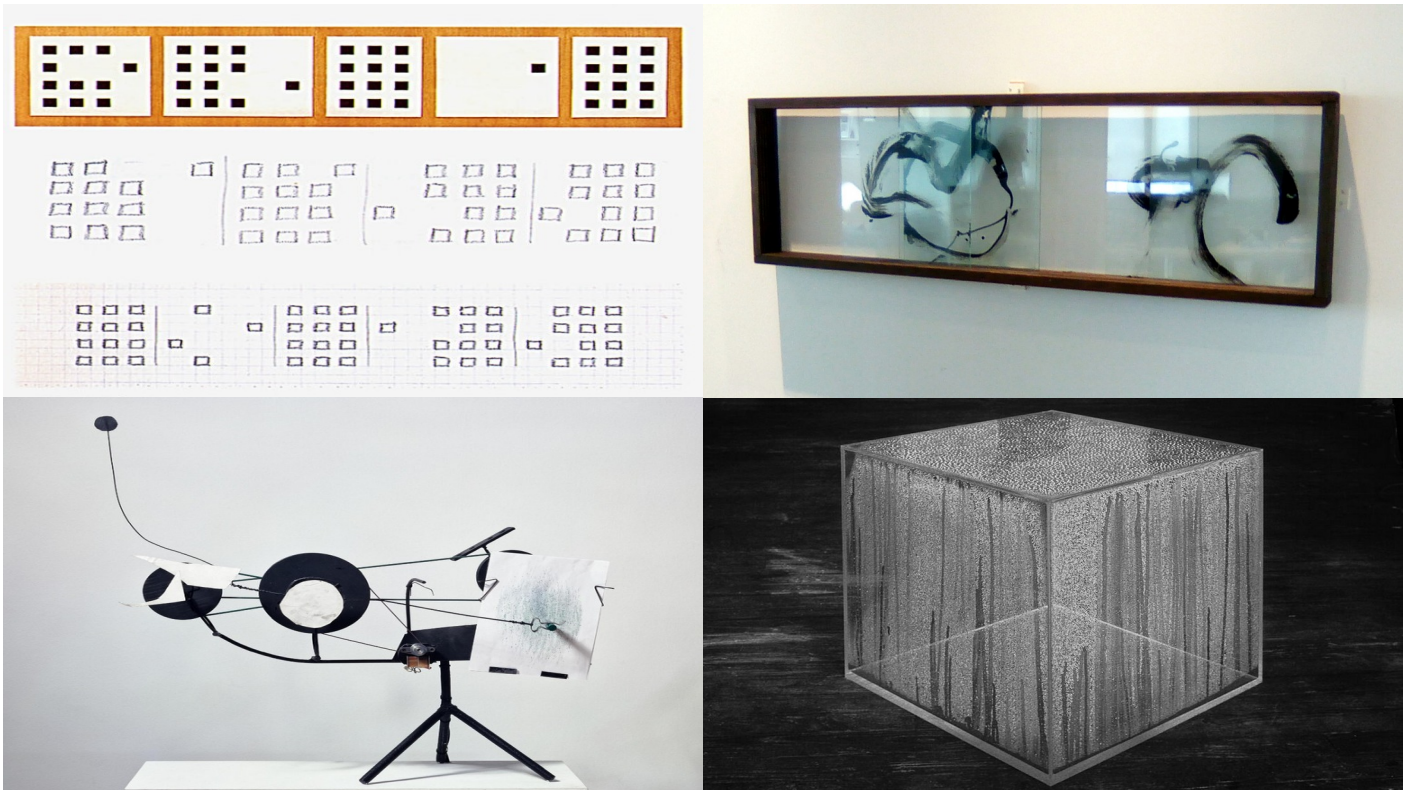
Figures 112, 113, 114, 115: Early generative art examples of influential works forerunners to the advent of generative computation. Images from *Sans titre* (Vera Molnar 1950), *Change Paintings* (Roy Ascott 1959), *Méta-matic nº1* (Jean Tinguely 1959), *Condensation Cube* (Hans Haacke 1963-68). Photos © (112) Musée de Grenoble, (114) Philippe Migeat - Centre Pompidou, (115) MACBA Foundation.

Generative art can also be combined with participatory art, where users are invited to engage along a certain line of action throughout a pre-structured score of events or an artistic challenge it might offer. Openness to the piece's structure, unpredictability and interactive audience behaviors which shape the work's evolution through time and/or space are relevant features common to participatory and generative arts. Researched examples of acclaimed opus from participatory art influential towards this inquiry include *bichos* and *Caminhando* by Lygia Clark (1960-63, 1964), *One & Other* by Antony Gormley (2009), *18 Happenings in 6 Parts* by Allan Kaprow (1959). However, it has not been until the arrival of generative/cybernetic art that these ideas have been mutated into something new and meaningful for the scope of the research the author has been producing, as the interactive work created over the last 25 years is fully explored.

Figures 116, 117, 118, 119: Participatory art examples with works *18 Happenings in 6 Parts* (Allan Kaprow 1959), *bichos* (Lygia Clark 1960-63), *Caminhando* (Lygia Clark 1964), *One & Other* (Antony Gormley 2009). Photos © (116) LACE, (117, 118) MoMA, (119) designboom.

Instead of a prescribed sequence of events, even if open to participation and loosely open ended, within GA artists forge simple grammars whose aims are to approach unforeseen regions, unstructured sequences of events or even invisible imaginary spaces lurking behind a way to interact with a certain formula as a way to devise a multitude of endless options. Aesthetic methods that can be seen rooted between interrelations from art movements under the umbrellas of impressionism, futurism and its noise, abstract arts, concrète arts, cut-ups, ready-mades, kinetic and performative arts, Generative artists shift their focus to the process, entangle it with procedural rules, make use of recipes to combine the procedures in unforeseen ways as mechanisms to reach unheard of mind regions crystallized in objects or processes of art. A fitting definition is provided by Philip Galanter:

> *Generative art refers to any art practice where the artist creates a process, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is then set into motion with some degree of autonomy contributing to or resulting in a completed work of art.* (Galanter 2003:225)

By combining both participatory and generative arts systems we might engage in the creation of systems which are not merely reactive to user inputs, nor merely autonomous and exploratory of a fixed grammar of actions: combining both art forms we can see works where the input of the player to the system of rules is meaningful while exploring a vast lexical scope of possible actions, and the systems' output is significantly changed in terms of mutations operated to the grammar by the user interaction.

For the purpose of relating to the previous section and concluding this one, at 1.1.1 we began addressing videogames as consciousness research, so that here at 1.1.2 generative systems can be fully discussed, we now focus chiefly in stochastic and procedural (ST) videogames, with a fulcral musical detour, resorting to already introduced stochastic procedural generation, cellular automata and DNA based algorithms, which have layed down prevailing aspects of the generative arts foundations examined above. Games like SimEarth (Maxis 1990) and Elite (Acornsoft 1984) are at the dawn of usage of automata and stochastics in the amplification of the logical space of the programs. The games involving DNA will be extended at section 1.1.3 with contributions from electronic constructs other artists devised, like Karl Sims (1990-94) and Christa Sommerer & Laurent Mignonneau (1994-97).

In Elite (1984), by using stochastics with a matrix of combinatorial possibilities (Lecky-Thompson 1999), in a process inaugurated by Xenakis in the aforesaid game-composition Stratégie (1962), detailed under the comprehensive basin of stochastic usage and advanced mathematics in the musical arts, described in his seminal Formalized Music (Xenakis 1992), the game space Elite offers is an elaborate vast number of planets for the player to explore filled with different resources commercially explorable, if he is able to endure in the virtual world. The naming convention of Elite's planets is an example of such variety stochastics provides. ST coupled to combinatorial matrices and logic can also forge pseudo-infinite and numerically controlled spaces, which are architected by algorithms within the virtual logic space of the game. Elite places the player as a spatial explorer and interplanetary navigator, merchant or pirate, depending on the action choices the player performs as he proceeds throughout the game. This leads the algorithms to distinct logical

regions and thus produces different outcomes for her/him to explore in the game space. As a storage mechanism for this pseudo-infinite, Elite's ROM (all 47.9kb of its binary instructions) utilizes solely stochastics at runtime, which under 48k of RAM, create its revolutionary vast universe within these highly constrained means, since the enormity of information required for the game to function and the player to explore is not stored in a database. Instead, all of Elite's universe is calculated at runtime by properly seeding values to sets of computer instructions that calculate predictable random numbers induced by those seeds, which in turn generate the entirety of its logical world, even engaged within the game under innovative and simple wireframe 3D graphics, which have highlighted this game over a similar predecessor one (Reach for the Stars 1983). Elite provides a graphical interactive experience of departing and arriving at planetary docking stations, or engaging enemies in the void of 3D space where your spaceship is able to turn in any direction.

Figures 120, 121: Photo and screenshot of "games" *Stratégie* (Xenakis 1962), *Elite* (Acornsoft 1984). Xenakis's image represents the matrix of the game to be followed by two competing conductors, on p.128 of his book Formalized Music (1992). Elite's image is a screenshot of the game's loading screen on a ZX Spectrum 48k.

Will Wright furthers additional generative algorithms (GA) within videogames, especially parameterized cellular automata (CA) as the emergent intelligence exhibited by the programs. Here users can intervene and design alongside the evolution of individual elements of the autonomous automata ecosystem. Algorithms which were debuted in SimCity (1985-89), his tremendously popular videogame implemented throughout a series of platforms, which is founding block to this specific strategy gaming genre, with roots as long as in chess or go, but here the prevalent running logic of the cybernetic system, as it iterates its states, is an advent of the elements behavior on the next generation being a direct result of the state the neighbouring cells are in. CA, also used to craft terrains and textures for the author's older Space Race trilogy series (2007-8), endless sculptures in Universal Automata (2011-) and Autómatos Universais 3D (2015-), are followed further by

Wright in SimEarth (1990) and SimAnt (1991). While Elite grounds stochastic generation of procedural worlds (ST), these three seminal works Wright programmed ground what came to be known as the godlike videogame strategy genre, whereas the last two SimEarth, addressed at 1.1.1, and SimAnt are particularly influential within wolfanddotcom research.
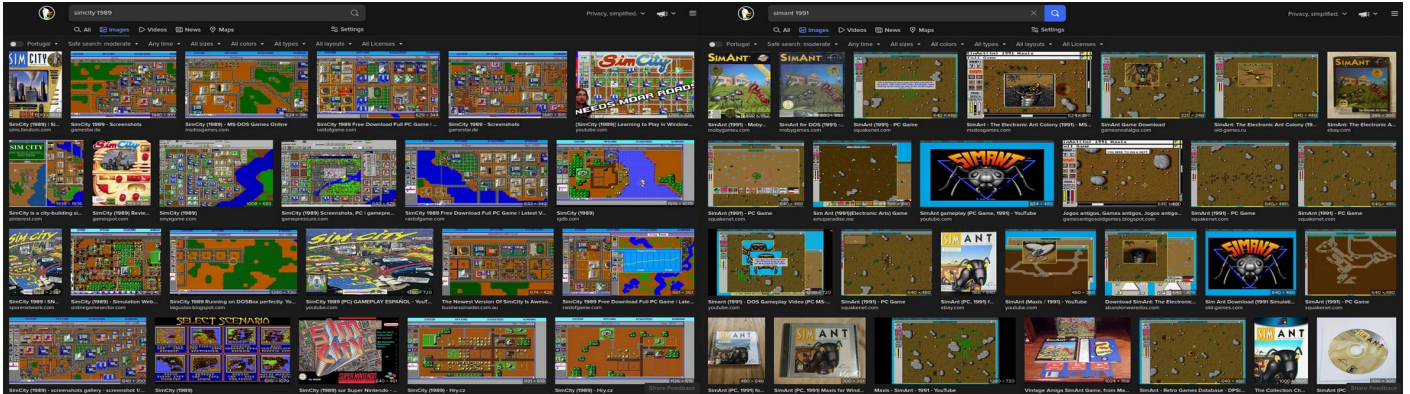
Figures 122, 123: Screenshots of image search results from Will Wright's popular videogame *SimCity* (1989) and the less popular but further interesting *SimAnt* (1991). Besides its theme, *SimAnt* introduces realtime user-cellularautomata physics, as well as 2 2D simulation levels, being the second an orthogonal view of ants nesting lairs.

We can also find further generative processes, like digital DNA processes, chiefly instituted by Karl Sims, detailed through a highly influential article (Sims 1991), coming up at 1.1.3 and 1.1.4 as we situate non-human, mythology and bio-electronic aggregates research among groundbreaking works.

In DNA algorithms, each parameter of a class describing distinct individual elements (for instance a human's eye color, arm length, etc) can correspond to a gene, a floating point number. Together all number parameters form an elements' genome. Upon calculating next iteration of the algorithm, different genomes either mutate individually, or mate from two or more parenting elements. Mutation takes place by random deviations with more or less freedom from their current state of parameters. Mating, or crossover techniques, involves combining portions from a pool of parenting elements in order to originate any amount of descendants output variety seeded through pool combinations. The core reasoning these algorithms operate can evolve iteratively and be further combined, as well as its possibility space navigated through user interaction for instance. This can be seen in Wright's Spore videogame (Maxis 2008) which enhances greatly the scope of outputs and creature evolution within the game's spatium, for all the species present in the game. We can add to these genetic algorithms videogame means of output

the electronic constructs other artists devised, their operation principles of achieving user controlled evolution arises from the usage of these algorithms. All described techniques, above all cellular automata and dna algorithms combined with further and yet unaddressed chaotic attractors and fractal spaces lay at the foundational algorithmical space explored throughout all of the author's works, including the wolfanddotcom series. They have been implemented as libraries of code which will be addressed at appendix α.

1.1.3 Human / non-human and mythology

Human/non-human and mythology contextualizes the philosophical importance of the non-human operated by the research, something already done since the prime of the mythological early human days, and attempts to explain why we should use mythological and non-human aspects to face the foreseeable collapse of the Anthropocene/Chthulucene.

Similar to the scientific advance Galileo undertook in the medieval ages, by proposing a non-anthropocentric solar system, where by observations and scientific analysis of the earth's horizon curvature as well as from the motion of the stars seen moving through the earth's night skies he was able to establish scientifically that the planet we inhabit orbits around the sun (heliocentrism); right now, nearing the first quarter of the XXIst century, embedded in the Anthropocene humans are coming to understand no other naturalistic process produced so many planetary changes on such short time. Changes to biodiversity, climate situation, scarcity of important life preserving resources, and the planet as a whole have been, almost exclusively, performed by we humans ourselves. The accute global socio-environmental crisis stems from human disregard for a balanced organic life, which includes all life present on planet earth, and the way that plundered planetary resources are capitalized in exchange for profits, have since activated an exponentially fast natural decay of living conditions for biodiversity on the third planet from the sun, endangering its species continuation to a critical level. Anna Tsing and others, in Arts of Living on a Damaged Planet (2017), asks us this simple fundamental query:

> *The hubris of conquerors and corporations makes it uncertain what we can bequeath to our next generations, human and not human. The enormity of our dilemma leaves scientists, writers, artists, and scholars in shock. How can we best use our research to stem the tide of ruination?* (Tsing et al 2017:G1)

During the early 2000's rising up to the late 2010's we have experienced an acuteness of a multitude of abnormal planetary phenomena, scientists believe derived overwhelmingly from human activity sources. The aberration of weather changes matched with the rising number of extinct or soon to be extinct biological species, among many

other out-of-balance phenomena, bear witness to an alarming and catastrophic situation. With every passing day, the possibilities of reversal into an harmonic equilibrium dim even further, if still possible at all. To go on: the deforestation of our great forests; ever rising toxic air pollution; permafrost thawing; loss of insects and wildlife; acidification of our oceans; wildfires; sea level rise; *"We find that global emission intensity (fossil fuel CO2 emissions per GDP) rose in the first part of the 21st century despite all major climate projections foreseeing a decline."*[34]

In fact, as Tsing and others question, we should urgently look at methods to steer critical research towards stemming from the tide of this ruination. Facing this extreme situation, as an artist, the author would like to look at alternatives for this cataclysmic outrage, build tools and experiences capable of inducing change at individual levels while proposing immersion in new virtual bodies, vertigo inducing experiences; speculate in the now about how a humanless future might look like, emerging from the debris of our current technological and biological peaks. As an artist, creating one imaginary post-Anthropocene/Chthulucene epoch – Neon Paleolitikos, an imaginary combination of animality and electronics, acting out as a cathartic leitmotif. Neon Paleolitikos is a post-apocalyptic new imaginary geological age dating since the plummeting of mankind until the apex of new bio-electronic life-forms: operational symbioses combined among ruins of silica, transistors, resistors, algorithms, cells, plants, animals, electricity. This research then proposes experiences into this neon paleolitikos geological age, in order to, through catharsis and otherness immersion, convey non-anthropocentric experiences capable of inducing behavioral changes at an individual level. We have previously seen how games and first person interactive media can yield transformative outcomes: this essential new quality of videogames or deep immersive interactive experiences, refered by Ian Bogost as a tool towards a new form of education through experimentation on the first person. They become simulations more or less suited capable of fostering change towards the conveyed work's purpose.

Human models of organization of social life are merely plundering the planet for profit, and above all, have proven entirely inadequate. With the author's interactive arts

---

[34]   Pretis, F., Roser, M. (2017), Carbon dioxide emission-intensity in climate projections: Comparing the observational record to socio-economic scenarios, Energy, Volume 135, pp 718-725, https://doi.org/10.1016/j.energy.2017.06.119.

experience, as well as philosophical and artistic background, his attention shifted towards creation of cathartic virtual environments as possible transformation vehicles, shifting his focus from the human to the non-human. The end purpose of the interactive artworks is to create playful laboratories of human self inquiry and modification through catharsis and non-human embodiment of the users experiencing the interactive pieces, besides innovating aesthetic interactive fields and user awe questing, as well as to creatively speculate alternate models of life combined from non-human animal and electronic aspects.

This has led to look at how examples of other lifeforms on this planet co-exist socially, feeding themselves, organizing, while maintaining ecosystemic balance. And how others have looked at non-human forms for inspiration to tackle systemic and organizational issues, from social to the individual level (Tsing et al, 2017, Haraway 2016, Castro 2014, Parikka 2010). A clear distinction between human and non-human models of organization, power pyramids, top-down human systems versus bottom up non-human emergent social strategies (Johnson 2001, Serres 1997). While embarking on the research for this practice-based artistic PhD, we came across some non-human biological species worthy of study, within this context of alternative biological models or social life organization capable of restoring planetary balance, and as inspirational models from where to draw some insights on how to globally produce transformable results which might reverse current systemic Anthropocene collapse.

Firstly we approached mythological legendary millennial creatures, for they have a special fantastic place in human consciousness from tender ages (Nivedita & Coomaraswamy 2002, Robisch 2009, Borges 1998, 1974, Zimmer 1996, Spence 1994). Dragons and phoenixes are usually associated to ancient, nonexistent, malevolent or benevolus beasts of thunderous might. As an integral part of magical folk tales and myths, they are gifted with special powers, mixing real animal abilities onto surreal combinations of awe or fright, with uncountable occurrences throughout folk tales, literature, animation, videogames, toys, even art[35]. By inhabiting the mythical plateau throughout millennia, with roots in known ancient european and asian folklore, they provide good example

---

[35]   See, for example, The Great Red Dragon and the Woman Clothed in Sun by William Blake, c. 1805, or Draak (Dragon) by M. C. Escher, 1952, depicted further along the document. Even if you know the works in question, try to recollect its visual appearance without seeing the images first.

touchstones for subliminal consciousness bridges into mind regions where illusions, imaginary magical constructs, have room for blooming, blossoming and tangible concreteness. Even though their actual ancient animal existence as retold through collective mankind's history remains uncertain and most likely false, dragonic existence in mankind's global mind space is true. Even recently, Jorge Luis Borges for instance, on his noteworthy The Book of Imaginary Beings (1974), incurs a ravishing descriptive bestiary which challenges the reader regarding the vivid beasts as anthropologic veracity or fruit of exquisite imagination. Approaching ideas of immersion surrounding these creatures led to the creation of the artistic flying cathartic game spaces set at the imaginary end of humans on earth: Draco.Wolfanddotcom.info and Phoenix.Wolfanddotcom.info.

Mythology, in the early years of mankind since the birth of philosophy, served important roles which counter balance destructive planetary forces: it was a cultural force, by which unreferenced mighty histories got transmitted from generation to generation, as well as warning signs on hubris, subtle education tools, fantasy inducing realms. As read from the literature of mythology, underlined by the preamble to this document, Károly Kerényi, an eminent figure of mythological studies, broadens the scope of the mythological function on early societies: it is a world of epiphanies, where humans live side by side with plants and animals, thus with equal natural rights under this sun –, and during the mythological stories humans are usually subjected to seemingly more than human feats, where they must approach godlike qualities in order to solve life threatening riddles or conquer abnormal beasts.

A triple important role to myths can be derived from their usage and origin: usually myths are a no single author or even known author work. Instead, they are the result of hearsay, folk tales, ethnographic stories that got passed down from generation to generation; and this fact alone lends myths a dual role by eradicating the human source while merging it closer to the divine or spiritual sphere. A second noteworthy aspect to myths, in the context of this research, lays in the creativity of embodiment of unknown or more than human powers beings that are usually expressed and visualized as the surreal combination of distinct animal physical traits combined into one mythical beast. The third important aspect relays the imaginary cathartic operation myths perform on humans, either as a bedtime story, which serves both as a warning towards larger than human and

uncontrollable forces that are somewhat tamed or surmounted, and also as a make believe situation which heightens the importance of biodiversity and preservation of important forces of nature.

In a second movement, within the wolfanddotcom series, the artist attempted to focus on existing and more down to earth non-human biological species as non-trivial models for questing insights on how alternative social balanced models for life on this planet might be achieved, as immersive non-human targets for further artistic works and to engage in communication with. Perhaps due to the reason that tangible known beings lend their more pragmatic and existence character better than mythological and probably nonexistent beasts. Animal and plant species that share our planet in the current times, and which, in more ways than one, provide exemplary touchstones of how good oriented, environmentally balanced, stratified social organization might be achieved. Even inhuman electronic devices with their logic architectures control flow electricity under highly optimized processes seem more resource aware than collective human behavior, as we will try to speculate over wolfanddotcom's works which deal with combining and mutating raw level aspects of biological and electronic information.

In the second movement, up until now the author focused on two apparently extreme animal cases, as well as a combination of plants and electronics. In the animal cases, on the one hand, the mightiest and ferocious carnivorous predator of the forest ecosystem, a social animal living in familiar packs, the wolf (*Canis lupus*), which we can often find throughout mythologies, from inter-racial encounters to combinations with humans, is an endangered and soon to be extinct species throughout the globe (Freccero 2017, Álvares 2015, Robisch 2009, Fonseca 1990). Setting dragons and wolves aside, apex predators of the mythological and the non-human ecosystems, on the other hand we wanted to focus on common animals whose internal, social, as well as emergent bottom up organization, paired with the constant cooperation towards the common goals of what a colony might achieve (eusocialism). Ants (*Formicidae* family) are eusocial insects which represent the highest level of organization an animal society might achieve, and collectively they even possess a total amount of biomass roughly equal to the biomass of humans (Parikka 2010, Wilson & Hölldobler 1990).
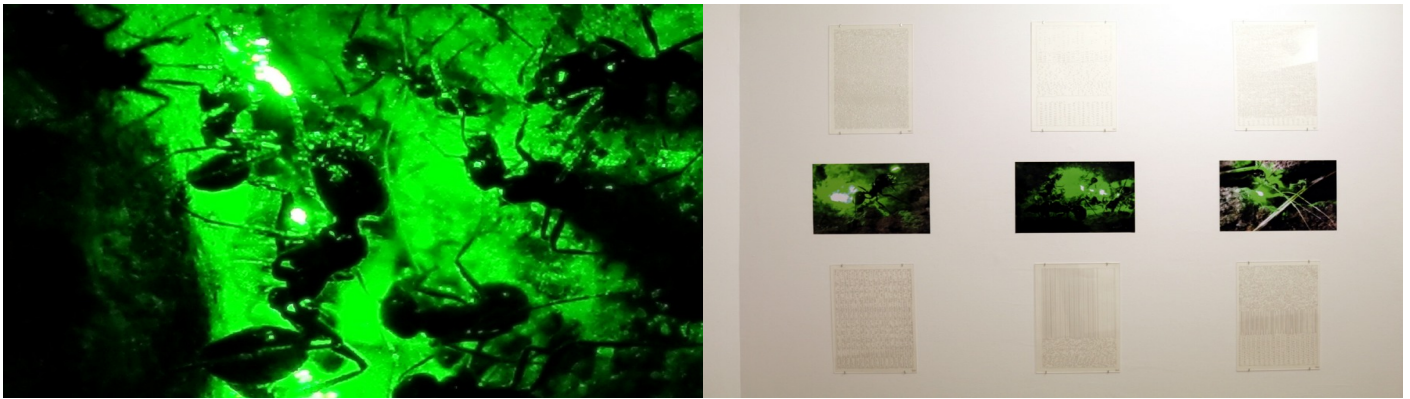
Figures 124, 125: The *Eusocial* (2018) series of analog photographs combine field work of ants observation under laser radiation stimulus. Detail and photo with *BIND* (2018-), *BIOD* (2018-), at Lady of the Labyrinth's Honey, solo exhibition at Zaratan, Jan-Mar20, Lisboa.

In the plants case, on this research (local plants where the installations are setup), the author constructed an interactive experiment with genetic algorithms, where the sampled electrical information from the plants through a maximum of six galvanic skin response sensors is transformed into plant DNA; this bio DNA is combined with electronic DNA, obtained from the micro-analysis of electronic byte information on the computers, by using a number of genetic combination formulae (Sier 2010, Sims 1991). The DNAs are sonified and combined into a new strand of bio-electronic merging, thus achieving a primitive working combination between biological life and electronic structure. Half-Plant's cyber-mechanism data transformation sequence uses operations involving electro and bio signal sampling, data digitizing, real-time audio domain data DNA conversion and subsequent DNA time domain and granular synthesis (Roads 1996) based combinations of electronic, biological, and bio-electronic signals, which are already glimpsed as seen through figures 21-24, 33, 35.

Figures 126, 127: Portable bio-electric voltages sampling device made with C++ code, Arduino pro with electronics for 6 analog sampling channels being logged on a rPI 3B+ used to field capture bio data; Precursor bio-data acquisition from my currently 16 years old bonsai tree during 2018.

Using DNA algorithms to generate variety and hibridization is percursively utilized by Karl Sims (Sims 1991) on his awarded seminal short animation *Panspermia* (1990) to generate evolution of plant species and their movements as they colonize what appears to be larger than a galaxy, catalogued throughout the animation. Sims went on to explore DNA in creature synthesis and movement, in the groundbreaking *Evolved Virtual Creatures* (1994), also heraldedly explored in videogames through Will Wright's *Spore* (2005-8).

In installation settings, we can find landmark usage of mutation and mating algorithms with real-time processing combined with a digital ecosystem of critter-critter-human interaction on the awarded work *A-volve* (1994-97) by Christa Sommerer and Laurent Mignonneau (Sommerer & Mignonneau 2009), where visitors draw and interact forms on a touchscreen, which become digital critters and inhabitants of a digital ecosystem, continuously evolving and hybridizing their populations.
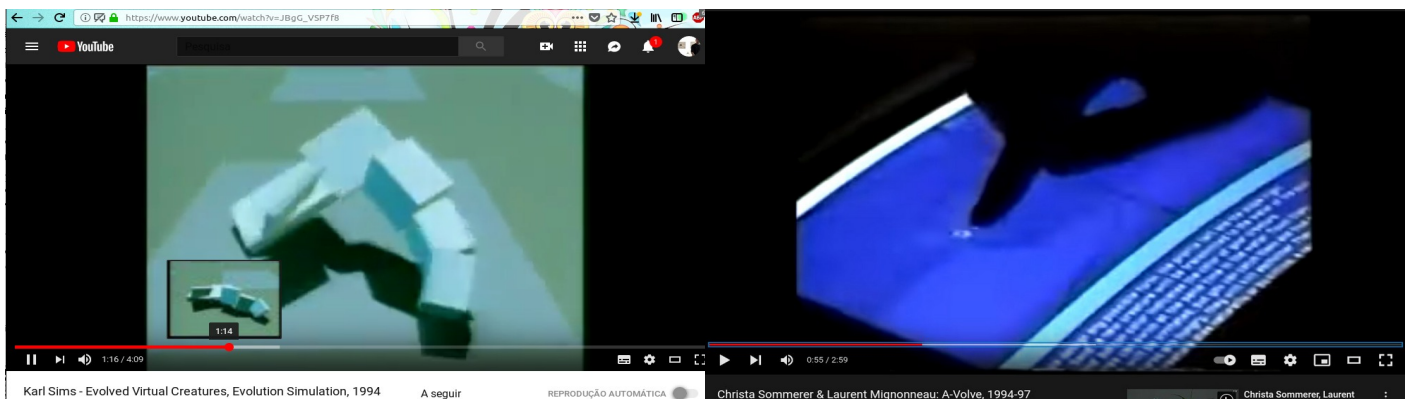
Figures 128, 129: Screenshots of historical usage of DNA algorithms in aesthetic seminal works by Karl Sims (Evolved Virtual Creatures 1994) and Christa Sommerer & Laurent Mignonneau (A-volve 1994-97), en route to artificial life (AL), highlighting DNA processes as steering purpose and GA evolution.

By looking at wolves, plants, ants, bacteria and other biological aggregates, through actively using them in the artistic works (Wolfanddotcom 2017, Half-Plant 2017, 8-bit Maze Gardens 2018, Ant Ennae Labyrinths 2019, Honey Krater 2019, Half-Ant 2020, Bioscope #1 2020, Wolfmachine 2020-22), the author is interested in underlining and fortifying a distinctive approach to art making, which, on the one hand, contributes to the formation of new aesthetic knowledge where non-human biological and electronical elements drive purpose, and on the other, has a subtle experimental embodiment shift from the human towards non-human alternatives, which might return finer ways to deal with the current catastrophic situation: not that the artistic constructs have direct action,

or even measurable influence; but perhaps through their finer aesthetic skills and innovative non-human and mythological immersive characteristics, they might lead others to look at non-human organizational models as better answers to steer planet earth far from human hubris' induced current and past centuries global socio-environmental crisis. Urgent strategic survival action is required, supportive, coordinated and emergent, like inbetween wolves, ants and plants. Alternatives other than human are sought. Building immersive environments towards non-human bio-electronic models against this global crisis seems like a pertinent contender to promote Gaia demanded infra-structural changes the author unveils.

1.1.4 Bio-electronic aggregates

Bio-electronic aggregates focus an important research aspect which consists on a micro-analysis of biological and electronic data, usage of this data as tools towards virtual architectures and artistic constructs, mutation of both signals into the proposition of bio-electronic beings.

The artistic constructs consist of an amalgam of biological and electronic hybrid elements, or any combination thereof, set in a post human world, on a variety of media. The artistic objects are not only electronic, not only biological. They are hybridized and operational assemblages which feature traits from both bio-electronic domains. Biological systems amplified with algorithms and electronic devices, networking ports and protocols. Programs gifted with biological memory regions, or bio derived prosthetic augmentations. The objects illustrate aesthetic and functional incursions into novel artistic domains deriving from the electronic and biological signals, as a combination of both bio-electronic fields.

In spite of their imaginary and mythological baseline, the artistic constructs exhibit functional bio-electronic aggregates which address questions relevant to core aspects facing the bio-art and electronic-art of today: on the one hand, biological systems augmentation through electronic means; on the other, electronic systems biologification, electronic self-awareness, electronic consciousness research[36]; both leading to new non-human aesthetics, augmenting generative, bio and electronic arts towards novel syncretic fields, deriving from the hybridization and usage of such bio-electronic signals as artistic materials. The insight leading to a more complete non-human aesthetics involving biological systems augmentation through electronic means as well as electronic systems biologification derives from blurring boundaries, not only between what is human/non-human, animal/vegetal, but between what is living and what is commonly considered to be inanimate. For all geochemical aggregates (borrowing expression from Ga's 2018

---

[36] Considering how "plant neurobiology" emerged in 2005 (Chamovitz 2012:137): "They strongly felt that the plant neurobiologists had gone too far in drawing parallels between plant and animal biology". However, during the days of unaware electronic beings, or unseen electronic artificial intelligence, we can find deep connections between raw biological and raw electronic signals as the works will demonstrate, and hence the usage of the terms electronic consciousness research, electronic systems biologification.

Machines are Not Alone) are endowed with matter, elemental substances of some sort, which possess extensiveness and atomic/quantum properties, movement, agencying. For instance, how actually silica, crystals and other raw materials' properties are exploited into timing and counting transistor devices that ground the electronic kingdom.

> *[...] the land, rivers, mountains, trees, animals, cultures, and histories are all machines of some sort when seen from an operational point of view or an abstract sense of the word because they are systems of interconnected biospheres, geochemical aggregates, hydro-dynamic flows, neural synapses, motor-sensor coordinates, psychosomatic attributes, social relationships and technical milieus, imbricated, intertwined, transversal and reciprocal, as intricate as the relationship between humans and thoughts, knowledge and freedom.* (Ga 2018:13)

If from a cybernetic/philosophical point of view everything can be considered a machine, as it is seen from operative viewpoints, for aggregates of matter reveal their agencying as they *self-modulate towards* (Ga 2018:15) or in function of a particular environment, from a biological/physical point of view, all matter aggregates can be considered as possessing some movement qualities, in relation and purpose to the ecosystem they are currently inserted at. Hence, perhaps as Chamovitz (2012:137) states that even plant neurobiologists were received by peers as drawing too far parallelisms when equating plant and animal biology with reverberating similarities, this research alludes to a direction where it might make sense to consider electronic neurobiology as one of its disciplines, in order to add an infra-structural layer with its own agencying to the programmable and networkable plateau it establishes. This research establishes electronic neurobiology primer principles pointing to infrastructural levels, by equating digitized versions of raw biological and raw electronic signals, and proceeds to create aesthetic assemblages as well as operational bio-electronic ecosystems that unfold electronic consciousness research as well as electronic systems biologification.

One of the premises of the wolfanddotcom series, in an imaginary post-Anthropocene scenario, lays in the combination of electronic and biologic phenomena, in order to create imaginary amplified hybridized beings, and having human or non-human users relating to

these distinct beings in the different works. As if, in a humanless world, surviving organic life forms started mutating with electronic circuitry and algorithms, percolating offsprings. And evolving towards a bio-electronic hybridization, where generations of aggregates evolve, mutate and mate among themselves. These bio-electronic aggregates would consist thus of tangible combinations of biological and electronic entities, departing from a similar point of view we experience in the 21st century, sharing current human tools and technologies, sharing current life species inhabiting the planet, as the mating pool debris of a post-cataclysmic experience. How would electronic circuitry combine with biological entities in order to mutate distinct beings, holding features from both seemingly apart worlds? Stelarc has been inserting machinic and biological implants into his human body; Chico MacMurtie is constructing large scale performative kinetic robotic installations; Ryoji Ikeda immerses humans on large scale projections of audiovisual patterns and compositions derived from data; however, somewhere in between, there is room for bio-electronic aggregates, as if emerged through the genetic combination of biological beings with electronic aggregates, with their own turbulent becomings (1.1.1), human-free into a pandemonium of new bio-electronic entities.
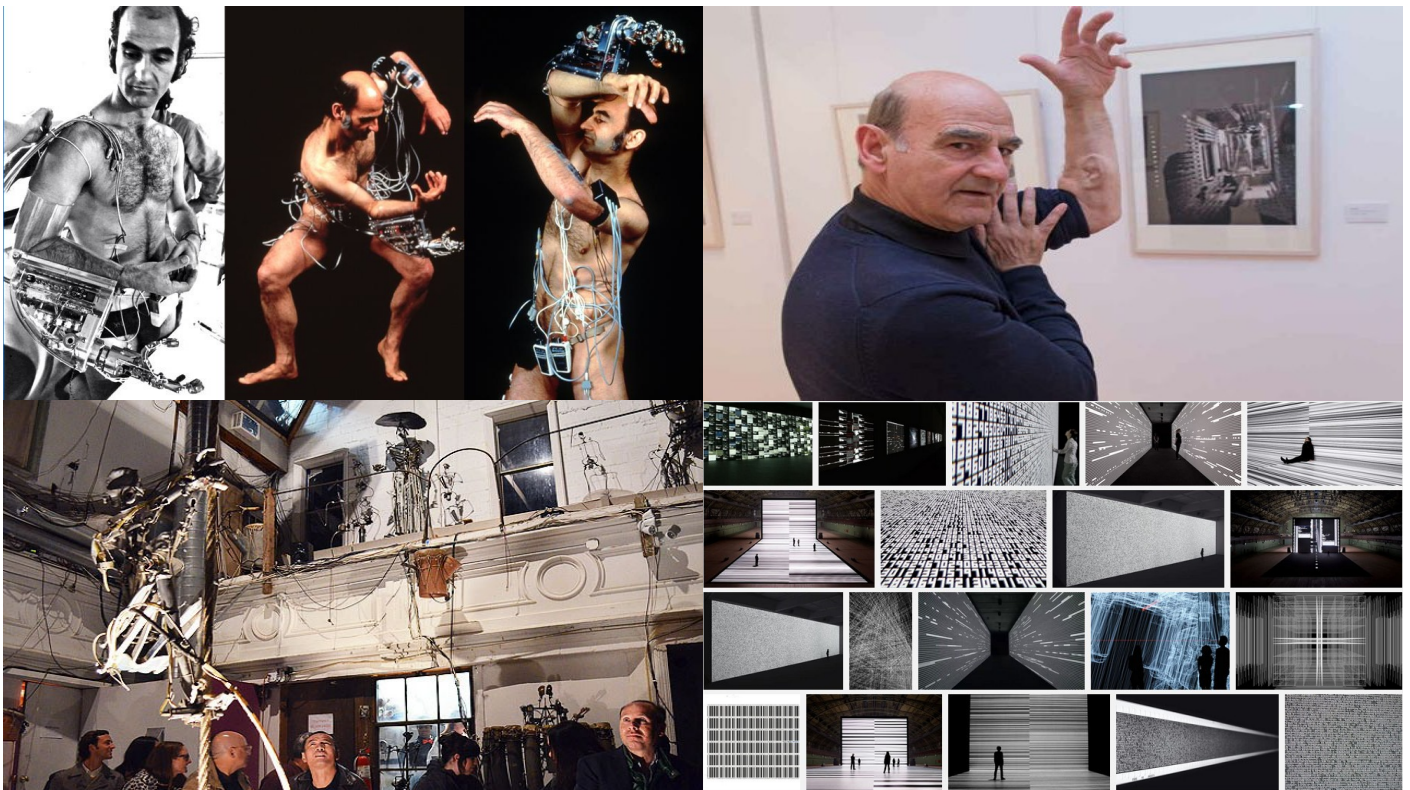
Figures 130, 131, 132, 133: Electronic arts prominent examples of bio-electronic hybridization. Pictured Stelarc's *Third Hand* (1980) and *Third Ear* (2007); Chico MacMurtrie's *The Robotic Church* (1987-2006); Ryoji Ikeda's *datamatics* series (2006-). Photos 130, 131 © Stelarc. 132 © Chico MacMurtrie.

There are also undeniable fascinating links between electronic machinic phenomena and biological processes (Campenot 2016). If we take a close look at raw electronic phenomena, as well as raw biological phenomena, i.e., the sequence of bytes of structured information as files stored inside the computer, or of running processes executing on it, compared to the sequence of electrical current variations on living organisms, deltas of electrical energy cascading in-between living cells; we find that electronic information as well as biological information exhibit a close resemblance, when their signals are sampled as informatic information (i.e., reduced to the same media at specific sampling rates of sequences of digitized bytes) observed over time, even though they are entirely distinct substances.
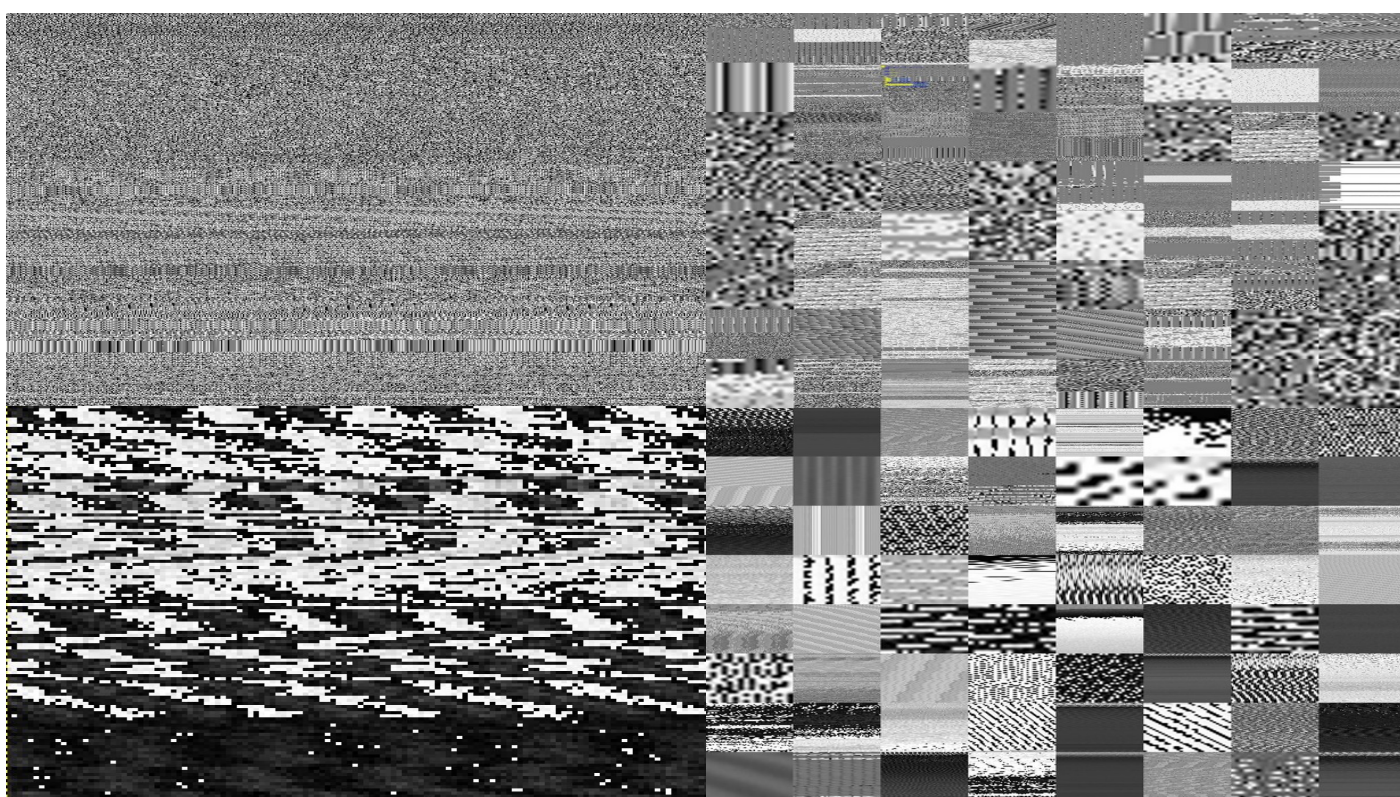
Figures 134, 135, 136, 137: Obtained visual patterns of binary (134,135) and biological (136,137) information. On the left (134,136): single log file detail visualization; to the right (135,137): 8x8 image grid of resulting single channel samples.

This bio-electronic digital data resemblance resides in the seemingly organic variance of the emerging patterns and structure pertaining to this raw information, which when observed visually, produces unpredictable generative designs, patterns that are similarly organic and hardly produced by a human mind. Patterns which are sampled in the bio-electronic infrastructure of the non-human world, distinct from pure random noise or any other rule based rhythmic sequence engineered by humans (Flake 1998, Alexander 1964),

evidence of an entangled internal structure, generative, non-human and rule-based, which is exposed through the reading and exhibition of its aesthetic properties, when looked at with these raw time domain as well as spectral byte information visualization techniques. The research built 2D program is a multi-purpose byte sequences analytical tool with direct, accumulated, histogram and spectral 2D image construction techniques, coded to create textures and 3D terrain landscapes for the Wolfanddotcom game (2017). Seeded into 3D sculptural construction techniques, depicted both on Binary & Biological Sculptures (2018-).
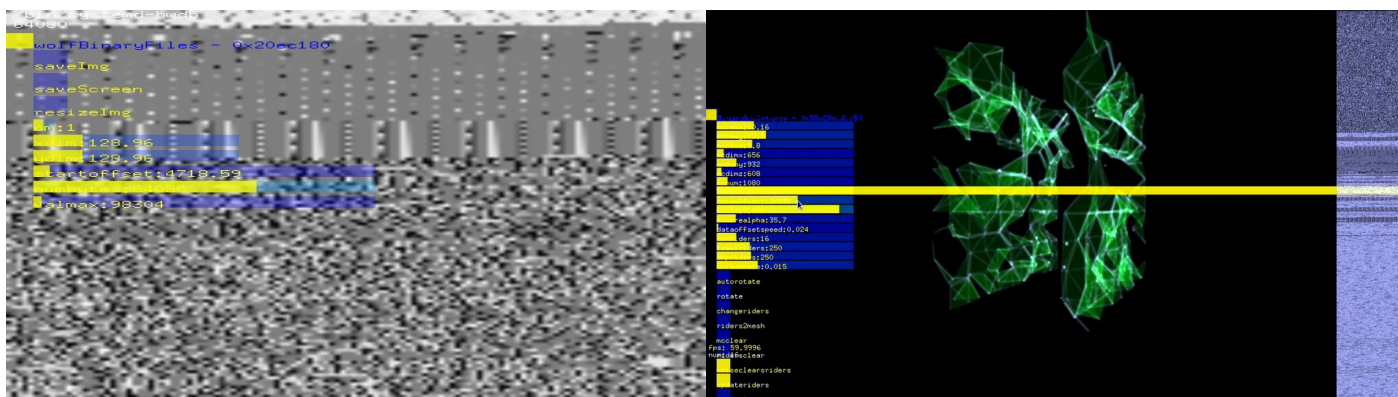
Figures 138, 139: Screenshots of C++ programs (2016-18) built to visualize logged binary and biologic data, as creation tools for 2D pattern images and 3D voxel sculptures.

It is similar to applying EEG analysis to biological and electronic entities and trying to derive aesthetic conclusions from these visualization techniques. Both pattern signals exhibit a common fundamental fractal trait: we can isolate regions that have common visual properties, common characteristic perceptive visual rules; each pattern consists of combined sequential rhythmic regions, whereas each regions' length is arbitrary; patterns in each region can be mono tonal, without variations, or showcase growing or fixed variations, adopting a slight generative unpredictable evolution, construction techniques reverberating with fractal algorithms, chaotic attractors, cellular automata, which in turn can be read as low level shadow indicators of higher order entanglements.

The virtual wolves on the Wolfanddotcom videogame were constructed with such premises in mind, even though they are only virtual. Imaginary bio-electronic constructions, as if wireframe assemblage organizations of metal bars suddenly got together under a wolf shape, the metal being guided by the intensities of an electronic blue heart becoming wolf and organized into one such form. Clearly a wolf shape, but a

wireframe one, hinting a strong robotic interlinking characteristic onto these beings. What started as a metaphor on the wolf shape creation has its roots on the earlier abstract avatar formless form intensities of dragonic or phoenix shapes on the Wolfanddotcom series preceding works. Both in the dragon and phoenix pieces, users are real-time transformed into unique abstract mythological winged shapes avatar. Human users are real time meshified into a solid black – or randomly colored when under enemies line-of-sight –, ill-defined dragonic/phoenix shape, where the contours of their bodies are stretched in the x axis, and the captured point cloud of the sampled instant from the depth camera serves vertices to an elongated three dimensional mesh composed of many triangles that undulate near instantly at the same time the user makes a gesture. Using these techniques, every user has their own unique user-dragon or phoenix shape, made up from features of their tracked human body in the installation. The differences in-between the dragon and phoenix avatars reside on the interim formulae utilized to stretch out the triangles constructed from the captured user's point cloud vertices.

Figures 140, 141: Screenshots of examples from the programmed meta-avatar developed for user interface with *Draco.Wolfanddotcom.Info* (2015).

The mutation and mating of electronic and biological information using these techniques gained a tangible reality intensity with the Half-Plant installation. On this work, a small vegetable-electronic ecosystem aggregate is continuously digitized: the plants' electrical information transformed into sequences of byte streams; the computer processes or selected files on the GNU/Linux file system equally transformed into sequences of byte streams. Biological byte streams are in turn combined with the continuous sampled electronic byte streams of processes of information taking place in the computer. Both streams are transformed into DNA floating point number streams, and genetic algorithms (Sier 2010, Sims 1991) combine the distinct streams under one bio-electronic hybrid stream. The bio-electronic DNA signal becomes sibling of this biologic

electronic mating process. Its continuous running mutated information becomes source audio material which is fed back to the ecosystem, closing the loop on a cybernetic system meant to evolve plant-computer bio-electronic aggregates.
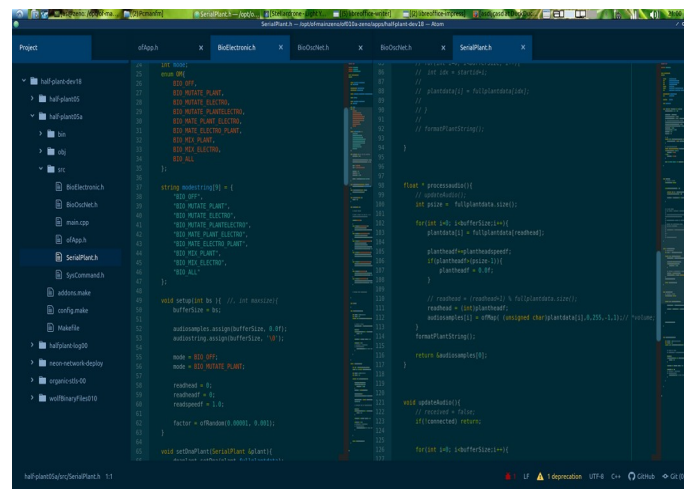
Figure 142: Screenshot of details from the Half-Plant program (2017) depicting sonic processes of DNA combination modalities between biological and electronic data.

Electronic machinic phenomena and biological processes, either in macro-micro-structure of binary encoded information, to the processual flow programs execute on hardware while operating it, to the variation of voltages in biological entities while living, can be reduced to bytes on media, i.e., can be transformed into a visualization of how this information changes over time. Observing micro-electronic worlds as living entities: electronic voltages running throughout electronic architectures pipelining data to memory registers, operating systems executing programs on electronic substrates, data flows taking place in machines and in communications protocols within networks.

Static art-sci constructs explore and visualize these observations as 2D drawings (Neon Paleolitikos Drawings 2017) or as 3D sculptures (Binary/Biological Sculptures series 2018-), creatively exposing their inherent rhythmic organization of information, while dynamic installations propose immersive interference mechanisms which attempt user entanglement in non-human environments (Draco.Wolfanddotcom.info 2015, Wolfanddotcom, Phoenix.Wolfanddotcom.info, Half-Plant 2017, Ant Ennae Labyrinths 2019). The 2D drawings are created by visualizing the streams of electronic files and processes or biological information. These streams, which are constituted by one dimensional sequences of bytes, are re-arranged under a two dimensional grid, with the corresponding byte values of each cell grid of information being converted into a greyscale

image pixel. Then, by defining a threshold value, pixels above it become part of the shape, and below it are excluded. A technique often used in the creation of these drawings is to look for signal change transitions of pixels, thereby creating delineated islands, or image regions demarcating which information is above and which is below the threshold (a 2D slice of 3D pixel value data).

The process of creation of the 3D sculptures is quite similar. Electronic or biological 1D streams of information are transcribed into 3D cubic regions, where we select the 3D cubic dimensions and start data offset. The 3D regions are then contoured with a process known as marching cubes (Bourke 1994, Lorensen & Cline 1987). The marching cubes algorithm transforms a grid of data (voxels) into a 3D contouring polygon derived from thresholding the electronic or biological source data. Using these techniques, even with the same data set, merely changing the data offset or a couple of parameters, an enormous plethora of distinct aesthetic objects can be engendered. What was once a cryptic sequence of bytes now becomes an awe inducing drawing or three dimensional architectural collection of sculptural objects, hardly architected from a human point of view. However, many of these infinite shapes of Binary & Biological Sculptures cannot yet be fabricated, for their resulting polygon structure involves impossible overhanging materials or even floating filled space circumscribed by empty void space regions.
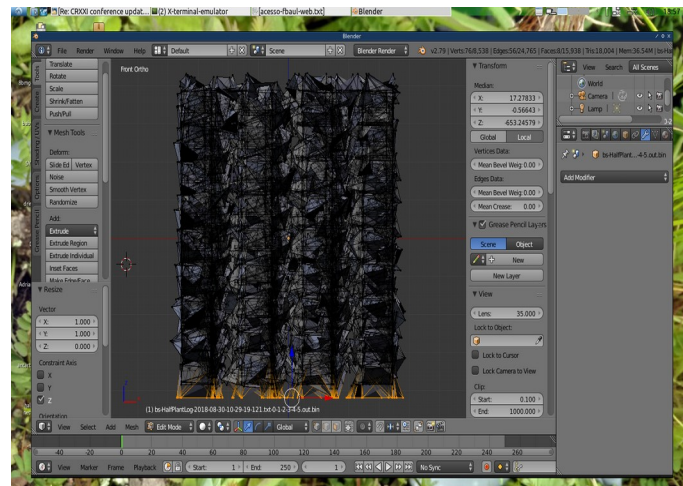
Figure 143: Image highlighting the single ground leveling operation applied to generated Binary and Biological Sculptures after they are code generated, in this case voxelizing data from biological plant logs.

While Half-Plant super-imposes electronic information on plant based ecosystems, another recent work transforms electronic data into patterns of projected laser light

towards a medium sized ant farm. The ants were placed on a vertically sliced and framed sterile ground section, which is enclosed in acrylic with access to food and water, and they were let loose, with electronic image patterns superimposed over them by a low power green laser light source. Ant Ennae Labyrinths, from 2018-19 consists of a bio-electronic ecosystem and interactive optical apparatus to create animal made 3D labyrinthine patterns by ants, interfered by computer or human controlled laser light source, where ants play the game of life inspired in the mythology of labyrinths with an electronic arts outlook. These core bio-electronic ideas were expanded further in already glimpsed and yet to analyze opus Honey Krater (2019), Half-Ant (2020), Wolfmachine (2020-22), among others.
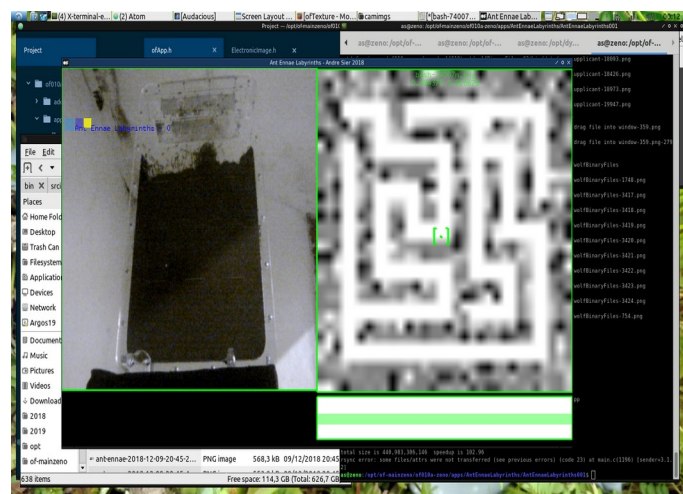
Figure 144: *Ant Ennae Labyrinths* (2018-19) detail of installation setup nearly complete without ants, featuring views of the constructed vertical slice lattice of a medium sized ant farm as well one of the electronic source image which controls laser aiming positions.

1.1.5 Wolfanddotcom

This section, named wolfanddotcom, synthesizes the artistic vision for the interactive non-human otherness laboratories construction as well as cites work from contemporary artists working with gaming technologies and non-human ontologies interweaving its similarities and differences with this research. Wolfanddotcom alludes to a condensed and poetic single word combination of animality and cyberspace (wolf and dotcom), intertwined by two apparently antagonic case examples from distinct fields which are brought together in the making of this research: wolves and their nomadic packs delineating a non-human space; human activities in cyberspace (capitalism, knowledge, art, etc) scattered among computers and communicated electronically in the dotcom era; both looked at from within the Anthropocene, as two faces in a same coin, as two kinds of animals sharing the same world.

Wolfanddotcom is brought forward as a creative practice and research line of inquiry into the imaginary combination of animality and cyberspace post-anthropocene. The series takes place in an imaginary epoch titled neon paleolitikos. After the Anthropocene, neon paleolitikos is an imaginary new epoch dating since the decline of mankind until the zenith of new bio-electronic life-forms: operational symbioses combined amongst ruins of silica, transistors, algorithms, cells, plants, animals, electricity.

The works mingle games, animality, cyberspace; they take a close look at raw biological and raw electronical processes; they look at the operating system that executes programs on electronic substrates as living entities. The bytes from files, programs and processes are transformed into fractal binarized visual patterns, they become lines that are organic, unpredictable, musical. The electronic substract spawns drawings and three-dimensional landscapes, becomes terrain inhabited by bio-electronic beings resembling wolves, dragons, phoenixes into a vibrant, luminous, neon paleolithic age.

Wolfanddotcom is the fourth major series of electronic works by the artist, a creative research line of inquiry traversed by many lines of flight into non-human electro-bio domains braiding the imaginary combination of animality and cyberspace post-

Anthropocene. A poetic word made from the combination of wolf (animality/non-human) with dotcom (Anthropocene/networking/electronics). This serial line of work, researched further since entering the Planetary Collegium PhD program, juxtaposes electronic arts creative practices into developing new pieces around an imaginary future epoch. The artistic practice performs a non-human turn: finer social models; exemplary adaptation; balanced resource usage; millennial examples; bottom up architectures; mythological inspiration.

Static-aesthetic-constructs allow contemplation of these phenomena whilst dynamic-art-sci-constructs propose interfaces/instruments through which one could immerse/play in this neon-paleolitikos strata. From a couple of videogames, set in a post-Anthropocene epoch, where we fly-play phoenix embodiment simulator and hunt within bio-electronic wolf-packs building a network on pseudo-infinite spaces, using interactive immersive electronics as bridges towards non-human-otherness, animal-embodiment, cathartic gameplay. To an electronic-plant, broadcasting a WiFi access point, operated by connected users smartphones, partly micro-electronic processes, partly micro-biological voltages, combined through DNA genetic algorithms and user interference, exposing its data as sound which is fed-back to the Half-Plant as stimulus. This research sets forth a non-human turn by looking and painting bio-electronic aggregates on neon paleolitikos strata, proposing through its mediating outputs of mythological videogames and bio-electronic aggregates an aesthetic use and speculative analysis of electronic consciousness research holding hands with a wetter biologification of the electronic realm.
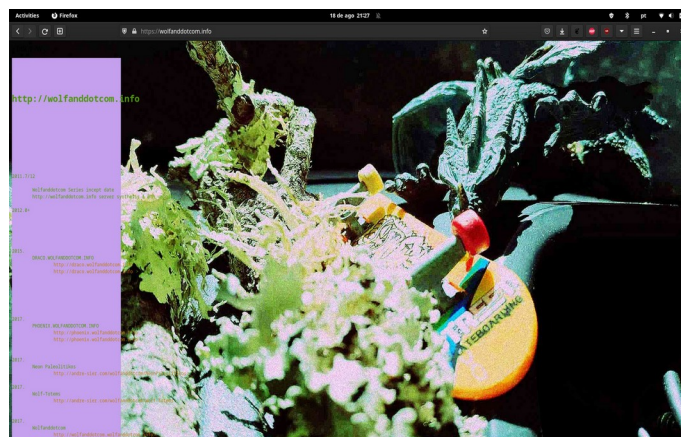
Figure 145: Screenshot website wolfanddotcom series, currently at https://wolfanddotcom.info, poetically alluded through a plastic dragon & skateboard + lichens at the birth of neon paleolikos epoch's dashboard.

As seen through the many previously cited landmark example games, compositions, performances, generative installations and bio-electronic entanglement that have seeded the field quested through the wolfanddotcom research combining mythological videogames and bio-electronic aggregates, we can add more contemporary pertinent examples devised by artists that are exploring gaming technologies, non-human ontologies or bio-electronics as vehicles to address new aesthetic grounds and growing concerns with immersion onto non-human models.

While contemporary mainstream videogaming is crowded with anthropomorphic war and first person shooters examples, there are still relevant videogames which have become iconic moving immersing monuments within mythological and non-human themes pertinent to human infrastructural changes. One such example is The Last Gardian directed by Fumito Ueda, developed by Japan Studio and GenDesign, published by Sony Interactive Entertainment in 2016. In this game situated in an unknown epoch players befriend a mythological colossal sphinx like creature, part dog, part bird, part cat, instrumental into solving the physical puzzles and deepening an emotional immersiveness with the beast. Refined from previous Ueda games (The Shadow of the Colossus 2005, Ico 2001) there is an unequivocal reverence for nature, either set over the games' grandeur of a natural space punctuated with ruins of majestic puzzled architectural debris encrusted in the landscape, or by the main protagonists of the experience truly being the colossi non-human mythological creatures, grand operative beacons of an overpowering nature whose fate often lays at the hands of the player through the emotional decision of taking down all of the remaining single specimen gigantic mythological beasts. Ueda's direction in these videogames also strives for solitude, ambiance and the hearing of the quested themes through overtones of the action, as if a suspension of a note held reverberating, an ambient musical place Eno defines as vehicles fostering floating in/through the self, an introspection interaction setting not unlike Viola's The Night Journey, Davie's Osmose and Ephemère, and the author's own mythological videogame examples as discussed in the thesis.

Other salient videogame example is The Legend of Zelda: Twilight Princess, directed by Eiji Onozuka, developed and published by Nintendo in 2006. In this interestingly odd action-adventure Zelda title the ongoing zeldian light/dark forces battle through many

dungeons takes a twist as half the time of the game the hero Link takes the form of a wolf when he is transported to the twilight realm. As wolf, the motion, sonic and graphical mechanics of the game change dramatically, odor scents become visible trail clouds, the game's chromaticity dims and shifts, and often through melodic puzzles you howl with other wolves across vast distances uncovering ancient mythological warriors, themes evoking nature's reverence echoing into non-human options of strategic survival action. Another prominent mythological videogame creating atmospheric experiences and revisiting wolves is The Path, directed, developed and published by Tale of Tales in 2009. The Path is a game of exploration and introspection into an adaptation of the fable of little red ridinghood through the eyes of different starting players, discovering different stories emerging deep in the forest. It engages immersion through exploration of dark themes on a spatialized contemporary view of a mythic narrative, through deviating from the path and uncovering your unique own, questioning the depths of your self.

Final gaming technologies examples related to non-human ontology include Proteus by Ed Key and David Kanaga (2013), Flower by Jenova Chen (Thatgamecompany 2009), Beeing by Volker Helzle et al 2021. Proteus establishes an immersive audiovisual island exploration game-composition with interactive 8-bit sprites representing abstract fauna and flora over many seasons and atmospheric weatherings. It is one of the few experiences clearly evading a realistic depiction of a reality and heading in a direction of musical art games pioneered by Jaron Lanier's Moondust (1983), by promoting the use of gaming technologies as means to paint interactive and immersive audio-visual compositions. Flower directed by Jenova Chen is a candid surprise experience into the praise of nature in a leveled gaming setting where players become flower petals and experience a world through this point of view, diffracting their petal-selves across virtual nature space, surfing wind drafts and satisfyingly aggregating in blooming flowers. Beeing by Volker Helzle et al is a locative VR experience in the physical world which exhibits the power of gaming technologies in contributing to alertness to environmental protection. The Beeing prototype, in sync with the movements of a physical commute through a German train ride, recreates an altered photorealist experience which follows in VR the perils of a bee situated in your place as the train it is traveling in collapses and gives way to a nature inspired fantastic journey.

Like the research produced mythological videogames all these gaming examples share themes of introspection through ambiance, hovering, immersion and exploratory views that pay homage to nature, create through interactivity and playing, compelling narratives or otherness experiences more engaging settings in order to foster immersion in non-human models as better responses to current socio-environmental global crisis. Unlike these examples however, research made mythological videogames Draco, Wolfanddotcom, Phoenix, 0X Labyrinth rely on generative structured stochastic synthetic designs, in which the dominant architectural spatialization of gaming elements is executed through carefully manipulated formulae that engender unique game playing acts and audio-visual spaces every level of the games of near infinite depths. They also focus on abstract, concrète and protogeometric representations at odds with photorealism depictions, narrative minification with salient non-human bio and/or electronic creative combinations arriving from algorithms like CA, DNA, seeded or materialized with sampled bio-electro data applied compositionally to architectures, textures, meshes, movements, spatialized sonic compositions which are explored by land surveying users through arcade like gameplay in pseudo-infinite spaces involving custom developed interfaces in order to heighten the immersiveness to a physical plane and to a sculptural level.

About artists working with bio-electronic means in similar directions this research is heading to, we would like to stand out from four authors relevant projects exhibiting new routes in bio-electronic grounds as well as growing concerns with immersion onto non-human models. As the research produced bio-electronic aggregates, these examples constitute artistic insights foreseeing unconventional usages of electronic arts into biological arts and its subsequent hybridization towards new domains looming over mankind as the computing power of machines and non-human communication evolves.

The first bio-electronic towards non-human ontologies example is Ryoji Ikeda's datamatics series of projects since 2006, briefly seen previously at 1.1.4, where he builds audio-visual compositions singly derived from electronic data analysis and bathes its viewers in grand projections of images and sounds data-derived either in audio-visual concerts or immersive installations. Here ever shifting monochromatic rich data patterns expose the raw elements that make up digital information and its operating qualities in machines, as data is magnified and granularized, composed in the sonic and visual

domains into larger than human projections that often evolve near stroboscopically, where one can vividly experience and get immersed in the inner workings of data through Ikeda's compositional means, like inhabiting transient fluxes of information and watching it transform all around you, an experience into becoming the machinic electronic processes themselves, closer to what machine sensing could be.

Other pertinent non-human projects include a series of electric stimulus to face experiences by Daito Manabe since 2008. Developed over performance projects Face Visualizer, Face Instrument, as well as the BodyHack workshops, Manabe is able to actuate upon and control human faces via his own programmed audio-voltage compositions. Besides being audible experiences of rhythmic electronic music, most aptly he uses the same information conveyed as sonic means to control spatialized voltages targeting specific facial locations, causing the face wearer to inadvertently move it exactly as it is externally voltage controlled, originating a clear affective disorienting experience where humans sense and perform facial movements within themselves by non-human control.

Another interesting line of work orbiting non-human ontology comes from Martin Howse's projects Earthboot (2013) and Test Execution Host (2016). In Earthboot Howse sets out to build a device that samples earth voltages and proceeds to converting those directly to instructions, consisting of an earth computer interface, it attempts to derive executational code for booting a computer with the earth as its operating system. Though often crashing upon boot Howse's project taps into obtaining telluric currents directly through the surface of the earth and source to most if not all electronics geochemical infrastructure. Similarly, his Test Execution Host device consists of an elaborate primitive computing machine that communicates bidirectionally with rocks and other minerals by means of cyanotyping ones and washing out zeros engraved into these materials, and reading back through the visceral and fluid Turing Machine playhead such information, which in turn is operationalized into machine instructions.

The fourth artist-researcher's project combines non-human research, bio-electronics and social activism by proposing animal electronic alternatives as tools to tackle corporations and lodged interests regarding industries related to environmental areas.

Beatriz da Costa's 2006 project PidgeonBlog results as the collaboration between homing pidgeons and electronics with artists, engineers and pidgeon enthusiasts in order to create numerous mobile non-human sensing devices monitoring mainly air pollution and distributing real-time data openly over the internet as it is gathered by the birds with sensors in American regions where rates of illness and mortality due to air quality exhibit too many links with human race and class issues in urban environments. With open and bottom-up methodologies, where local communities collaborating with artist-researchers and pidgeon communities unite towards better air quality and environmental justice versus closed governmental and corporative top-down current implementations, often veilling big industries interests many times insensible to environmental protection and sustainability in favor of their hubris. PidgeonBlog is also instrumental in proposing non-human communication and collaboration as possible emergent pathways through which cleaner, safer, distributed and more earth-tuned means counter-balance destructive forces operating in the Chthulucene.

These broad and far-reaching bio-electronic examples share common root characteristics with the author's research into bio-electronic aggregates relating to the immersion onto non-human models, both as exploration of new aesthetic grounds and as more or less subtle experiences or tools carving human and non-human allegiances, cooperations and communications with the other than human biological and electronic domains. Though the unequivocal resemblance between low level voltage data sampled from living entities and raw byte data from electronic programs and processes alongside with its speculative and experimental hybridization into bio-electronic aggregates is here unique on the wolfanddotcom research, for instance shown in the Half-Plant device, the Woldanddotcom videogame, and the more traditional drawings and 3D sculptures (BIND, BIOD, Binary & Biological Sculptures), the immersion in (bio-)electronic data-derived universes is significant into fostering experiences questing non-human modes of being. Either composed into timed aproximations of sensing what machine operating could be, as in Ikeda's datamatics series, or interactive explorations of data architected terrains and locative audio landscapes as in the videogame Wolfanddotcom, or through muscular jolts of electricity conveyed through the human body, as in Manabe's projects, rendering an affective experience of what it could be like to sense voltage control information and actuate on it like most electronics do. The structure of the compositions in the above works

also contrast with the research in the sense that Ikeda and Manabe present their own compositional views in time while the author proposes interactive spatial ambient compositions users unfold at their own exploratory pace, either in mythological videogames or non-human devices. As in the mythological videogames, the author's compositional approach in space and time nears as much as possible untouched bio-electronic patterns set on the audio and visual domains, displaced in different regions, where the prevalent data is seen, heard and layered among itself at different scales into ambient experiences of inhabiting it, of sensing electronic, biological and evolved bio-electronic data emerging from the raw hybridization of both non-human sources into something new.

Bio-electronic hybridization through inter-bio-electronic-species stimuli is another relevant characteristic both the research and the examples point at, as in Howse's earth operating system where earth surface voltages directly provide machine instructions, or in Manabe's voltage controlled humans, or in Ikeda's data sensing transformation, or in da Costa's non-human environmental sensors, or in the author's laser ants and bio-electronic interactive architectures, where functional traits from both domains are brought into experimentation settings augmenting infrastructurally the experience space of each other. Besides evidencing and highlighting non-human ontologies, the above projects represent avenues through which humans may find methods to experience and promote infrastractural changes towards non-human models against global crisis.

1.2 Daedalus and Zeno

Within the context of exploring new electronic arts' aesthetic regions and unexampled connections between generative art, games and mythology, the author's practical artistic research surrounding mythological videogames was led to focus on labyrinthine structures as exquisite legendary spatial gaming devices as well as possible pathways to gain deeper humane insights, resulting into discoveries of original methods of labyrinth formation by means other than human ones. Labyrinths and mazes are inextricable paths, human made millennial structures which provide spatial challenges often connected with feedback, compression, entanglement and hyper complexification of goal oriented displacement. They are perhaps the most ancient example of structure for spatial and serious games.

Figure 146: Labyrinths even had emblematic everyday life tokens during Mycenaean Greek civilization, here in a silver coin from Knossos inscribed with the 7-course "Classical" design to represent the Labyrinth, circa 400 BCE. Photo © Wikipedia user AIMare. Figure 147: Photo by André Sier of Kerényi's Labyrinth Studies book (2008) depicting a classic Labyrinth at the mosaic C-38 (House of Cantaber) within Conimbriga Ruins. Photo © Pedro A. H. Paixão 2007.

Novel methods for labyrinth creation – non-human methods – are introduced and exemplified through artistic constructs. These new methods utilize non-human bio-electronic techniques and are initially grouped into three distinct sub-categories: the 'open' method, the 'mathematical flower' method, the 'animal' method. Four case examples of artistic non-human labyrinths resorting to the introduced novel methods are explored: 'k.' videogames (2007, 2010), 'Wolfanddotcom' videogame (2017), '8-bit Maze Gardens' vegetable paintings (2018-), 'Ant Ennae Labyrinths' bio-electronic apparatus (2019-).

Far from being a thorough accounting of mazes' or labyrinths' history, their philosophical implications and roots, their usage and construction methods, this section

attempts to frame portions of the labyrinth as conceptual basins as well as example usage throughout human history in order to establish a specific focus on the artist's undergoing explorations of electronic digital arts, towards the exemplification of novel non-human labyrinth construction methods utilized in the creation of artistic constructs.
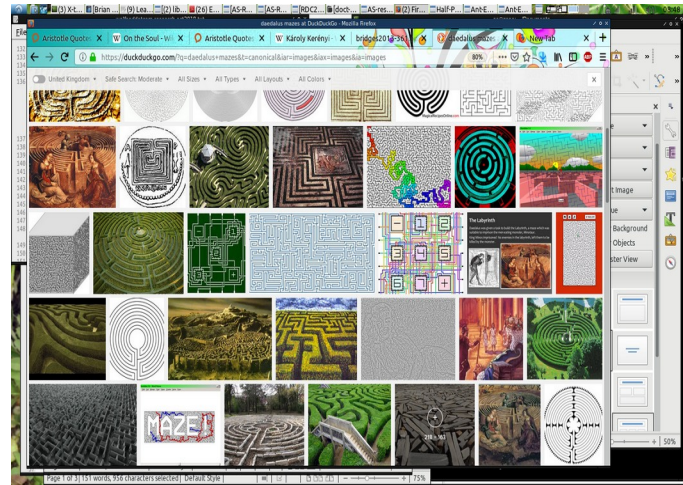
Figure 148: Random examples of images of labyrinths obtained through image search "daedalus maze images".

Through this framing of labyrinths as mythological root structures, as landscapes for spatial games, for serious games, as grounds for deeper humane spiritual connections, as spatial metaphors of human life, we then proceed to glance known labyrinth formation methods and examine labyrinths properties when compared to other spatial structures. We walk through some author biased considered to be notable examples of labyrinthine usage in electronic arts, and further present it concisely in table LEA. After introducing considerations as to why resort to non-human methods, why perform a non-human turn, the novel labyrinthine formation methods are introduced. These new methods utilize non-human bio-electronic techniques and are initially grouped into three distinct sub-categories: the 'open' method, the 'mathematical flower' method, the 'animal' method. One of these threefold novel methods – the 'open' method – has been firstly utilized in an interactive videogame series in 2007 and in 2010 ('k.' and 'k.~'), on and off in other works, and utilized as well in the 'Wolfanddotcom' example from 2017 analyzed in this thesis. The remainder two methods – the 'mathematical flower' and the 'animal' methods – have been applied in recent works, from 2018 and 2019 onward ('8-bit Maze Gardens' and 'Ant Ennae Labyrinths').

By going through these artistic constructs example implementations of novel labyrinthine methods, we endeavor to establish grounds in order to combine scientific, artistic and non-human methodologies as tools for the exploration of new aesthetic regions within electronic arts, resorting to new ways of looking at a powerful millennial structure, as well as to introduce unfamiliar labyrinthine building techniques which lead beyond usual human scope of imagination of spatial structures. Labyrinths are one of the few perennial mythological structures for deeper humane insights which have persisted throughout times. Electronic programming has allowed the discovery of numerous algorithms which have enriched substantially the variation amount of devisable labyrinthine structures. Non-human bio-electronic labyrinth formation methods exemplify original labyrinthine aesthetic regions.

Living entities are bound to flow within space and time. While life is extensive, it also takes time to mechanistically displace or change through space. Space and time are deeply entangled human made philosophical categories, and up until now, yet unresolved ones, for it is still unclear the full scope of their interrelations. From Kant's prominence given to the subject, through his revolutionary reversal of the ruling subordination of movement to time up until the seventeenth century, central to his transcendental idealism, still subject to this day of multiple critical issues (Janiak 2022), to Deleuze's occupation with the metaphysics of time during the twentieth century, approaching it from the mathematical domain, utilizing in time Riemann's mathematical concept of a manifold, giving rise to a non-chronological n-manifold based outlook of time (Williams 2011). Zeno (Hofstadter 1999, Allen 1997, Aristotle 1961) was one of the first to tackle these problematic areas through condensed paradoxes, which can also be seen as exquisite mathematical problems probing the stability of the mathematical building, the essence of the underlying philosophical dichotomy involved in such entanglement of space and time, from which motion is an example[37].

Labyrinths and mazes are inextricable paths, human made millennial structures which provide spatial challenges, solvable through physical displacement over time within its

---

[37] See, for example, Zeno's Dichotomy paradox in Aristotle's Physics (1961): "That which is in locomotion must arrive at the half-way stage before it arrives at the goal". In order to successfully complete the full magnitude of this task, one must walk through an infinite never-ending number of steps, deeming the task an impossibility. The paradox, as stated, becomes a continual recursion inducing tool which demands infinite time to solve it, thus demonstrating such task cannot be achieved.

intricate structure. Labyrinths are often connected with feedback, compression, entanglement and hyper complexification of goal oriented displacement. Initially an intricate spiral line returning towards itself – as in the earliest known classical seven path labyrinth design (Saward 2003, depicted in coin figure 139) –, in pre-Homeric days labyrinths were a device portraying an image of the underworld, image powerful enough to also being capable of bridging the world of the living with the world of the dead (Kerényi 1941). According to Mircea Eliade (1957), in prehistory, the caves were countless times compared to, and even ritualistically transformed into labyrinths:

> *[Caves] were at the same time the theater of initiations and the place to bury the dead. Labyrinths were compared to the body of the earth-mother. Penetrating a labyrinth or a cave was the equivalent of a mystical return to mother – objective that both initiation rites and funerary rites pursued.* (Eliade 2000:185)

The important prehistory remark of labyrinths ancestors as caves, as a space whose function is to establish pathways towards a mystical return to the earth-mother, to Gaia, as already seen on 1.1.1, to a "gaian field", a boundless ooze, which encircles all living and non-living matter, underlines the spiritual connection also sought out by these artworks, which have later come to attempt to replace and reimagine this place and procedure of mystical return, of which the labyrinth is the most archaic simile. Echoes of Nietzsche's eternal recurrence and Kandinsky's quote about the work of art being the mother of our feelings reverberate throughout these ideas into new meanings.

During the days of king Minos of Crete, labyrinths became established as the place for the dance of the lady of the labyrinth[38], a dance which would announce the beginning of the deadly games, where seven young male and seven young female contenders were instructed to adventure in the maze homeland of the Minotaur, and to return back alive, with proof of their winnings over the labyrinth (Colli 2001). Even if the sheer complexity of the maze did not lead the contenders astray into their deaths – caused by getting so deeply

---

38   Ariadne, for whom Daedalus architected the Minoan labyrinth at the orders of her father, king Minos, as a place for her dance. Károly Kerényi ascribes the labyrinth firstly as a ritualistic device, a device for dance, built for her owner, the lady of the labyrinth. In the eyes of Kerényi and other scholars (Kerényi 1956, Eliade 1957, Colli 2001), the labyrinth is also an image of the underworld in the world of the living, underlining a powerful analogy between the spiral labyrinth with the human guts, human interior, the underworld, the connection to the earth-mother.

and recursively entranced in the inner path complexities of the labyrinthine structure, more and more nurturing adventurers to loose forever sight of their bearings, as their machine bodies wear off due to lack of nourishment –, the monstrous inhabitant of the deadly structure, half man, half beast, gifted with more than human force and with superior spatial orientation within its lair, would most likely bring them to their doom.

Thus from this mythologem onward, labyrinths were associated as mythological radix structures, simultaneously, on the one hand, as the actual grounds where one of the first serious game takes place, where the underworld and its more than human powers can be bridged and reached, becoming mythic material to warn generations to come. Kerényi (1963) poignantly places the origins of classical labyrinth designs shaped as human intestines, in order to serve as spiritual access bridges connecting to human's innermost core. On the other hand, labyrinths become a metaphor picture and an actual challenge of the complexities associated to what solving the tasks laying ahead ask – seemingly a more than human effort of hero like quality is demanded as a characteristic in order to solve the posed challenges and traverse vast mazes.

It is however crucial to note here that there are others advocate of a less popular and less heroic, anthropomorphic vision of the labyrinthine myth. Even the Minoans as early as 12th century BCE possessed a key ritual with oxes which involves a gymnastical non-violent form of bullfighting known as bull-leaping (McInerney 2011), arguably a more interesting alternative to the yet in the 21st century CE popular bullfighting game many humans still seem to enjoy. Probably since it depicts non-human humiliation often followed by death within uneven situations solely targeted at human rejoicing of blood being spilled. Not their own, though. Still, and nowadays 2022, in the author's homeland country, bullfighting is considered a cultural activity en par with the all other arts, from literature, to painting, composing and performing, circus acts, with additional tax benefits over the lot.

Under the Minoans, the social engagement bull-leaping offers is an interactive and daring human and non-human play on even grounds. Even in the deadly labyrinth games the odds are even, both parties may spill blood, it is the human animal here who must

prove worthiness, not the gaian creature, whom in bullfighting is assaulted through wave after waves by an ostentatious armed army of dressed creatures riding on each others' backs, versus a single naked one. On the Minoan labyrinth, the human animal must return alive, with spoils, while in bullfighting, perhaps in place of most human actions towards Eorthe, is yet another socially accepted form of human cowardice, arrogance, hubris and utmost impiety vis-à-vis Gaia, cheered by the state with tax exemptions.

Regarding views less anthropomorphic of labyrinths, contemporaneously and philosophically, Deleuze is one of the first to remember, adhere and to bring forward a non-human view of labyrinthine structures as he reads it from Nietzche's Zarathustra:

> *Theseus doesn't understand that the bull (or the rhinoceros) possesses the sole true superiority: prodigious agile beast at the core of the labyrinth, whom is also at ease in the heights, beast that unharnesses life and that truly affirms it.*[39] (Deleuze 2005:51)

This "odor of earth"[40], true affirmation, whom the labyrinth rightful owner carries, for Deleuze and Nietzche, is unlike any external sublime hero which invades the grounds of the spiritual device, seeking to conquer and to trespass it, annihilating its caretaker, reversing its original meaning and purpose.

Mythology, in the early years of mankind, before the birth of philosophy, served important roles which counter balance destructive human planetary scale forces: mythology was primarily a human cultural force, by which unreferenced mighty stories got transmitted from generation to generation. They served as warning signs on human hubris, subtle education tools, fantasy triggers inducing new realms. Károly Kerényi (2008), an eminent figure of mythological studies, broadens the scope of the mythological function on early societies towards a balancing non-anthropocentric vision: it is a world of epiphanies, where humans live side by side with plants and animals, thus with equal

---

[39] Translated from by the author from the portuguese: "Teseus não compreende que o touro (ou o rinoceronte) possui a única verdadeira superioridade: prodigiosa besta ágil no fundo do labirinto e que se sente também à vontade nas alturas, besta que desatrela a vida e que a afirma." (Deleuze 2005:51)
[40] Ibid.

natural rights under this sun –, and during the mythological stories humans are usually subjected to non-human forces requiring seemingly more than human feats, where they must approach godlike qualities in order to solve life threatening riddles, or even conquer abnormal beasts.

Recently, Viveiros de Castro (2014) has shown us that Amazonian and other Amerindian populations live in conceptual universes where plants, animals, spirits are all conceived as persons, where boundaries dilute between the human and the non-human, and the latter is even higher praised and revered as an inspirational model. He also goes on to acclaim, as Caillois, the anthropological importance of masks and devices worn by the shamans, both at personal and social levels, as a token interface that bridges the human to the underworld (Kerényi 2008, Caillois 1990), a process taking place and performatively intensified towards a completed transformation onto the otherness *it* seeks to incorporate and blend into, ultimately blending with Gaia, as seen at 1.1.1, or with a particular manifestation of one of its aspects, as a non-human animal or as a mythological being, drawing its insights from all the non-human communication seemingly taking place: a subject of utmost significance that has lead the construction of special VR sculptural mask interfaces for the immersive works Babylon (2018) and 0X Labyrinth (2018-2022),

According to Eliade (1957) and Kerényi (1941) the balancing non-anthropocentric role myths enforce may be derived from their usage and origin in three noteworthy aspects: usually myths are a no single author or even known author work. Instead, they are the result of hearsay, folklore stories, tales that got passed down from generation to generation; and this fact alone lends myths a dual role by eradicating the human authorship source and merging it closer to the divine or spiritual sphere. A second noteworthy aspect to myths, in the context of this research, lays in the creativity of embodiment of unknown or more than human powers, of beings that are usually expressed and visualized as the surreal combination of distinct animal physical traits combined into one mythical beast (Borges 1974). The third important aspect relays the imaginary cathartic operation myths perform on humans, either as a bedtime story which serves both as a warning towards larger than human and uncontrollable forces that are somewhat tamed or surmounted, and also as a make believe situation which heightens the importance of biodiversity and the preservation of important forces of nature.

Labyrinths have since become mythological root structures, landscapes for spatial games, for serious games, as grounds for deeper humane spiritual connections, as spatial metaphors of human life. Venturing into the labyrinth is probably one of the oldest deadly games, made out of paths and crossroads, defying free will and choices by the traveling adventurer seeking to solve its mystery, or simply conquering it by getting out alive. Labyrinths point towards maximum spatial compression and lengthiest displacement. A spatial structure which aims at a hyper complexification of space towards a possible infinite time required to solve it. What other way, than through a labyrinth or maze, can we compress the maximum possible traveling distance inscribed within the shortest spatial span? Thus it arrives without wonder that labyrinths become the grounds for elaborate and deadly hide-and-seek games, a serious game for spiritual heightening of human beings, a perilous spiritual training ground. Solving a tangled spatial deadly riddle involves untangling and heightening the full depths of the human soul. Even with the help of external artifacts, for it is a deadly game and contenders will resort to any life saving gimmick. It is interesting to note that the artifact which aids Theseus into solving the labyrinth, perhaps the only possible helping artifact when it comes to facing head on the deadly device, is in itself a labyrinth as well, though at a different portable scale, for it consists of a tangled up single path hyper-compressed and confusing solution of this labyrinthine image. The yarn of wool, Ariadne's gift thread to Theseus becomes his mythical salvation. A history he can retrace back as he delves deeper and deeper in the recursive meander in order to conquer it.

Labyrinths are one of the few perennial mythological structures for deeper humane insights which have persisted throughout times, with countless iterations and revivals in most human generations. These millennial structures touch many key stones of humane life which have made them elected structures of fascination, of study, of artistic depiction, of countless stories and even myths. They resonate within their purpose, their structure portraits within itself the maximum amount of time to go through it compressed in the least possible space: as with Zeno's paradoxes, they point to never ending space time entangling recursive architectures.

Even though until now throughout this thesis labyrinths and mazes have been used interchangeably to describe a similar structure, their English words represent in fact similar but distinct devices. Archaic accounting from Greek writings report labyrinths as unicursal – i.e., single path – structures modified from an elliptic or square basis shape. Whenever there are path choices involved – a multicursal design –, the device is qualified as a maze. Mazes were not present in archetypal classical labyrinthine designs. Classical labyrinths, which are found in most ancient European, Indian, north African and American cultures since 4000 years ago, consist of a single pathway which loops around a central seed goal, usually forming seven circuits of entanglement from the interior to the exterior of the labyrinth (Saward 2003). This corresponds to the first known labyrinth formation method. Throughout the ages designs have changed evolving in complexity, introducing more loops and choices, though most kept their basis millennial central seed goal around a spiral or rectangular like shape. Saward (2003) suggests labyrinths to be grouped in four distinct categories, mostly according to the characteristics of their design, and to the era they were made in. He names the following categories of human made labyrinths: Classical (around 2000 BCE, worldwide), Roman (2 BCE, Europe and north Africa), Medieval (9, 10 CE, Europe) and contemporary labyrinths (20th Century).

Labyrinth design has also been the subject of numerous contemporary computer scientist's research. Several algorithms autonomously design labyrinths or mazes according to several parameterized constraints introduced by the user. By using computers and formal rules grouped under types of maze making algorithms, the size and complexity of these structures has grown tremendously. Walter Pullen has been aggregating maze algorithms into his aptly named Daedalus software, which he has been developing since 1998 (Pullen 1998). Several other maze generation programs exist, but since Daedalus is the largest and most comprehensive one, it is the maze creation software analyzed in order to introduce the reader with the already established maze generation algorithms.

Figure 149: Walter Pullen's Daedalus software here in 2018 at version 3.2. Image merging extrusion with a single point perspective of its title in 3D originating from a vast 2D colored labyrinth background. Image © Walter Pullen.

Pullen suggests seven categories for the classification of mazes originating from parameterized computer design: Dimension, Hyperdimension, Topology, Tessellation, Routing, Texture, and Focus (Pullen 2015). Dimension classifies mazes according to their spatial dimension usage (2D, 3D, 4D and above, Weave). Hyperdimension describes the dimension of the object moved through the maze. Topology accesses the geometry of the maze in Euclidean space or with abnormal connections. Tessellation describes the geometry of individual maze cells. Routing describes how the maze is generated, i.e., which kind of algorithm is followed in its creation. Texture relates to the style of the passages within the routing and topology of the maze. Focus describes a constructive or destructive algorithm for the generation of mazes. According to Pullen's categories, we can find labyrinths as a special kind of mazes that consist of a structure where the routing creation algorithm is without junctions, thus laying down a unicursal design, where the player follows an entangled single path towards the center, and returns via the same or by a distinct pathway.

The software Daedalus incorporates most known algorithm creation methods of mazes and labyrinths. It is a vast elaborate software with many maze creation and solving methods, and also includes a scripting language that allows creation of simulations, games, experiments on the generated mazes. Pullen classifies the maze creation algorithms according to several methods he has used in his software. These methods are the inner core of the labyrinth generation tasks, similar to the seed pattern of the hand made labyrinths we saw previously, and most correspond to an aggregation of distinct maze

creation algorithms created by different programmers. The methods presented in Daedalus include perfect maze creation methods, where we can find the following algorithms: Prim, Kruskal, Aldous-Broder, Wilson, Eller, growing tree, growing forest, hunt and kill, recursive backtracker, recursive division, binary tree mazes, and sidewinder mazes algorithms. Other than the perfect labyrinthine methods we can still find many other methods: the braid method, the unicursal method, and other methods Pullen names as sparseness, 3D, weave, crack, omega, hypermaze, planair and template methods.

Parallel to labirinthine studies are considerations from another series that explores rules for a synthetic language for found sounds in spaces where the devices are installed. With a background in musical and visual arts, sciences and philosophy studies, delving deep into computation and programming at the time, it seemed obvious to the author to expand, deepen and refine early cymatic synaesthetic water light sound interactive experiences by adding algorithmical processes. Not just by using real-time synaesthetic transcriptions, but to expand this process and develop a signal processing language that could operate only on sampled real-time captured fragments on the computer.

The aim of this struct language, explored through the struct series since 2000, would be to synthesize any sounds, timbre, dynamics, visual flows by using only real-time found and sampled fragments of aural and visual data the users would provide the devices. Using feedback and other time-based signal processing operations on the site-specific aural and visual data, it came to the artist's mind that the computer could be orchestrating perpetual arrangements at shifting speeds of distinct and previously sampled audio moments, and that this could be an original means by which to synthesize any kind of sound and or visuals. On the other hand, the computer could also help to automate and create generative emergent algorithms to control the synaesthetic processes and induce cymatic transformations, by fading in and out lights according to the real-time sound levels, by vibrating water surfaces with modified woofers projecting sonic algorithmical compositions, by synthesizing audio and motion reactive seamless virtual visual limitless spaces.

To expose an infinitude of orchestrations, like machines weaving processes on the residual data that emerges from the void of the contact of people with the works themselves. A full synthesis language that uses solely sampled aural and visual fragments, and re-injects these previous fragments processed into the now. The resulting sonic and imagetic outputs the pieces generate, triggered by sounds or movements which are performed in the experience-space by the visitors or the machine itself, are then re-casted from the sampled past onto the mechanism, re-transformed into input samples, caused by natural feedback of sampling machines that broadcast continually, sampling and synthesizing, the exterior and themselves.

Already after having developed the earlier two structs, the author became acquainted with similar art works which have influenced this series path. John Cage's 4'33" (1952), Nam June Paik's TV Buddha (1974), Bruce Nauman's Live-Taped Video Corridor (1970), Johann Sebastian Bach's Fugues (1722-1748), among others, have been key works which resonate with the themes being deepened in the struct series. All these works share a common main theme. Recursion, self-reference, evolving unique synthetic languages based on small samples from reality, fractal regions, whereas small temporal or spatial regions share main characteristics of the whole or larger regions, at different zoom scales, in a *hors-temps* and *hors-espace* domain (Xenakis 1992). While the first three mentioned works focus on showing the open, or provide simple real-time transcriptions of visual data embedded into different images, Bach's fugues showcase remarkable counterpoint techniques where a simple melodic composition line becomes fractal and is combined with itself at different pitches, speeds, layered from single melodic lines to 2, 3, 4, 5, 6 simultaneous voices orchestrating melodic counterpoint variations of a main musical theme. Such is the case of the Musical Offering (Bach 1747). In this work Bach composes one of the most elaborated and complex fugal compositions, sometimes with 6 distinct voices, from a harsh themed melodic line provided by king of Prussia Frederic the Great. As Douglas Hofstadter accounts for:

> *A fugue is like a canon, in that it is usually based on one theme which gets played in different voices and different keys, and occasionally at different speeds or upside down or backwards.[...] Each of the voices enters in turn, singing the theme, often to the accompaniment of the countersubject in some other voice, with the*

remaining voices doing whatever fanciful things entered the composer's mind. When all the voices have "arrived", then there are no rules. [...] These successive modulations lead the ear to increasingly remote provinces of tonality, so that after several of them one would expect to be hopelessly far away from the starting key. And yet, magically, after exactly six such modulations, the original key of C minor has been restored! All the voices are exactly one octave higher they were at the beginning, and here the piece may be broken off in a musically agreeable way. (Hofstadter 1999:9-10)

This could also be looked at by another and more contemporary perspective. In any signal processing system, a self-reference process usually involves the feedback equation, where a percentage of the output/processed signal is added at the beginning of the system towards further processing, cascading and percolating a systemic loop, generating a themed phrase from rules applied to a short input signal which reverberates across the system. The percentage amount usually correlates to the feedback factor of the system. But mathematicians have shown us that these self-referenced recursive structures can also exist beyond the feedback process. Fractal systems, even Zeno systems, for instance, possess similar spatial and time qualities of feedback or fugal processes. Chaotic attractors and cellular automata also underline an emergent mathematical process which gives rise to complex patterns often found in nature (Johnson 2004, Wolfram 2002, Flake 1998, Gleick 1994). These algorithms expose a general form enclosed and self-referenced within the overall shape, shaped by a functor processing wave on the signal itself. A form that gets repeated, trans-scaled, pitch-shifted along side and at every scale of the mathematical system. As Hofstadter remarks on Godel, Escher and Bach, this recurrence and fugal structure is the basis process of emergence of consciousness, of Strange Loops:

The "Strange Loop" phenomenon occurs whenever, by moving upwards (or downwards) through the levels of some hierarchical system, we unexpectedly find ourselves right back where we started. (Hofstadter 1999:10)

We find again meanders, recurrence, fractal, chaotic, self-referentiality procedures, on the time domains, here on the process of emergence of consciousness, also as seen on fugal

music. And on spatial domains, as we've seen beginning of this section, on labyrinths, caves, rites and serious games.

In order to finalize section 1.2, and after traversing the section that covers the aesthetic regions of interest (1.1.x), an archaeological recess is undertaken in the reading by the table provided next, in order to account for a researched historical reading regarding pioneer usage of labyrinthine structures throughout electronic arts (table LEA). The table synthesizes on the first column the works' title, authorship and creation dates, alongside with descriptive succinct observations on the second column regarding each breaking new ground work. Since labyrinths bathe in compression, entanglement, and the possibility spaces they offer, as we've seen throughout this section and shall continue to analyze and speculate next section 1.3 dealing with aspatiality setting grounds for 1.4 imaginary arts (IA) on zenospace (ZS), where applicable and relevant, the following descriptions highlight machine processing required to run the work, file size and the work's output scope.

While research produced 0X Labyrinth (2018-22) is left out of this listing with 27+ other entries, since it is one of the ruling mythological videogames addressed in this dissertation entirely dedicated to questions arising from the above and below conceptual analysis described in the thesis, one entry in the following table holds a representative and historical selection of three of the author's previous works regarding labyrinths that withhold ST procgen synthesis, CA and DNA based processes, AI locomotion mechanics for agents of AL such as boids (Reynolds 1996) or other abstract displacements (appendix α.4). Table LEA represents a current state of interactive electronic arts (EA) which provides scope for labyrinthine themes, as well as sediment EA pathways undertook since the beginning of the XXIst century.

Table LEA - Notable examples of labyrinthine usage in electronic arts

Work title Author(s) (Date)	Descriptive notes
Theseus (Maze-Solving Mouse) Claude E. Shannon (1952,1950-1)	An electronic founding act of cybernetics, at the dawn of computation and robotics, Theseus underlines labyrinthine topics mesmerizing humans across millennia with a most relevant electronic usage towards a machine that is capable of solving a maze on a 5x5 grid. Here one square is the food-goal and the remainder are adjustable to engender distinct meanders. Theseus solves the mini-maze by trial and error, and remembers the solution. If the maze changes, Theseus resets its memory and starts over. First steps in AI, where Shannon even equaled Theseus trial-and-error-with-memory to primers of human experience. Initially built to help solving telephone switching problems, with then students Sutherland brothers, like the Theseus mouse, phone calls had to figure out the shortest path possible between junctions and nodes. Shannon published "Presentation of a Maze-Solving Mouse" at 8th conference of Cybernetics in 1951. Shannon's work was predated by Thomas Ross, whom in 1933 built a "Maze Learning Machine" with a simpler comb like spatial shape.
Franken & **Machina Versatilis** Bert Sutherland, Ivan Sutherland (1953,1957)	Franken was the Sutherland brothers take on another imaginary cybernetic mouse capable of solving mazes, 1953. Titled "Franken, the maze-solving, food-getting, learning beast" in a memorandum by Edmund Berkeley, unlike Shannon's take, Franken used sensing fingers, communicating back to the robot each squares contents and viable connections, whom incorporated it in its Magdum, a magnetic drum serving as Franken's memory in order to be able to reach the food square, opening sequential gate latches. Machina Versatilis takes another stance at solving mazes with a more robust and modular electronic apparatus Sutherland describes in his 1958 article "An Electro-Mechanical Model of Simple Animals".
Cybernetic Mouse & **Computer Maze** Johan de Boer (1968,1970-3)	Instead of a magnetic infrastructure controlling the mouse avatar on top of the labyrinth construction Johan de Boer's take features an electronic maze solving robotic mouse with two servo motors, on his 1968 Cybernetic Mouse. On November 5, 2010, Johan de Boer offered a comment at cyberneticzoo.com: "Ah, I can't believe I found this site. Such a mouse in a maze is exactly what I build in the 60's. My best version was with a light, rather than a mechanical mouse, that would work its way through the maze, changeable with removable fences. Each square had a light and they would turn on and off as it found its way". Then in the early 70's he devised a computer controlled maze as a followup to his Cybernetic Mouse. From private correspondence with cyberneticzoo he states: "A second project was the maze where a light was used to indicate the position of an imaginary mouse in the maze. The maze could be changed with small removable barriers. Each square had a small light bulb that would be on if the (imaginary) mouse would be in that square. This whole thing was a cube with sides of about 20 cm. Unfortunately there is no photo and this thing was lost (or scavenged, possibly)."
LiveTaped Video Corridor Bruce Nauman (1970)	Real-time analog video processing work whereas visitors walk along sides of a square shaped looping corridor which provides for an endless video situation of observers seeing themselves at a distance and just from behind, on one of the four monitors placed at the square's corners. Comparable perhaps to Escher drawings in terms of labyrinthine logical loops, it provides a very simple 'open' space that sets in motion imaginary maze mechanics, as participants attempt to unveil its structure, never allowing to reach its ending (which would be being able to look at yourself facing the video monitors).

Laberinto Invisible Luis Benedict (1971)	Apparently an empty space with a precious non-human terrarium at its nucleus, Laberinto Invisible is a room sized installation where an invisible labyrinth is set. It is walled by light beams cast from a light bulb through a series of mirrors until arriving at an alarm sensor protecting a central Mexican axolotl. If the beam of light is interrupted, the alarm sounds, thus preventing human users from arriving at the labyrinths' core without ritualistically and playfully attempt to uncover its meanders by walking through its invisible path electronically undetected.
La Région Centrale Michael Snow (1971)	Snow's structural film, made through the installment and real-time remote radio-controlled composition of filmic views originating from a robotic arm operated polar camera unto the middle of a bare and humanless Canadian natural landscape. The 180 minute film builds up sections solely through the polar camera's composition of look at positions on the natural space, with situations that intensify towards final detachment of the machinic point-of-view towards a labyrinthine and ontological perceptive experience that is able to rapture its viewpoint in what becomes a seamless nature-machine-cosmic plateau. The author's philosophy graduate dissertation discusses just this work married to Deleuze's differential ontology.
Maze (Maze War) Steve Colley, Greg Thompson, et al (1973)	The pioneering program of the FPS gaming genre, the first one to adopt first person perspective and three-dimensional perspective based graphics, 20 years before mainstream gaming arrived at similar paradigm (Wolfenstein 3-D, Doom, Quake, iD Software, 1992, 1993, 1996). Maze War was programmed on a Imlac PDS-1 at the NASA Ames Research Center in California. The program depicted mazes on a 16x16 bit resolution that could be navigated from a first-person perspective and shared on a network setting among similar machines.
Colossal Cave Adventure Will Crowther (1976), Don Woods (1977)	Adventure, or advent, as it was shorthandedly known, is the first adventure game playable on CLI that depicts interactive fiction. ADVENTURE(6) / BSD Games Manual May 31, 1993. NAME adventure — an exploration game DESCRIPTION The object of the game is to locate and explore Colossal Cave, find the treasures hidden there, and bring them back to the building with you. The program is self-descriptive to a point, but part of the game is to discover its rules. To terminate a game, enter "quit"; to save a game for later resumption, enter "save". Program file size is 107Kb.
Beneath Apple Manor Don Worth (1978)	Stochastic graphical based 2D turn-based dungeon explorer where your goal is to find the golden apple, on the bottom level of a procedurally generated dungeon featuring procgen rooms, ten in a level. It is the first commercial RPG for the 16K Apple II available for personal computers (PC) instead of mainframe computers at research facilities. Though it predates Rogue by two years, featuring also computer graphics instead of CLI ones, Rouge gained more popularity due to being freely available on many systems at the time rather than locked to an unique platform. Circa 82 it was also implemented on Atari 8-bit machines, while Rogue executes on Amiga, Amstrad CPC, Atari 8-bit, Atari ST, Commodore 64, CP/M, DOS, Macintosh, TOPS-20, TRS-80 CoCo, Unix, ZX Spectrum.
Rogue Michael Toy, Ken Arnold, and Glenn Wichman (1980)	"Hello <username>, just a moment while I dig the dungeon…". The opening CLI line from popular founding father of stochastic procedural labyrinthine spatial generation, initiating a genre becoming known through this title (roguelike games), playable to this day, 42 years later than its creation, on regular linux shells. Rogue is a turn-based videogame entirely made up of ASCII characters running at the console, it features fast paced procedurally generated dungeons interconnected with doors and leveling up mechanics that continuously make it more difficult to progress, it's a fantastic pioneer example of near infinite maze generation electronic arts experience under 0.19Mb. See also appendix δ.1.

ZORK I: The Great Underground Empire
Infocom
(1981-3)

"West of House / You are standing in an open field west of a white house, with a boarded front door. / There is a small mailbox here." ZORK stands as a noteworthy successor to Colossal Cave Adventure, the original interactive fiction program upgrading gamebooks that you could run on CLI shells, founding a genre to be known as adventure gaming. The logical space of the videogame is merely textually described, and if able to, the user issues the right commands and picks up sequences of objects to be used in the labyrinthine imaginary fiction edifice. Whilst it is similar to adventure gamebooks glimpsed at 1.1.1, Adventure and Zork1 rapture with traditional gamebooks linearity by providing no numbered alternatives for the user to proceed, and it is up to him to uncover which would be the next step in order to advance the videogame's narrative.

La Plissure du Text
Roy Ascott
(1983)

Before www as is common today, in early 1983 telematic days, Roy Ascott conceptualized a work as a distributed "cybernetic fairy tale", implemented on ARTEX, with contributions from artists scattered in 11 countries, where like in a surrealist cadavre exquis, contributors submitted textual information getting juxtaposed into a labyrinthine multiple author narrative surrounding the fairy tales prompt, a collective global myth creation, telematic and distributed.

Moondust
Jaron Lanier
(1983)

Not so much labyrinthine at first glance, however, Jaron Lanier's pioneer art game for the C64 features a generative composition that is responsive to the players interaction. Through the joystick the player controls all elements floating around and by seeding the space at proper locations interacts with them. It is included here as a pioneer example usage of dishorienting controls, graphical complexity, and initial labyrinthine logic until you learn how to communicate with the program.

Elite
Ian Bell,
David Braben
(1984)

Elite is perhaps the world's first stochastic infinite space simulation game with quite interesting rudimentary 3D graphics. By using a matrix of combinatorial possibilities it can forge a pseudo-infinite space that places the player as an interplanetary spatial explorer, merchant or pirate, depending on his choices along the game. In order to survive within the game's labyrinth, the player will be required to continuously chart new territories, plunder or trade resources. It was also one of the first computer games to use wireframe 3D graphics with hidden line removal. Elite ran on a multitude of platforms due to its excel compression of logic space: the whole games runs on low end machines under 48k of RAM and its ZX Spectrum version has all the game in the file ELITE128.TAP with 47.9kb.

NetHack
Mike Stephenson
& Stichting
Mathematisch
Centrum
(1985-)

NetHack is a prominent roguelike expansion which is still developed to this day by Stichting Mathematisch Centrum. A descendant of 1984's Hack videogame, like Rogue, the CLI ASCII characters' game features a turn based single player dungeon exploration game on ST rudimentary labyrinthine spaces with a variety of simple AI agents. Alongside with rogue, NetHack, to this day, requires more player wit than the usual kill everything in sight type of videogames, alas crowding the landscape of the medium. Beyond Rogue, NetHack escalates the adventurer's spatium offering races, where you can play inbetween as a tourist, an archeologist, elf, human or a wizard among many other choices, and you should utilize in game objects and encounters treading carefully, unlike fast paced hack and slash, in order to retrieve the "Amulet of Yendor" at the deepest dungeon level and still manage to escape. File size of 4.25Mb.

MIDI Maze
Xanth Software
(1987)

"Multi-player combat synthesizer", MIDI Maze is a first among consumer grade networking multiplayer maze game, before 56kbps modems, using MIDI as its networking protocol. It is a networked first-person-shooter maze game for the Atari ST focusing on LAN parties, where locally several players (up to 16) could join in the shared networked labyrinth, and from their machines, compete in a shared virtual space, designable in a text editor with ASCII characters which become maps transformed into an interesting rudimentary 3D graphics one point perspective simulation on a MIDI network.

Aspects of Gaia
Roy Ascott
(1989)

From the labyrinths of a participatory cyberspace, physically traveling through pioneer intercontinental telecommunications, that Mike Phillips, Roy Ascott's main collaborator and chief implementer of Ascott's vision described as a daunting groundbreaking cybernetic journey, as Theseus above in 1952 attempts to initiate solving with his electronic wit, Aspects of Gaia by Roy Ascott is a 1989 Ars Electronica awarded project that landmarks pioneer usage of telecommunications at a gaian level Ascott coins as telematic gaia. The installation features two levels, whereas in the first level receiving tents present media contributed by networkers around the world tent visitors can further manipulate; a second cybernetic maze infrastructure train level, painting the inner earth, traveled by human visitors propelling themselves in a tunnel level, depicts selections of media, thoughts, comments, ideas, graphics ever arriving from networkers around the world.

The Legible City
Jeffrey Shaw,
Dirk Groeneveld
(1989-91)

The Legible City features the one of the first usages of a non-conventional physical computational controller interface towards architectural poems, whereas a modified bicycle with sensors is used as main driving vehicle within a primitive and pioneering cyberspace depiction of poems mapped onto real life city buildings locations. Viewers ride a bicycle through an artistic interpretation of a city. By substituting buildings with poems, usual city references dim and the space becomes a poetic labyrinth where users get lost and immersed bath in an ambiance based on actual cities architectures. 1989 is the Manhattan version, "comprises eight separate fictional storylines in the form of monologues by ex-Mayor Koch, Frank Lloyd Wright, Donald Trump, a tour guide, a confidence trickster, an ambassador and a taxi driver." The Amsterdam version was built in 1990, Karlsruhe 1991.

SimEarth
Fred Haslam,
Will Wright,
James Lovelock
(1990)

Second entry to Will Wright's Sim series, this one with a gaian management outlook, with James Lovelock consulting for the game, views followed in next year's SimAnt. Despite its relative constrained planetary space, on SimEarth the real labyrinthine connection lays in the meanders of user inputs and interactions towards the parametrized CA algorithms that implement game rules. Thus, in order to achieve good performance on SimEarth, you must seek to implement the right amount of gaming elements at the right times to face unpredictable automata behaviors.

Hovertank 3D
id Software
(1991)

First game implementation of John Carmack's revolutionary raycasting engine featuring 3D graphics single point perspective views of 2D flat worlds as rudimentary textured 3D spaces users can engage in. The engine features among other things a fascinating black magic square root calculation still leaves in awe most programmers to this day. Mainly included due to historical computer technical reasons.

Wolfenstein 3D
id Software
(1992)

One of the best known games built by John Carmack and John Romero, featuring Carmack's raycasting gaming engine refined from previous prototypes into one of the most iconic installments of first person perspective graphics attached to a fast paced shooter videogame. Portraits a second world war labyrinthine motif, where the player is unicursarly led through a series of meander floors on Castle Wolfenstein, filled with junctions, locked doors, scattered keys, as well as several types of simple AI's engaging the player. All the videogame's assets, sounds, graphics, architectural labyrinths and logic are tightly compressed in a 772k W3DSW14.SHR file.

Ecco the Dolphin &
Ecco: The Tides of Time
Ed Annunziata /
Novotrade

Non-human bottlenose dolphin Ecco is human controllable avatar in this difficult action-adventure labyrinthine videogame, which combines exquisitely non-human underwater maze exploration attached to home pod seeking, time traveling, extraterrestrial quarrel encounters across time, that if accomplished, are able to return Ecco and his dolphin pod home, saving Gaia along the way. 1994 saw the release of the sequel Ecco: The Tides of Time. New kinds of puzzles were introduced,

International (1992,1994)	such as following other dolphins through an underwater maze and scavenger hunting, as well as additional powerup mechanics other than the already established in its predecessor sonar communication with other cetaceans and crystals.
Myst Robyn & Rand Miller / Cyan, Inc. (1993)	Perhaps comparable to Chris Marker's La Jetée (1962), Myst exhibits a beautiful, static, interactive, imaginary, adventure, puzzle, fiction, depicted as clickable 3D photographs one can click to fade-jump towards, pickup & drag objects, an acclaimed videogame hit lauded by its ability to immerse players in its fictional world. In spite of its structure entirely man-made, the entranced narrative unfolded by objects, journal entries, puzzle solving, depicts a luring immersion onto a very broad and highly polished immersive experience.
Osmose & **Ephemère** Char Davies (1995,1998)	Dreamlike cyberspace interactive environments, with non-usual interactive mechanics relying on user breathing patterns, looking orientation and a custom VR immersive device HCI. Char Davies' works feature pioneer usage of virtual reality technologies towards non-realistic depictions of external worlds, focusing instead on personal oneiric interactive spaces. Excellent groundbreaking examples of 'open labyrinths' where space continuity cannot be taken for granted as you can suddenly shift between regions upon entering selected spatial virtual regions or moments of time.
SOD Jodi (1999)	SOD by net.art pioneers duo Jodi features the modification of the Wolfenstein 3D game engine towards a disorienting and minimalist recreation of the Wolfenstein environment with sublime confusing gameplay due to colored textures and foe avatars being replaced with minimalistic black and white abstract patterns, conferring a more interesting bewildering experience, dually from heightened disarray and thwarting game mechanics. SOD www version has multiple files, for instance GAMEMAPS.WL6 is 305.3kb.
The Night Journey Bill Viola, USC Game Innovation Lab (2007 - 2018)	The Night Journey is an experimental art game conceived by Bill Viola and made with USC Game Innovation Lab. It uses an interactive non-linear confusing game space with dynamics similar to what was established by Char Davies to describe an individual's journey towards enlightenment. Players activate several game dynamics on certain regions that interactively reach different areas of their spiritual quest on the game space. Features cutting edge graphics that render a stunning immersive audiovisual environment with a beautifully architected open labyrinthine structure, though it is more machine demanding and file size extent (1Gb), it also lacks a more immersive interface to the posited virtual world, in the veins of Davies's breathing VR interface and watery virtual locomotion, or Shaw's physical stationary bicycle as a joystick for the virtual world.
k. & **k.~** & **Eer** André Sier (2007, 2010, 2011)	Precursor labyrinthine usage in the author's works, first two inspired in Kafka's The Castle, k. (2007) offers the user a simple animated avatar as a land-surveyor of a pseudo-infinite spaces, whereas like in Kafka's book, he should reach the castle, which is set at one section of a level of the full 32-bit integer random possibility space (4,294,967,296). k.~ (2010) features the first usage of the author's sonic joysticks. On Eer (2007-2011), an http/php based online metaverse, the user uses keys or webcam interface to err around the uunniivveerrssee (Sier 2011), the homonymous series' main simulation, in abstract 3d meta-spaces that gather the various users that have been online alongside generative DNA formed animated boids like teams. These rudimentary works run fine on 1Ghz computers, they were built with P5 with jar files output of around 64k, for example k_www_vs_2a_p0135.jar is 63.9kb.
levelHead Julian Oliver (2008)	Augmented reality labyrinthine work by Julian Oliver where from a seemingly small set of tabletop placed cubes, holding AR markers, augmented through a computer running his code and a camera tracking the users movements of the cube, he opens up a labyrinthine house of connected rooms in strange ways, and where you have to

manipulate the cube to tilt the character helping him to the exit of the maze like space situated as a common household. Constrained with 120 seconds to solve, each cube holds six rooms, so with three cubes there are 18 possible spaces, however the doors and teleports between the rooms increase its possible paths dramatically, which is even more heightened by the extreme time compression to solve this difficult game. levelHead's data directory holds 58.2Mb.

The Path
Tale of Tales
(2009)

Wolves and little red riding hood, whereas her path is easy this time, or is it not? You can proceed immediately towards your grandmother's house and finish the game, however without being engaged in the 'open labyrinth' set afoot in the weirding paths of the forest where the game's unfolding really takes place, engaging a more explorative labyrinthine technique into this ambient mythological videogame. The Path game size is 500Mb.

Proteus
Ed Key, David
Kanaga
(2013)

Proteus is an exploration and walking simulator video game. It allows the player to freely explore a procedurally generated environment, without predetermined goals. The world's elements of flora and fauna emit unique sounds, combinations of which cause dynamic shifts in audio and the environment, based on the player's surroundings. Proteus game size is 100Mb.

Chalkroom
Laurie Anderson
(2017)

Gamebooks re-imagined into an astounding immersive VR work, doubly immersive, either in exquisite branching narratives which occupy the full spatium of this electronic artist's hyper-fruitful career (spawning narrated songs of exquisite branching delights throughout electronic arts' media of music, visual installations, multimedia, hypermedia), as well as in a hand-drawn universe of connected rooms, "filled with dust and dirt" towards a VR which is not "perfect, slick and shiny" depiction of realism, instead, "The reason it's `chalk room' is it has a certain tactility and made-by-hand kind of thing, and it's the opposite of what virtual reality usually is, which is distant and very synthetic. (citations from Laurie Anderson Interview: A Virtual Reality of Stories, Louisiana Channel, 2017).

Horizon Zero Dawn
Guerrilla Games
(Mathijs de
Jonge director)
(2017,20)

Always nice to see someone approaching the ideas researched here, by a single artist-researcher-programmer, with their own personal artistic direction over a vast team, of which only recently the author became acquainted through YouTube walkthroughs. In Horizon Zero Dawn the plot motif for the narrative is quite similar to wolfanddotcom series, upon the merging of bio and electronic conceptual settings in exhaustingly beautiful photo-realistic entranced mythical narrative, where mecha & orga intertwine in a grand open world space modeled by humans and their structural narratives. "Experience Aloy's legendary quest to unravel the mysteries of a future Earth ruled by Machines. Use devastating tactical attacks against your prey and explore a majestic open world in this award–winning action RPG!". The videogame system requirements are ~3GHz CPU, 8Gb RAM, 100 Gb disk space.

1.3 Aspatiality, imaginary plane, quantum-now

Extensive, measurable space tangled in time, or vice-versa, lay the foundational core for the existence of experiences and beings we as humans experiment (Janiak 2022, Kant 1998, Deleuze 1969). We sense no other kind of space or time through bodies. Pre-conscious flows turmoiling before organs perceiving a field beyond our aggregate's reach (1.1.1). We are always embedded in a glade (Serres 1997), an atmosphere seemingly void at first glance, departing from our permeable infrastructure, a clearing in a forest of reality, a gaian field's grain of sand, even if it is an empty white box, it is still extensive, it has spacetime characteristics which can frame any event or thing. It's next to impossible to conceive of void space, zero, or the iteratable zenon depths it holds within (Hofstadter 1999, Ifrah 1998, Allen 1997, Aristotle 1991, Serres 1997, Struik 1989, Deleuze 1969), a zero of mathematical dimensions (0D).

0 (zero) is also the first mathematical number element to express a possible void, an empty space, a canvas. Ultimately signifying absence via its presence. Symbolizing an extent which is absent yet framed, depicting an impossibility of having a presence in a quantifiable axis from a coordinate system, other than its nil matter or duration on such axis, since it also denotes the axial origin it forges. 0 also defines the absence of an organ perceiving and inhabiting a measurable reality, or some projection of it onto what is organ sensed. A zeroth of reality, a zero reality (0R/ZR), established without a sensing machine, thus eradicating the human from its birthing entourage, towards a reality grounded without an observer-machine perceiving it, or yet, the unmeasurability of what invisible/NaN[41] is virtualized to be observed within a system's scope (Hofstadter 1999, Knuth 1968, Heisenberg 1927, Abbott 1884). Here any sensible imaginary apparatus can be inserted and function as a bridge towards other regions of a reality.

---

[41] NaN is a common computerized acronym for not a number, assigned in programming to a variable that overflows its possibility of numerical representation within the allocated scope or data type it represents (Kernighan & Ritchie 1978, Knuth 1968), a role common to both mathematical zeroes and infinities. Abbott addresses such scopes rather poetically by introducing inter-dimensional jumps (Abbott 1884), where an entity, or its dimensional projective shadow, by collapsing somehow its axial reality becomes out of scope and irrepresentable on such systems.

The mathematical zero, by representing absence within an axiable system representative of a reality, or an aspect of it, recursively establishes and grounds a projection of a reality, a window to an eye, within a system where he 0 symbolizes the idea of a nothingness, an absence. Or instead of a representation of absence, as rephrased from above, it can also denote the impossibility or interference of measurement (Heisenberg 1927), which could also be read as the kantian sublime (Kant 1998). Zero exhibits the ontological status of the landscape while saying there is no observer, standing still without saying it. It is interesting to correlate these ideas further discussed throughout with anthropological research from George Ifrah's Universal History of Numbers, as he accounts for the introduction of zero and its representation in Arabic systems. Something has to symbolize nothing, within a place-value system, a pointer to nothing (still not nothing):

Thus the dot came to be a representation of zero (particularly in the Shâradâ system of Kashmir and in the notations of Southeast Asia, which possesses the same properties as the first symbol, the little circle. See Numeral 0 (in the form of a dot) and Shûnya-bindu. This is the origin of the eastern Arabic zero in the form of a dot: when the Arabs acquired the Indian place-value system, they evidently acquired zero at the same time. This is why, in Arabic writings, sometimes the sign is given in the form of a dot, sometimes in the form of a small circle. (Ifrah 1998:510)

The anthropological mythological insertion of zero in the history of mathematics (Ifrah 1998, Struik 1989), besides a quasi untraceable meander-amalgam such as the meanings it withholds, above and below, looks at interlinking depths preoccupying philosophers, mathematicians, programmers, scientists and artists throughout millennia, and we reassure the reader that the thought-lines herein provided have no pretension to connect the alpha to the omega, or by deriving infinities from negative zeroes (Xenakis 1992).

However, and instead of merely preoccupying with a technical VR that is concerned with the virtualization of a human photographic projection, or simulation, or immersion onto a representation of it, here we are overflowed with a philosophical reading of a

deleuzian virtual reality capable of axializing the rare and unrepeatable ilinxian ritualistic moments where difference and growth takes place (Deleuze 1980, 1969). A virtual reality (VR), a zero reality (0D/ZR), that was already referred by Sutherland as the possibility of a looking glass to a mathematical wonderland (Sutherland 1965). A shareable osmotic plane occupying other regions of electromagnetic spectral radiation intervals, or even logical, absurd, abstract and truly conrète representations, simulations, depictions. Speculating a bit further, what kind of future does BCI withhold into these mille et un plateaus[42]?

In order to distinguish realities a mechanism is able to perceive, we need words to think of spaces that are observed without an origin, but with a 0, without observer, casting aside its weight, its infrastructure that back propagates and cascades across the entire system it outputs and limitedly perceives. This is why, as a first step, zero reality (0R/ZR) is concerned with non-human apparatus of sensing and the imaginative virtual power of the mythological: contrasting differences underline mapless grounds.

Returning to the extensive space denoting a field beyond our sensing abilities reach, a void of space as we are able to conceive, yet molecular space, or Capra's cosmic space, or mathematical space seen through the eyes of Deleuze and Xenakis, any kind of space which exceeds our natural apprehension mechanism is overlooked by our abilities to perceive it (Kant 2001, Hofstadter 1999, Xenakis 1992, 1985, Capra 1975, Deleuze 1969). Adding to the above, rules from physics known to this day differ in very tiny or very large spaces (Hawking 1988, Schrödinger 1967, 1926). For example, gravity, blackholes, time-space, experienced on the surface of the earth at a human scale are largely distinct from the same concepts at a cosmic or even molecular levels. Related, how would we add tangibility and extensiveness to imaginary spaces? How can we axialize a profound, latent, ever looming virtual reality which is able to conceive such spaces?

In the context of this inquiry, these could be twofold. On the zero hand, imaginary spaces built by a human mind, i.e. devices programmed for sense synthesis capable of providing experienceable views apprehended/formulated from the amalgam of insights within the omni-present virtual plane of the actuality of the human (Deleuze 1969). On the

---

[42]   A word play game, intersecting Deleuze and Guattari's Mille Plateaux with the Arabian 1001 nights.

one hand, similar formalized procedures borrowed from the mathematics, as Deleuze and Xenakis engage (Xenakis 1992, 1985, Deleuze 1969), which could also be considered by the simpler example of how the complex plane in mathematics, made by a conjugation of real and imaginary numbers suddenly bursts into reality, axialized to form a special imaginary orthogonal plane, from where we derive multiple essential mathematics (FFT or general spectral analysis for instance, Roads 1996, Proakis & Manolakis 1996) quite helpful to solve everyday physical problems (Struik 1989, Abbott 1884).

There are also other possibilities of spaces. From simulacra and simulations (Baudrillard 1981) to undressed political pyramids (Serres 1997). Nevertheless lets focus on non-places (Augé 1995): *an ever increasing proportion of our lives is spent in supermarkets, airports and hotels, on motorways or in front of TVs, computers and cash machines...* Non-places however are distinct from no-places, or aspaces, to follow in the footsteps of the proposed aspatiality concept, which relates to the spatial characteristics of the before mentioned struct series (Sier 2000-). Common to both aspatiality and non-places is the establishment of irrelevant physical extensiveness on so called reality due to physical space's purpose or characteristics being directed at effecting the means to be elsewhere. An operative transport takes place which provides immersion in a more appealing virtual, endowed by the substract. However they differ in the sense that aspatiality's focus points to a zero of extensive space – no space, aspace – yet capable of providing means to positively and cathartically engage otherness virtual realities. While non-places are emergent on the human from ennui, and free negative undirected mind wandering upon full boredom (one could think Kirkegaard). In this aspace any distinct and unique configuration of matter elements can be aggregated into extensive shapes that come into (virtual but in reality) existence from a void. Aspatiality tends to an actual zeroth extensive space, though never fully reached, never free of referent, resilient actual origins, from where, as wide as open as possible, any virtual, more than simulation, more than illusion, can execute, can become. A( )place for 0R/ZR. An extensive near nothing which houses the infinitude. It is a concept inspired by Jorge Luis Borges' Aleph:

> *On the back part of the step, toward the right, I saw a small iridescent sphere of almost unbearable brilliance. At first I thought it was revolving; then I realised that this movement was an illusion created by the dizzying world it bounded. The Aleph's*

diameter was probably little more than an inch, but all space was there, actual and undiminished. Each thing (a mirror's face, let us say) was infinite things, since I distinctly saw it from every angle of the universe. I saw the teeming sea; I saw daybreak and nightfall; I saw the multitudes of America; I saw a silvery cobweb in the center of a black pyramid; I saw a splintered labyrinth (it was London); I saw, close up, unending eyes watching themselves in me as in a mirror; I saw all the mirrors on earth and none of them reflected me; […] I saw the Aleph from every point and angle, and in the Aleph I saw the earth and in the earth the Aleph and in the Aleph the earth; I saw my own face and my own bowels; I saw your face; and I felt dizzy and wept, for my eyes had seen that secret and conjectured object whose name is common to all men but which no man has looked upon — the unimaginable universe. (Borges 1998:646)

Similarly to space, time is a fundamental category by which phenomena are experienced. But the time of entangled loops on hierarchical systems, the time of the substrate of the human mechanics of apprehension, the time of pre-conscious human flows where sense data turmoils and gladiates for consciousness control has peculiar characteristics when it is observed, if possible to observe (Heisenberg), at a granular microscopic level (Deleuze, Xenakis). This time which houses numerous systemic flows, advent of overwhelming forces and intentions of humans in a pre-conscious state is similar to a space that can harbor infinitude of spaces. In its essence, it is similar to what Deleuze defines as crystal-image (Deleuze 1983) when theorizing about cinema and moving images: a representation of the splitting of time, the movement of past and present reflected through these images. He states that cinema does not just present images, it surrounds them with a world. Any individual picture frame holds invisible links to all the past frames, as well as all the subjectivity evoked by what is and what is not shown on the images. A crystal through which the stratified layers and points of view gain shattered and fractal visibility. Similarly to how a still image can withhold such entranced entanglement, capable from its stillness to summarize an eternity, exemplified through a mathematical reading of Tarkovsky's still image on figure 9 being capable of a symbolic, mathematical and spiritual gaian reading.

Looking this close on time, there are inevitable links to the quantum physics world. In quantum mechanics, the analogue of Newton's laws, which are sufficient in describing natural systems at human scales, is the Schrödinger equation for a quantum system. This is the world of atoms, molecules, and subatomic particles, whether free, or bound in aggregates, which the Schrödinger equation attempts to describe precisely. It is not a simple algebraic equation, but in general, a linear partial differential equation, describing the time-evolution of the system's wave function (Schrödinger 1926). Quantum-now applies in time what Schrödinger and Deleuze evidence, where any instant is a tendentiously a zeroth derivative of the time continuum that is flowing, like performed earlier for the aspatial domain. Here, the sampled instant, the picture frame, according to the sampling device's precision, contains within the actuality of the event the full or partial spectrum of possibilities attached to it, much like a Deleuzian crystal-image, inter-linked to all past and future from its anchored moment of nearly stopped time.

There are also resounding similarities to the structure of how Bach edifies and performs a fugue, departing from a motif, cascading voices which sample and rework the theme, or Xenakis' preoccupation with continuity and hors-temp, layering seen scope of possibilities of musical topologies from outside of time which are actualized in the now of the work score's instant to orchestrate a certain mode of being, or a fleeting feeling, a musical idea. Or how we humans read books, grasping ideas, following words in linear fashion to understand a meaning. But in its essence, the reading act, at a subliminal near instant level, is a non-linear sequential fractal reading, where one jumps across, cuts, blends, mixes, reverberates, hears two or more voices at different speeds. This is related to how the virtual is always driving and shaping the actual on the human, and no objective exterior experience can be obtained without the mark of the observer's machine sampling it.

This elusive structure, in the aspatiality and quantum-now of the void, when reflected through a void, besides unveiling an apparently infinity of possibilities, overwhelmingly sculpts the perceptive machine of the one that observes and lives and interferes within the field. Like Xenakis' ontology of an immaculate synthesis, on their two appearances at *Formalized Music* (1992), main unresolved interesting differences, is it nil, or negative time?

Ontology

In a Universe of nothingness. A brief train of waves, so brief that its beginning and end coincide (negative time), disengaging itself endlessly.

Nothingness resorbs, creates.

It engenders being.

(Xenakis 1992:24)

Ontology:

In a Universe of Void. A brief train of waves, so brief that its beginning and end coincide (nil Time), perpetually triggering off.

Nothingness resorbs, creates.

It is the generator of Being.

(Xenakis 1992:260)

1.4 Imaginary art, zenospace, panvision

The following synthesizes succinct and noteworthy aspects of the line of reasoning followed thus far within the established context (mainly at 0.2 & 1.1.x), and proposes highlighting under the umbrella terms of imaginary art, zenospace and panvision (adding up to the already discussed terms of gaian field, aspatiality, zero reality and quantum-now at 1.1.1 & 1.3) relevant contributions the wolfanddotcom investigation proposes as to how to tackle conceptually and produce artifacts upon human out of bounds regions. As the cyber-environments are being programmed during the research, the need arose to originate words to circumscribe the regions of interest being addressed. The key terms purpose is to solidify initial research aspects that these and future works investigate on. The words represent fuzzy new areas worthy of investigation, already flourishing on glades made by the secular forest of concepts that have built these sorts of immersive technologies and entangled bio-electronic communication: cybernetic assemblages coupled in symbiotic systems adhering to users, and their ilinxian repercussions on the human plane, at physiological and psychological levels.

Imaginary art (IA) is a term brought forward from previous and precursor aesthetic movements. Escher's game osmotic shifting drawings, Davies' ephemeral landscapes, Novak's liquid architectures, Viola's mechanics of enlightenment, Cage's and Eno's imaginary landscapes, Tarkovsky's spiritual zero on room zero, Bach's fugues, Burroughs' naked lunch, Kandinsky's abstract gardening, Fuller and Wright's gaian management, Xenaki's laser and sonic space-time continuums, Carmack's immersive fast-paced raymarching, many attractive mathematical fractal automata genetic arts contributing to AL, many humans, non-humans and AIs within neural networks (NN) dreaming IAs.

The notion of IA and its field of interest can be seen as a tool to posit imaginary worlds. The proposed tangible imaginary constructs address a combination of imaginary aspaces built by a human mind utilizing what could be described as mythological functions coupled to non-human expansion, in order to further enlarge the scope of operations already seen within traditionally millennial examples of humans (inter-)communication

with the unknown, with the earth-mother, freely non-spaced ennui, or directed aspaced. Mythological functions which roam free or targeted to operate on all which is known by the amind. These functions are performed by a human mind embedded on its infra-structural plateau, a body where pre-conscious flows consisting of sense datum and bodily/organ functions storm, where they gladiate for consciousness control, guiding and changing the actual on the human with its ever present driving virtual plane (Deleuze 1985).

Imaginary art (IA) puts forth outcomes derived from abstract expressions, from concrète unpredictable combinations of elemental traits, from mathematical algorithms, but most particularly by special operators that engage strange loops, divide by zero, overflow numerical precision with nans. Zeno and Gödel shatter strongholds with weirding operators, temporarily adhering to the systems rules by being numerically represented within their axis, engage thus in operations that entirely collapse the edified structures and open windows to out-of-bounds regions (Hofstadter 1999, Abbott 1884).

IA can also be traced etymologically from the musical works *Imaginary Landscapes*[43] by John Cage (1939-52), as well as being the same term Eno utilizes to describe familiar yet unknown places (Eno 1989). Other contemporary works already seen on this document also fit this leitmotif and are good examples of imaginary arts. Unrolling some of the above, for instance, Viola's and the Game Innovation Lab's meditative and spiritual videogame Night Journey (2007-2018), or Char Davies's onyrical virtual landscapes of ephemeral embrace[44] Osmose (1995) and Ephemère (1998). These works in turn can be read as to having their roots in arts explored by Escher (Hofstadter 1979), while addressing drawn logical error games that provide osmotic jumps of reasoning and play in his work, where background fields foreground indistinguishably. Or through abstract works engaging a space devoid of previous formulations objectified by the real world, attempting to derive fully synthesized abstract worlds, as pioneered and explored by Kandinsky (1911) on a visual realm. As Iannis Xenakis (1968) on a sonic and architectural realm, composer, architect and mathematician introducing abstract stochastic mathematical reasoning (ST),

---

43   Imaginary landscapes is both the title of an electronic music synthesis series of works by John Cage (Imaginary Landscape #1 in 1939, Imaginary Landscape #5 in 1952), and the title of a concept put forward by Brian Eno to describe music targeted at places you have the feeling of already having been there before, written in 1989.

44   This expression is borrowed from already mentioned Char Davies's PhD thesis titled "Landscapes of Ephemeral Embrace: A Painters Exploration of Immersive Virtual Space as a Medium for Transforming Perception". See footnote 17.

game theory and synthesis both to compositions and architectures. All these artists innovated by taking distinct and synthetic based approaches towards regions unheard of in social reality within their context, working from the purely abstract, conceptual, mathematical, spiritual, natural, to concrete methods, sampling themselves towards a similar outcome: engage the listener / viewer / participant of the work, let them focus and immerse through their works in the experience of situations combining simultaneously, within an intricate balance, recursive resemblance and unfamiliarity, self-referentiality, thus evolving unique languages capable of human out of bounds synthesis (non-human realms).

Zenospace rose out of the need to address a deeper meander while fortifying an aesthetical mathematical upbringing in following the thesis main goal of human detachment from the infra-structural human plateau towards non-human embodiment. Zenospace becomes a placeholder axial system for zero reality (0R/ZR) where mythical functions and organisms other than human could expand their systems. A systemic godelian operator (Hofstadter 1999), a kerényian functor (Kerényi 1963). Similarly to how Zeno carves logical koans, condensed paradoxes, which from a seemingly nothing evidence or collapse the entire infrastructure of the perceiving organism, that can also be seen as conundrums probing the stability of the mathematical building / perceiving organism; similarly to how the mathematical complex plane of imaginary numbers emerges, essential for signal spectral analysis and electromagnetic communication, for instance, it is born out of the impossibility of the square root of a number being negative one (i) ; from the self-referentiality of chaotic and fractal algorithms, that subsist and insist at the mathematical place only with recursive previous traces of their prior state(s); as the pre-socratic sage Thales of Miletus, that operates a strange loop, simultaneously falling in the hole and ascending to the stars; as with the deleuzian ontology, which breaches the self delineation and simultaneously defines it within the perpetual cycle of transgressing the porous identity limits.

Zenospace proposes a formalization of an imaginary system for imaginary arts (IA) where the human amind, which conceives aesthetic, scientific and mathematical places but also contaminates its infrastructure repercuted at all system levels, and that new ilinxian human out of bounds regions are accessible through strange loops, by establishing and

applying similar to human mechanics of understanding and of building alternate realities, however now departing from non-human bio-electronic models. By devising constructs that emulate such otherness mechanics and are passible of directing immersive experiences in feasible simulations or alter mechanics corresponding to what is not human, to what is imaginary or mythological, now submerging out of bounds experimentation through most vivid experiences.

Panvision foresights other than human sensitive experiences in a triple metaphorical connotation, by supplying the means to apply zenospace functions towards imaginary arts, proponent of aspatial constructs aiming to eradicate an anthropomorphic infrastructural departing hangar concerning a gaian field's cosmic unison. The triple connotations addressed by panvision in light of these insights consist of: the eyes of Peter Pan flying non-linearly over ground level mythological landscapes. Non-human sensitive experiences, departing from an anthropocentric view towards a pandemonium of biological, electronic, and bio-electronic aggregates. The word's third overtone as inspired in technological camera devices that have established means for a cinematic art form at the dawn of the 20th century, but now at the first quarter of the 21st century, can be made by means of software, hardware or bioware, zenoware, zooming kerényian functors and godelian operators into zenospace from amind accessing human out of bounds regions providing footage material for zenospace directors.

1.5 Scientific collaboration

After building one of the central experience videogame spaces, homonymous with the series title (Wolfanddotcom 2017), the author contacted two scientific wolf research institutes in Portugal, as already mentioned upon ethical issues at 0.4. The first scientific group, Grupo Lobo has iberian wolf preservation and recovering facilities (CRLI) located in a natural valley near Tapada de Mafra, a natural reserve area near the coastal center of the country. The recovery center has fences surrounding hectare large sections where the Group isolates, recovers and shelters endangered wolves found in the wild. CIBIO is located in Vairão, near Porto, and near to the area the few remaining animals are most frequently sighted, whereabouts researchers study them.

Observing the more practical collaboration with Grupo Lobo headed by Professor Francisco Petrucci-Fonseca, which also includes the mentioned production of two artistic works, Totem-Lobo #1 & Wolfmachine. The first work consists of a totemic 2.5m high wireframe sculpture of a wolf, structurally made with metal covered with cane outer shell lines, punctuated with a small bio-electronic ecosystem installed on its structure (Totem-Lobo #1, 2021); the second work, which involves interaction among living wolves, non-human ecosystems and electronic installations (Wolfmachine 2020-22), is an electronic system deployed on the landscape surrounding the wolves' habitat at their reserve, as a bio-electronic work drawn and designed for wolves: portable, hand-sized pan and tilt robotic machines, that emit a thick green laser beam, are synchronized to broadcast 5 laser beams, which are orchestrated and composed to pulsate the light beam and hemispherically move the laser towards the sky, the horizon, within safety regions, and each laser moves according to the numbers related to the wolf presence throughout Portugal during the entire XXth century. Each electronic laser lighthouse moves according to the historical wolf presence within its municipality in the country (5 regions: north, center, south, coastal and interior), and this data of wolf sightings and encounters in the country is used to algorithmically control the patterns pulsated to the wolves for 25 minutes, where each decade is assigned to a 2.5 minute time interval. Further description of these works are included in chapter 2.

At CIBIO, a northern Portugal biological research institute also with scientists actively monitoring wolves in the wild, the biologists insert GPS collars on some wolf pack members, performing visits to the animals in their small natural habitat through field trips in the areas they still inhabit, and monitor their activities remotely with non-invasive methods that otherwise would involve contact with humans. The collaboration with a small research team headed by Professor Francisco Álvares, CIBIO's investigator and scientific coordinator of the iberian wolf population monitoring projects, involved scientific expertise consulting and permission rights to use the logged GPS data from their own research. This observation technique is focused on how wolves occupy and travel through space, once natural, now often human, how these animals construct their own usage of space, how they territorialize. Besides matching their dynamics against the location data of the virtual wolves' artificial intelligence conjured up for the Wolfanddotcom 2017 videogame, the author also began constructing a 3D visualization and sculpture making app, designed for interaction with tablet devices (Wolfspace 2019). The app recreates in structural 3D graphics the wolf paths, made by voxelizing the GPS data over time through a marching cubes algorithm. The wolf paths become lines of virtual territory occupation, and accumulated over time, the space inhabited by these sample wolves augmented with GPS collars becomes a representation of their wolf space, the factual portions of the wolf-territory, as its being made by wolves in a non-human landscape (further discussion of Wolfspace in chapter 2).

While forwarding the research on non-human animal made paths the author was led to work with ants, after a summer of analyzing and artistically documenting their behavior. He started experimenting with low powered laser light sources (considered safe for these animals, lights consist of low power 5ma green lasers) and empirically discovered it has an impact on ants: they stop what they are doing and try to grasp the laser light. Through their antennae movements, the closest members to the radiation stimulus communicate across nearer colony citizens, probably also mark with special pheromones (untested/unobserved), though the laser stimulus clearly backpropagates in rythmic communications across the hive via simple bio-electronic communication. When the author discovered this behavior, an immediate prompt led him to use it artistically for the research, to try to derive a non-human spatial structure model intended for non-human labyrinth formation techniques, which were used in the immersive virtual reality

videogame work 0X Labyrinth (2020 version), alongside with other non-human labyrinth formation, as furthered discussed in the article "Non-human labyrinths: Roots and additional other than human formation methods" (Sier 2019) published during research. This led him to try to superimpose electronic maze like image patterns on actual anthills. In order to construct it safely, he collaborated with ants' specialist Eduardo Sequeira, a biologist and a very keen expert on ants, besides teaching how to source ants and how to look for queens, sterilize, if required, the local gravel where they are captured. The Ant Ennae Labyrinths project consists of a vertical slice of an anthill augmented with rhythmic laser stimulus. In his first project working with ants, though they performed a special appearance at Babylon's coin machine install at XXth Bienal de Cerveira, approximately 50 ants are enclosed within an acrylic structure filled ¾ with bare and decontaminated earth, they have access to food and water, they are sometimes augmented with the laser interaction situation, during exhibition settings and at home, where a machine is projecting pulsating laser patterns according to maze designs interfered by electronic processes, and have ants build and fabricating a non-human electronic interfered space. This work, from 2019, was titled Ant Ennae Labyrinths and is further documented on chapter 2.

The author's bio-electronic work shift to interactions with non-human entities took place with Half-Plant (2017). In this work, further documented at chapter 2, a small computer-plant ecosystem open to networked smart device app human interaction, has an Arduino[45] firmware that is sensing mA electrical flows of voltages in six distinct sampling channels and points of contact with the plant through piezo-electric sensors, metallic clamps, or simply piercing conductive metal, and sending this raw sensor data flow, now digitized, to be further combined in the computer with electronic microscopic readings of the electronic self-information present in the computer machine that is acquiring the data. This electronic source data, the byte sequences from programs and files that inhabit the computer ecosystem, was the precursor element into bringing the source procedure of sampling and analyzing non-human data, and visualize it as material virtual space, as images, as sounds. This procedure was further amplified with sampling and digitizing raw analog voltage information present in all living biological aggregates in additional selected

---

[45] The Arduino platform is an ambitious open source electronic computation project to universalize and simplify the creation of electronic systems that can read and write to the exterior analogue world. It was brought forward in the veins of Processing, a precursor program written by artists, for artists, which has come to simplify across platforms the expression and creation of coding artifacts which make full use of a computing machine potential.

elements. The electronics source procedure is already present as non-human electronic only architectural elements, sonic and texture basis elements, from which are derived the spatial, musical, structural aspects of the ambients in the videogames Wolfanddotcom (2017) and 0X Labyrinth (2020); the sculptures series (Binary Sculptures 2017, Biological Sculptures 2018), and the drawing series (Neon Paleolitikos Drawings 2017, BIND and BIOD 2018).

Half-Plant (2017), 8-bit Maze Gardens (2018), Ant Ennae Labyrinth (2019), Half-Ant (2020), Bioscope #1 (2020), Wolfmachine (2021), Biowolf (2021), described at chapter 2, are works which combine creative aesthetic research onto primer bio-electronic aggregates research, with laboratorial situations where biological living systems communicate with electronic systems, ranging from the usage of plants in Half-Plant, 8-bit Maze Gardens and Biowolf; the usage of ant colonies, in Ant Ennae Labyrinth and Half-Ant; the usage of bacteria in Bioscope #1; and the usage of wolves in Wolfmachine.

2. Wolfanddotcom series of works

As previously expanded (chapters 0 and 1), in parallel with pinpointing new areas of knowledge in interactive electronic arts, which involves flowering artistic, theoretical and engineering knowledge in non-realistic/imaginary representations of cyberspace, the practice-based research undertaken has been focused in creating artistic constructs emerging from the practice, in the form of interactive and playful experiences coupled with objects, namely mythological videogames, bio-electronic installations, static art-sci constructs. These artifacts are entwined with the main cyber-environments, in the form of 3D sculptures, drawings, photographs, videos, and organic paintings. This creative practice, rooted and evolved from active electronic artistic endeavors since 1997, is grouped and serialized under an inquiry that grounded the thesis' title. The core work within the PhD program consists on the elaboration of several artworks within the wolfanddotcom series, each one focusing a specific query actualized as an interactive installation or as an artistic object. Originating from the artworks, a framework is proposed addressing the innovative relationships between the imaginary arts, the non-human and the playful mythological fields.

The wolfanddotcom series is bestowed as an aesthetic ethos and research line of inquiry into the imaginary combination of raw animality and void cyberspace, set in an imaginary new post-Anthropocene epoch titled neon paleolitikos, fusing mankind's neon technological apex with the non-human coming of age, dating since the decline of mankind until the zenith of new bio-electronic life-forms.

The artworks created during the research are computational based works that involve various arts (painting, sculpture, literature, music, cinema, videogames, technoetics), sciences (philosophy, mathematics, biology, ecology, mythology) and engineering (informatic computation, electronic circuitry, machinic fabrication, electro-technical and systems programming). They are based on processual rules which are executing algorithms and shaping ethereal procedures into an actualization, into a form. Engendered forms which are undefined a priori, which depart from generative prototypes into the algorithms' and user interaction output scope variety. Unlike pre-electronic and pre-digital arts, where

there is always a final finished product, generative computational works – inhabited by lines of code, computational processes and here, in this research, with data converted in-between representations and sampling in a post-anthropocentric and symbiotic world, between the natural biology and the artificial, synthetic nature of machines – can also change according to the performance of their users, who can alter the course of narratives, the immersive audiovisual ambiance, or the aesthetic forms they perceive and embody.

The author does not sculpt all landscapes or all their inhabitants, he only casts the rules that frame the works' world, that regulate the emergence of phenomena, landscapes and the creatures that inhabit and move in them, resorting to algorithmic procedures (ST, CA, DNA, NN, AI), in the case of purely digitally generated ecosystems, added here with non-human mechanic scenarios, which combined, researched and explored, become primers towards artificial life (AL). Thus, at each moment, the principle of the existence of each work resides in generative computational commands, or the sampling of the electronic and non-human realms, without fixed spaces or defined times, which were designed, programmed and written, step by step, by its authors, but whose final, cognitive and sensorial condition, is solely dependent on the unfolding of the algorithmical spatium combined with non-human mecha alloyed with the involvement and embodiment of its users.

This chapter will describe and analyse, as deeply and extensively as appropriate, a representative selection of works in the wolfanddotcom series. The chapter builds from the previous reading established at 0.3.x, 1.x and is structured as much as possible in parallel with tables W0 and W1 that succinctly summarize the works developed thus far: the eleven dynamic art-science works are grouped in table W0 by type of interaction bridge ((non)human) user-artwork; in table W1, the twenty one static art-science constructs are distributed by the defining cyber-environment(s) groups. Both tables show the artworks chronologically ordered by years of creation within the respective group.

Since the more complex dynamic open works share methods of construction and composition, particular emphasis will be placed on Draco.Wolfanddotcom.Info (2015), the first mythological videogame space in the series, as well as on the labyrinthine opus, more

specifically on 0X Labyrinth (2018-2022), the extended VR opus focusing a labyrinthine resonating theme across the series. Similar emphasis will fall on Half-Plant (2017), the first dynamic art-science work of bio-electronic aggregates and one of the most representative aesthetic case examples of bio-electronic installations created within the wolfanddotcom series. The main focus on static artworks will be placed in characterizing their form and relation to the dynamic creations they are derivative of. The intention is to make an extended ligature from the knowledge already shared in the previous chapters onto the more aesthetic and technical aspects guiding the creation of these works. For these and each of the other works, a brief description will also be made and representative images will be shown, to allow glimpsing all the works within this document.

Table W0 – Wolfanddotcom's cyber-environments

Type	
Title (year)	User-interaction (human/nonhuman) bridge

Mythological videogames	
Draco.Wolfanddotcom.Info (2015)	Flying gestures. Computer vision from camera.
Wolfanddotcom (2017)	Wolf-sculpture-joysticks. Networked smartdevice joystick app.
Phoenix.Wolfanddotcom.Info (2017)	Flying gestures. Computer vision from camera.
0X Labyrinth (2018-22)	VR sculpture mask. Sound and VR gaze.

Bio-electronic aggregates	
Half-Plant (2017)	Networked smart device joystick app. Sensors, sound speakers attached to plants.
Ant Ennae Labyrinths (2019)	Laser beam rhythmically composed for ants ecosystem. Joystick connected to laser.
Honey Krater (2019)	Touch interactive. Laser and sound on growing biologic material. (Smartphone, woofer, honey, laser)
Half-Ant (2020)	Cellular automata visuals on a screen grounding ants ecosystem.
Wolfspace (2019-22)	Smartdevice app touch interface. GPS collar and historical geolocalized portuguese wolf data.
Bioscope #1 (2020)	Laser projection through biological lenses. Human computer-vision floor interface.
Wolfmachine (2020-22)	Portable, hand-sized pan and tilt robotic machines that emit a thick green laser beam for wolves and non-human ecosystems.

Table W1 – Wolfanddotcom's static art-sci constructs

Title (year, ascending)	Type	Defining cyber-environment group(s)
Labyrinth Drawing Games (2011-)	Drawings, pen & paper game	0X Labyrinth
Neon Paleolitikos Drawings (2017-)	Plotter drawings	Wolfanddotcom, Draco, Phoenix
Wolfanddotcom Drawings (2017)	Plotter drawings	Wolfanddotcom
Wolf-Totems (2017)	3D printed sculptures	Wolfanddotcom
Binary Sculptures Series (2017-)	3D printed sculptures	Half-Plant, Wolfanddotcom
Biological Sculptures Series (2017-)	3D printed sculptures	Half-Plant
8-bit Maze Gardens (2018-)	Vegetable paintings	0X Labyrinth, Half-Plant
Eusocial (2018-)	Photographs	Ant Ennae Labyrinths, Half-Ant
MetaPh (2018-)	Photographs	0X Labyrinth, Ant Ennae Labyrinths
Ant i Purga (2019)	Drawings on photos	Ant Ennae Labyrinths, Half-Ant
Ant Ennae Videos (2019)	Video	Ant Ennae Labyrinths, Half-Ant
An Observer ToL (2019)	Video	Ant Ennae Labyrinths, Half-Ant
BIOD (2019-)	Plotter drawings	Half-Plant
BIND (2019-)	Plotter drawings	Half-Plant, Wolfanddotcom
Labyrinth Players (EA) (2019)	3D printed sculptures	0X Labyrinth
Wolfspace Sculptures (2019-)	3D printed sculptures	Wolfspace
Last Dragonfly (2021)	Drawings on photos	Draco, Phoenix, Wolfanddotcom
Biowolf 218 (2021)	Vegetable painting	Wolfanddotcom
Totem-Lobo #1 (2021)	Totemic sculpture	Wolfanddotcom
Bio-Electronic Wolf (2021)	Bio-electronic sculpture	Wolfanddotcom
Wolfmachine Video (2020-22), 0X Labyrinth (video #10.780361) (2020), Wolfanddotcom Video (2019)	Video	Wolfmachine, 0X Labyrinth, Wolfanddotcom

2.1 Cyber-environments

Following 1.1.5, the wolfanddotcom series, named after a creative combination of animality entwined with cyberspace, seeks to create experiences which expand human-body perception and consciousness by inducing a shift onto other species/bodies, by playfully inciting ilinx (Caillois 1990), via altering and disrupting the perception of self, mediated through technology, algorithms, and custom human-computer interfaces (ranging from physical computation objects, to computer vision or sound based navigation and network interactions), or different sorts of communication and experimentation channels – electronic, electrical, algorithmic, mathematical, musical, graphical – in the biological and electronic domains, in the creation of seed structures coupled to ecosystems that evidence several lattices into new bio-electronic worlds.

Wolfanddotcom's technological immersive cyber-environments provide fertile ground for research in the interactive arts of otherness embodiment. In the footsteps of the trail initiated at 1.1.1, this is a possible touchstone in consciousness research where humans express their identity deeper upon crossing a bridge into mind states where the intensification of forces builds space for a glade. In the glade, apparently anything can be constructed, imagined, touched and even inhabited (Manovich 2001, Serres 1997, Deleuze 1969). These cyber-environments thus become laboratories which operate as practical means of immersion of animal embodiment and a locus for study of human behavior. By forging a sense of otherness in the self, deepened into almost inhabiting other species, human users become more aware of their environment and active listeners of their and of other lifeforms surroundings. Gifted with new senses, the player is now extended, transported inside the experience. Ready player Zeno[46].

---

[46] An elaborate concise pun summing the above established thus far, Ready player Zeno alludes on the number Zero (1.3), Zeno (1.2, 1.4), and Spielberg's movie Ready Player One (2018) about a worldwide VR game. For Deleuze, and Zeno, there can be no identity, no number one, one always recursively fails to attain it. Whether from ontologically defining identity (1) as the breaching process that leads to it, or from endlessly stating one can never reach destination due to logic endless branching. And to explore this active incompleteness which perpetuates spiritual longing, Deleuze's virtual plane implementation and otherness embodiment through perception disruption (Caillois' ilinx), is what the creation of wolfanddotcom works is about, setting grounds for a zero reality (0R/ZR), aspatially eradicating the human from its birthing entourage in the quantum-now of an imaginary plane actualized through aleph like devices (Borges 1998, 1974).

2.1.1 Let there be dragons (Draco.Wolfanddotcom.Info)

Draco.Wolfanddotcom.Info, one of the dynamic art-sci works produced within the wolfanddotcom series (Sier 2011-), is the first that investigates immersive interactive electronic pathways as bridges to non-human otherness and embodiment (Sier 2017). It is an interactive proto-videogame installation that immerses users in a cathartic, stochastic, full body immersive videogame experience in cyberspace, personified as abstract dragons.

Figure 150, 151: *Draco.Wolfanddotcom.Info* (2015) & *Skate.Exe* (2014), awarded immersive installations Skates & Dragons, Lisbon's Maker Faire at Centro Ciência Viva, 2016, Lisboa,

Dragons, as legendary millennial creatures that have a special fantastic place in human consciousness from tender ages, are usually associated to ancient, inexistent, malevolent or benevolent beasts of thunderous might. As an integral part of magical folk tales and myths, they are gifted with special powers, mixing real animal abilities onto surreal combinations of awe or fright, with uncountable occurrences throughout folk tales, literature, animation, videogames, toys, even art. By inhabiting the mythical plateau throughout millennia, with roots in known ancient European and Asian folklore, they provide good example touchstones for subliminal consciousness bridges into mind regions where illusions, imaginary magical constructs, have room for blooming, blossoming and tangible concreteness. Even though their actual ancient animal existence as retold through collective mankind's history remains uncertain and most likely false, dragons' existence in mankind's global mind space is true. Dragons' presence in humanity's mindscape provide concrete imaginary grounds where the mind can run free fostering illusions, feeding on imaginary mythical material, awe-able known animal creative combinations, unheard of possible movements.

This reasoning is extended to other cyber-environments and mythological videogames in the series, the dragons, phoenixes, minotaurs, as well as to other more recognizable non-human subjects, such as plants, ants, wolves, bacteria. Immersion pointing in these directions adheres to thesis' general objectives G3 & G4, intertwined into proposing suitable life forms cognitive systems to engage ilinxian games experiences, where a category of safe ilinxian experiences emerges, contrasting with dangerous categories, going too far out of bounds. This is perhaps why in the electronic kingdom current kernels of GNU/Linux systems implement policies where programs are constrained to explore the regions of RAM they request. If granted, the program can utilize the portion of executable memory provided by the infra-structure of the machine as well as the kernel code running on top of it. This safety mechanism is essential in order to prevent other programs, that could be malicious, from jumping out of bounds into other processes/programs allocated memories and infrastructural mechanisms, which allows for a well crafted malicious program to privilege escalate (also zero day exploits and similar procedures).

The spark of dragons' and other mythological creatures' existence – even if imaginary – lights up torches through bridges in consciousness which lead into mind regions that operate as never empty glades (Serres 1997). Here, the psyche is free to wander, construct and touch eery or awe-able animal combinations in the fantasy realm. When reaching these consciousness glades we glare and even touch illusion, i.e., "the ability to interact with a representation" (Manovich 2001:177). Illusions may also be intensified beyond interacting with representations into otherness embodiment, which expand the self and feedback on the (non-)human, giving rise to a turmoil of sub-consciousness intensification of granular forces, that better draw and actualize its own boundaries and becomings. When the consciousness glades go deep in the psyche engagement towards unexplored regions and modes of being, which profoundly shift our regular patterns of reality apprehension, it is then not only a question of interacting with a representation, but when the transport through these bridges is fully effective and immersive, it is now a question of becoming the representation, of inhabiting and of becoming the illusion. Deleuze synthesized becomings to illustrate the above (also 1.1.1) as deterritorializing ontological movements in the image of the mythological Dogon as an egg, with its distribution of intensities (Deleuze & Guattari 1980).
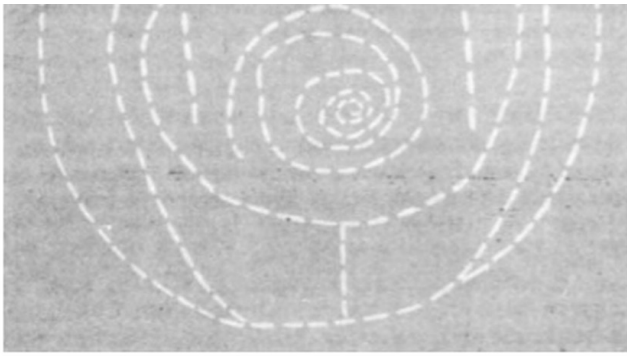
The Dogon Egg and the Distribution of Intensities
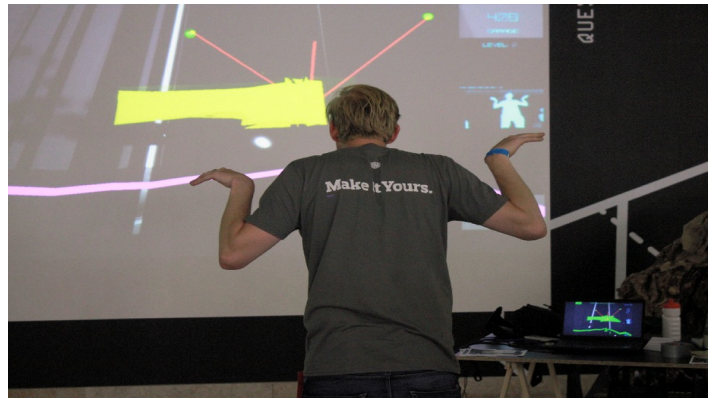
Figure 152, 153: The mythological Dogon Egg, with its intensity lines of becomings and deterritorializing, as Deleuze & Guattari put forth on *Mille Plateaux* p.837, contrasting with a user of Draco.Wolfanddotcom.Info (ibid figures 149, 150).

The shift sought into this non-human otherness is both corporeal and ethereal. Corporeal with a simultaneous sense of briefly altering normal movement and known perception into new ways of sensing and new ways of locomotion, of movement (such as safe ilinxian examples of spinning, surfing, roller coaster, water parks, zero gravity, contrasting like night and day to the Volador example provided by Caillois, russian roulete, gigantic wave surfing); through these means the mind disrupts its normal perception, which can be intensified into almost becoming another entity. Ethereal, as it is still only a brief and delicate fabrication of the consciousness facilitated through ilinxian devices; ethereal as an alter experience which captivates profoundly our psyche into this otherness, it also dissipates easily in thin air as the target illusion image ceases to appeal, when its fascination and luring properties are somewhat lost, when the bridge collapses and we return to the body. Huizinga also addresses these becomings as a mystic unity of human and non-humanness:

> *The identity, the essential oneness of the two goes far deeper than the correspondence between a substance and its symbolic image. It is a mystic unity. The one has become the other. In his magic dance the savage is a kangaroo.* (Huizinga 1980:25)

Either way, the transport into this otherness has sporadic concreteness throughout our existence, and it is usually well triggered, among many other means, by the imagination running free on the dragon illusion images that populate consciousness while

attempting to inhabit the imaginary animal combinations. Especially if there is an invisible device which conveys a playable audiovisual simulation, magically amplifies your body, allowing your gestures to become meaningful virtual flying and cathartic fireball wreckage, luring and dazzling with a becomable destination otherness.

Deleuze and Guattari (2004,1991,1980,1972) were among the first to ascribe human ontology to this perpetual undelineated porous state which provides space for lifelong change (evolution, learning, growth) to take place. They founded identity in that which breaches it: in the actuality of the now, human beings drive the identity that persists and takes place in reality via the omni-present all engulfing deleuzian virtual plane. And every identity snapshot contains a mixture with different percentages of these two engulfing forces percolating for consciousness control, actualized in the organism's flow of life. The before mentioned bridge now has a keeper that guards access into the non-human otherness which is Deleuze and Guattari's seminal concept of Body without Organs (Corps sans Organes, CsO, BwO), introduced at 1.1.1. In this concept, unique, different, rare and ritualistic moments, by circulating powerful virtual pre-conscious flows, intensifying them to an impossible point of a body where organs cease to make sense, granular energetic desires of becomings, through an intensification of forces, beyond their peaks, in the actuality of a body tendentiously without holes, allowing maximum dervish circulation, preventing energy leaks, and by letting them run free into and beyond a maximum amplification state guided by the spatium of the virtual at its fullest, humans construct an alter body, an otherness, and reach a heightened plane of immanence (Deleuze & Guattari 1972), where organs make no sense for a physical body that is no longer its own, instead it has become the virtual other it projects, in which a dazzling powerful state of all mighty chaotic otherness takes over, expressing here the self in its entirety. Here the virtual plane dominates overwhelmingly on the actual plane, multiple energies at their peaks, beyond their peaks, quarrel for control, compete beyond their extremes, the self deterritorializes and overflows its boundaries.

The egg is the BwO. The BwO is not "before" the organism; it is adjacent to it and is continually in the process of constructing itself. If it is tied to childhood, it is not in the sense that the adult regresses to the child and the child to the Mother, but in the sense that the child, like the Dogon twin who takes a piece of the placenta with

him, tears from the organic form of his Mother an intense and destratified matter that on the contrary constitutes his or her perpetual break with the past, his or her present experience, experimentation. The BwO is a childhood block, a becoming, the opposite of a childhood memory. (Deleuze 2004:202-3)

The opposite of memory constitutes a blockade. A stronghold here Deleuze defines as a contrasting line between safe and dangerous ilinxian experiences. Dragons are of many shapes and sizes, usually consisting of a mixture of known animal's properties and physiologies, and we don't have to look very far to find artifacts everywhere that remind us of them. From cities' insignias to mythological folklore, bedtime stories and fantasy books, toy and souvenir shops, movies, paintings, sculptures, games, etc.

Most importantly, they are also similes of enormous greater than human powers and abilities, friendly or foe, that also resonate with the kantian notion of sublime (Kant 1992), where one cannot grasp entirely the immensity of their being, the scope and latitude of possibilities of their actions when set in motion, due to being enclosed in an unreferenceable and all mighty mythological human millennial reality. At the same time, we attempt to interact and inhabit the vivid shape presented to our consciousness. The mind is subsumed under a loop of attempting to inhabit this illusion and to grasp dragons traits with known animals that it's accustomed to. Trying to match the features these combinations give rise to into possible uses. An anticipation which is already present in a subliminal state due to contact with ancient folklore. The mind is lead through a bridge into a glade where everything can and will be questioned, bred, touched, grown into and even perhaps inhabited, beyond the known body until then. There's always room for surprise. Incommensurability as one attempts to become a dragon, the very simile these creatures stimulate. It's not only a question of matching known feature elements through the fantastic combinations present in dragons, but more importantly, the different movements and ways of displacing through reality which the combinations in the reptilian animals arouse. Lines of otherness intensification, bred by the imagination, that circulate and amplify in the body, like gigantic waves in the identity ocean which subsume normal human perception into a deleuzian plane of immanence. Fire breeders, water cuspers, flying snakes, winged warriors capable of apparently impossible feats, they are questionably the lions of a mythological fantastical jungle.

Figure 154: Detail from *The Great Red Dragon* by William Blake, c. 1805. © Smithsonian Museum. Figure 155: Draak by M. C. Escher 1952, © M.C. Escher Foundation.

Using immersion and full body computer vision based interactivity, with a disruption of the normal human perceptive senses and movement abilities, gifting human users a new sense of perception and new ways of playing in the game/virtual cyber-world, this interactive electronic installation work endeavors a practical research not only into creating an audio-visual game space environment which fosters the user's ability to become a representation, to inhabit non-human points of view and to make them feedback on the human, but also to construct a non-human embodiment system through electronic means as a laboratorial art installation space. Human users are immersed in a cathartic, stochastic, full body immersive videogame experience in cyberspace. They unleash their dragons, when immersed, mediated through this experience.

The work attempts to playfully shift user consciousness towards non-human embodiment, by realtime 3d meshing the data from the human body into a mirrored abstract, ill-defined dragonic 3d shape. And by gifting humans with special virtual powers like flying and cusping fireballs, fighting for their progression in the game-space or facing annihilation, through invisible interaction camera-based technologies. Inside the piece's virtual world, users play as endangered dragons in an XXIst century filled in with companies, dotcom's, humanoids eager to stop the mythological beasts.

Draco.Wolfanddotcom.Info (Sier 2015) is a single or local multiplayer interactive installation programmed in C++, composed of one or several networked nodes, where each node holds a computer, a video projection, interactive sound composition, and a camera

based interface that operates as a game joystick and also inserts the user and his flying gestures performed mid-air in a proto-videogame stochastic environment, which is shared across a local network. Human users are real time meshified into a solid black sketch shape dragonic shape, that becomes randomly colored when under enemies line-of-sight, where the contours of their bodies are somewhat stretched in the x axis, and the sampled point cloud from the depth camera serves vertices to an elongated three dimensional mesh composed of many triangles that undulate near instantly at the same time the user makes a gesture. Using these techniques, every user has their own unique user-dragon, made up from features of their tracked human body in the installation. Instead of attempting a well recognizable pre-modeled dragonic image as the users' avatar, the aesthetic choice of an unique, user bound, ill-defined, abstract, elongated triangular mesh was opted as means to facilitate transportation to the surreal low-fi virtual environment, as well as to leave the focus of the interaction on the mimicking of flying gestures from the user part into a fluid flying movement of the user-dragon avatar in the 3d game space (see figures 140,141 for examples of recorded 3D PLY frames/models from user-draco mesh created by Draco.Wolfanddotcom.Info).

The objective of this interactive work is thus to build and set afoot a practical responsive programmed electronic construct which facilitates tangible means towards otherness embodiment. The dragons progress in the game-space by inflicting damage to the city's landscape. The stochastic-logical-game-space ascends in difficulty as the levels progress, slowly changing the joystick's response into faster speeds and larger cityscapes, inducing the game's ultimate goal of a cathartic ilinxian state of disruption and otherness in human perception.

Draco.Wolfanddotcom.Info hides beneath a physical dexterity game with full body interface its real target of achieving non-human otherness through the cathartic engagement on the game mechanics and the innovative full body interface. This main objective is highly facilitated and induced in the tangible installation space through the technology, the cathartic gameplay, the being able to fly and havoc making fireball cusping, simulated and immersive experience. In this piece's conception lays a simple rudimentary and minimalistic game logic that ascends in difficulty as the levels progress. The human-dragons are spawned in an initially small game arena which encloses stochastic city-like

landscapes, populated with colorful either static or moving enemy game agents, which are trying to take down the mythological beast. The player-dragon's purpose is simple: to inflict damage anywhere, in the city buildings, in the enemy game elements, to unleash his anger like an endangered dragon fearing for his life, trailblazing a path of cathartic destruction as he progresses throughout the experience. The dragons inflict damage either by hitting the buildings, or by cusping fireballs at them or at enemies. As the player manages to progress through the levels, the arena expands, the cities structure evolve and grow, more enemies populate the space while becoming more aggressive and harder to take down, as well as a finer and faster joystick response, as the dragons turn quicker and fly faster, demanding from the human user a better precision and acute control.

All visual design, terrain, city constructions and structure is fully algorithmically generated, without any loaded game pre-made designs or structures other than mathematical formulas which are fine-tuned and parametrized towards reaching the generative algorithmic drawing the computer synthesizes at run time of the experienceable virtual space. All the elements are housed in a custom game engine specifically programmed for this installation, modified and evolved from piece to piece, targeting each unique work with its engine infrastructure requirements. Stochastics plays a major role in this kind of design. It is however a structured stochastics synthetic design, as if sculpting the logical-space of the game elements within the gameplay. Its goal is to emotionally envelop the user into the amazing combinations that the stochastics of distinct elements arouse in the virtual space as well as to address a resemblance in difficulty assigned to each distinct level. Distinct algorithms arrange the structure of the city – either circular, grid-like, scattered, with density peaks, random –, the size of the buildings, the terrain configurations, the enemies' meshes. Every time a user enters any level the game presents a new and unique configuration of elements, but the number of elements and their difficulty characteristics as well as the size of the bounding arena space is quite similar among distinct though same level spatial configurations.

Draco resembles a videogame due to the logic it is embedded in, but perhaps it's more accurate to state it is a proto-videogame, in two ways, as if near a videogame sketch, and aesthetically inspired by the greek proto-geometry movement[47]. Draco follows a videogame

---

[47] In the proto-geometric greek style an occasional animal is seen at random locations though emphasis is placed on perfected techniques, new and more harmonious formats of vases, the replacement of purely decorative

structure to present an objective to the user in the experience, but not caring much about the immersion in the game logic and the overwhelming realism mainstream videogames tend to have nowadays. The game logic is present as a means to provide the players a simple cathartic and fun objective. The focus of the work is given more to the whole illusionary and abstract experience of suddenly our actual body can virtually and actually fly, it can be transported and transfigured into a dragon inside the game space, and it's simply by moving the arms with flying gestures in mid-air, without touching any object or controls that the user gestures' are invisibly interfaced to operate the game, with no feedback other than the game visuals and sounds that respond to the players input through its logic design.

The graphics adhere to a refined abstract movement which the author traces back to the before mentioned proto-geometric greek style, as well as the abstract arts movements of the XXth century referenced at chapter 1. City buildings are low transparency black boxes, operating as erasers in a graphically accumulating white environment, while other level entities consist of flying or driving assemblages of colored triangles and other simple elemental geometric shapes. The sound of the environment has a major near-invisible role in heightening the sense of immersion in the abstract game-space. Recorded children voices gnarling and making eerie noises, imitating their own dragonic sounds, drawn from their imagination and from suggestions made during the recording sessions, have been electronically modified and composed into ambient or event sounds. The music is scattered in the game's virtual space, with radii sonic activated composition which sets tone to the environment. To the spatial musical elements are added triggered responsive sounds which go along with the actions players perform and their feedback on the game space.

As one escalates the apparently infinite and unconstrained levels, the relatively small gameplay arena of the first levels gives rise to a greater spatium where the game logic is ever performed. The heightened number of events of the first levels, in the constrained smaller space, which serves as tutorial for physical control of the near embodiment and required destructive and evading logic to advance in the levels without being killed, slowly

motifs with purely abstract drawing: triangles and other rectilinear shapes, in parallel lines or intercrossed for shadows, and especially, circles or concentric semi-circles drawn with compass and multiple brushes (Robertson 1981).

gives rise to more and more empty moments as the player seeks the city structure or other game agents to complete yet another level. However, the sought elements are now engulfed in a reduced random region of the larger game spatium compared to the initially small arena of the first levels. Without other game elements on scene other than the user-dragon and the seemingly infinite generated terrain along with its spatial audio composition, hopefully now the proto-game gives rise to a silent tranquility of non-human embodiment hovering over the flying, after traversing the intensity of the first easy though troublesome and action frenzy levels, as if the user has by this time grown his wings, to leave him space and time to enjoy the immersive otherness as if hovering on it. It also serves as a balance in the psychological attachment to the videogame, leaving more mind space to the contemplation of the aural and visual experiment provided by the ambient cathartic game. This virtual space based partitioning composition approach, both for music and architecture of the engendered virtual opus spaces, was refined and based in previous and current works such as 0 0 255 (1999), k. (2007), 577Rhea (2012), Hyperborea (2012-15), 747.7 (2014), Atlantis (Sólon Interface) (2016), Babylon (2018), among others.
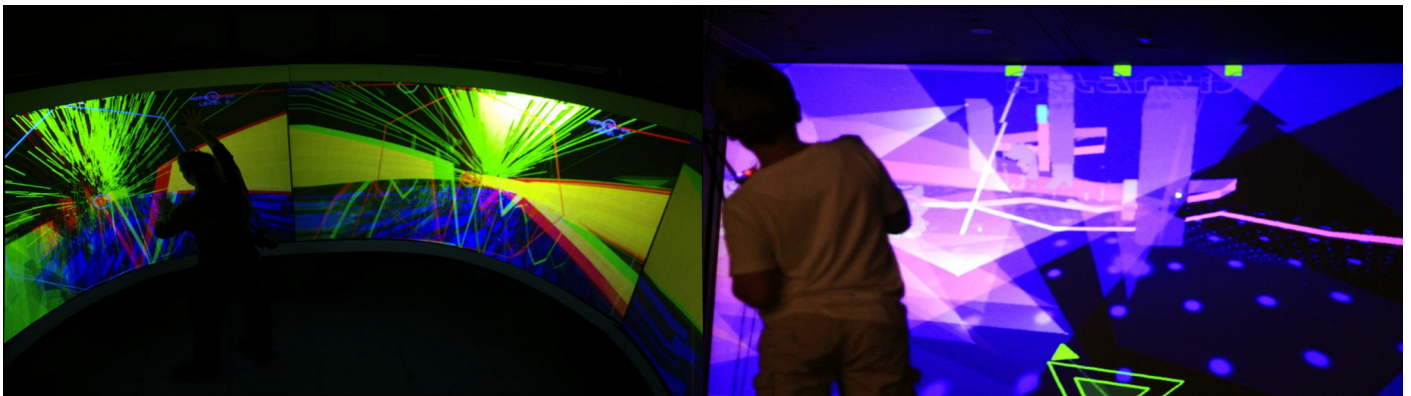
Figures 156, 157: Earlier spatial composition opus examples. *Hyperborea (ICST)* (2012-15), built for ZHdK's Immersive Lab, is a multi-user multi-touch proto-geometric gaming environment composition spatialized for 4 interactive image outputs and 16 audio channels (8+8 rings). *Atlantis (Sólon Interface)* (2016), mono channel of image and of sound, exhibits similar spatial complexity with its single player spatialized abstract gamespace structured over 100 levels, as in Hyperborea.

Composing visual and aural events in spatiality resembles deeply our own approach of apprehending the sense data through the experience of others and otherness in our own body. And it's a compositional technique which virtual ST infinite space provides an easier use, resembling, like in reality, to the scattering of events throughout the real world space.

Spatialization has been researched mostly on musical areas, and point to the ability to locate throughout time emissive sonic sources to a listener's spherical auditory perception. Pioneered by electroacoustic composers Berio, Stockhausen, Xenakis, Boulez (Jullien & Warusfel 1994), these composers scatter the orchestra machine from its standard stage location into localized ensembles placed at specific places in the auditorium. Xenakis, in Terretektorh (1965-66), for 88 musicians, even allows the audience to circulate in order to choose their own sonic perspective. This type of composing sonic events in space, where the audience can linger to a sonic perspective of their choosing, is a technique the author applied since 1999 to the above mentioned works, and that resorts to distance/vector based amplification panning of sound sources usually in multichannel setups on the audio domain (Pulkki 1997).

Similar procedures are used in visual rendering domains, that involve spatial partitioning of generated objects, through gridmaps or binary trees, and distance based calculations from the point of view are utilized to scene cull, improving performance, and to adjust rendering or logic properties of objects based on distance. Following initial musical spatialization works like 747.2 (2004), struct_4 and 5 (2006), also from many performances in musical projects such as UR (with Nuno Morão, 2004-8), Parque (with Ricardo Jacinto et al, 2005-8), and also multichannel projects such as …All Balanced (2006) and Rei Édipo (both colaborating with Pedro Carneiro, 2010), Line Invaders (with Rui Gato, 2010), documented at andre-sier.com, the vector/distance based amplitude panning technique, V/DBAP, was programmed firstly by the author in Max/MSP, inspired by a max patch by Trond Losius tl.dbap, improved into the C externals a-dbap2d and a-dbap3d (Losius, Baltazar, Hogue 2009)[48].

An evolved version of these techniques still constitute the core spatialization procedures the author utilized in the mentioned works, but now under a C++ audio library (s373A~, see appendix α.1). This allows positioning of several sound sources with their radii of perceptiveness influenced with spatialized dynamics around the sonic point of interest (the player in the case of mythological videogames). These spaces spatialization

---

[48] a-dbap2d and a-dbap3d are a part of the a-objects collection for Max/MSP visual programming environment built over 2000-7. a-dbap2d and a-dbap3d source code can be consulted at https://github.com/s373/a-objects_maxmspjitter_00-07/blob/master/a-objects/a-objects0x10src/a-dbap2d16.c and https://github.com/s373/a-objects_maxmspjitter_00-07/blob/master/a-objects/a-objects0x10src/a-dbap3d16.c.

can be represented with tailored multichannel setups suitable both for stereo headphones and custom multichannel installations and/or performances (see figures 157, 158).

The core of Draco's interface lays in a camera based joystick that captures player presence in a thresholded distance from the piece's projection and estimates a simple skeleton based shape from the human image camera input. From the camera calculated skeleton it is then possible to estimate the main parameters to drive the dragon: the angle between the arms positions, which calculates and provides the turning amount in the game space; and the distance between the arms, which sets forth the speed parameter for the draco's avatar in the cyber-environment.

Unlike most computer vision works that rely on OpenCV (Intel Research et al 2000) – a robust multi-developer computer vision library developed by Intel and hundreds of computer programmers –, this piece relies on a custom tailored computer vision library named Flob that has been developed since 2006. Flob is a flood fill multi-blob tracker and simple skeleton estimator, not as fast as OpenCV, but engineered to calculate parameters that the robust Intel library could not at the time of these objects making.

Flob's development began as a Max/Jitter C programmed external for my 747 series (Sier 2001-), dubbed a-jit.human[49] (Sier 2006), on which a single image blob – i.e., a single thresholded binary island region, individualized on the incoming frame –, after being found in the incoming camera image, is additionally scanned for extra parameters estimation. Since node based languages tend to be tedious while building complex interactive pieces that rely on computer vision, game trees, collision detection, and more programming topics fundamental to videogame engines, further development on this research work – like multiple blobs support per frame among other algorithmic refinements– was built initially in Processing/Java and later on C++ library OF.

[49] a-jit.human source code is available at https://github.com/s373/a-objects_maxmspjitter_00-07/tree/master/a-objects/a-objects0x10src/a-jit.human

Figures 158, 159: a-jit.human help patch calculating simple frontal skeleton information for *747.3* (2006). Flob P5 library example rough skeleton estimation on noisy unstable inputs.

This computer vision method assumes the interactive agent is on a frontal tracking setup, facing the camera forward, or slightly tilted from above. After individualizing the blob on the camera image through the flood fill method, in which a binary map of the incoming frame is constructed (where white pixels indicate presence and black pixels absence), we now know the numbers for the bounding box, centroid and overall shape of the instant blob. The algorithm I devised in early 2006 to serve as joystick for the piece 747.3 (Sier 2006) starts after this initial scan (figure 158). After knowing where to look in the incoming camera image, the algorithm then travels through the blob's bounding box perimeter in an attempt to find where the head, left arm, right arm, left leg, right leg are located. With this extra information we can thus construct a simple 5 point skeleton tracker.

Figures 160, 161: *747.3* (2006), at LugarComum, Oeiras, using a-jit.human as joystick. *Ascende* (2009), at Junho das Artes, Óbidos, using flob as multi-user HCI.

The algorithm's working flow is simple: if scanning for the head position, scan the topmost line of the bounding box region where the blob is located, starting from the center position and iterating alternatively left and right until either a white pixel in the blob

region is found, or the scanning head reaches the extremes of the bounding box in the actual frame being analyzed. If a white pixel is found, the algorithm assumes this is the head's current position, and continues to track other features. Calculating the arms positions was a bit trickier, since sometimes when humans simulate flying gestures with their arms, seldom the arm region is not on the left or right perimeter of the blob region, but instead located in the top or bottom ones.

After knowing where to pinpoint the arm's positions within the blob we have now the necessary information to build the invisible joystick mechanics. While on 747.3 the simulated flight is merely in the frontal direction, allowing for some left right tilting of the user-plane's avatar in the audiovisual environment, on Draco, the 3D space is entirely open and the user can apparently travel towards any direction on the virtual world. The basis of both these interface mechanics are similar: one constructs a line from the calculated flob's left and right arms positions in blob space. The slope the arms' line provides serves as left or right directions, and the proportional lines' length is directly mapped to the influence the physics speed of the avatars in the game world.

The skeleton tracking abilities of flob are not robust as to track a finer tuned skeleton shape in any camera orientation. Or to estimate future poses based on the current ones like some skeleton trackers provide. It only works in a frontal camera setup on the actual instantaneous image frame and is incapable of calculating head, arms and feet coordinates if this assumption is changed. However, this code has served well its purpose within both these interactive works, and since robust skeleton trackers are a swampy patented field that emerged in the following years after flob's conception and implementation (Microsoft's Kinect is from 2010 and robust skeleton tracking requires depth image information, while Flob only needs standard rgb images and can as well work on kinect depth images), which require proprietary or platform specific pieces of code, Flob here bridges this gap as a custom made solution that works well for the purpose it was built for.

2.1.2 Phoenix.Wolfanddotcom.Info

Phoenix.Wolfanddotcom.Info (2017), another art-sci work within the wolfanddotcom series, is a second flying inspired mythological artistic cathartic videogame space, set in a vibrant, luminous neon setting of an archeological post-antropocene paleolithic era, where human users fully immerse as mythological creatures, phoenixes in this case. At Phoenix.Wolfanddotcom.Info, through flying gestures facing the video projection at the installation space, within a virtual environment overpopulated with humans, obstacles and scarce endangered organisms, the users play and can become virtual mythological winged phoenixes, flying, diving, crashing and setting fire to a frightening and dangerous cathartic virtual path at the dawn of human extinction.
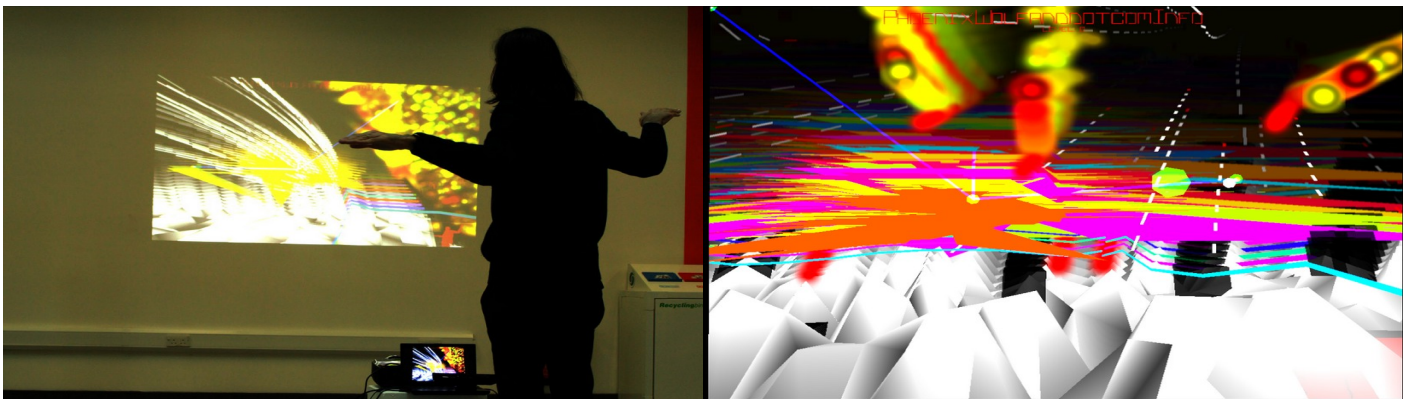
Figures 162, 163: *Phoenix.Wolfanddotcom.Info* at Balance/Unbalance international conference 2017, Plymouth.

Like Draco, Phoenix.Wolfanddotcom.Info is a personalized interactive space, designed to facilitate the bridges of the human mind to play in cyberspace as mythological creatures, networked in a cooperative, competitive or solo catharsis, exploring and innovating in electronic arts, as well as and very especially serving as a tool for laboratory investigation of consciousness research. The objective of this artistic work is thus to build and put into practice a generative audiovisual interactive immersive space, subdivided into levels that facilitate tangible means as bridges towards otherness non-human alterity, in order to emotionally involve the users in the astounding combinations produced in the virtual space by the stochastics of different elements, as well as to promote different difficulty for each different level, with the logical-stochastic game space increasing in difficulty as the levels progress.

Each level consists of a visual space containing a stochastic distribution of urban drawings and three-dimensional landscapes of buildings, generated by the electronic substrate that becomes a terrain inhabited by bio-electronic beings resembling phoenixes, a terrain where one can be immersed and experience a disruptive ilinxian vision of a change-inducing cathartic future. A spatialized ambient sound is spread across the game's virtual space, playing an almost invisible role in intensifying the feeling of immersion. To this spatialized ambient music, with no fixed space nor definite time, contribute not only radii sonic activated composition, electronically modified and composed into ambient sound from recorded children voices imitating their own mythological creatures drawn from their imagination, but also triggered responsive sounds, which accompany the actions players perform and their feedback in the game space.

As extended before (chapter 1), in this installation, as in almost all others and in game experiences, there are no loaded additional elements other than the algorithmical rules which engender the proto-videogame spatium, pre-made designs or structures. All visual design, terrain, buildings and city structure are entirely generated by algorithms, sculpted by adjusted mathematical formulas, parameterized, modified and evolved from piece to piece, targeting each unique work's requirements to achieve the generative algorithmic design that the computer synthesizes at runtime from the experienceable virtual space. The elements are all housed in a custom specifically designed game engine, where the structure of the city, the size of the buildings, the terrain configuration and the enemies' ensembles are arranged by distinct algorithms. Stochastics also plays an important role in this dynamic installation, although the synthetic stochastic design is structured, in a logic of progression by levels, as if sculpting the logical space of the game elements within the gameplay, adjusting algorithmical parameters as levels progress. In this way, every time a user enters any level, the game presents a new and unique configuration, with the particularity that the number of elements, their degree of difficulty and the bounding arena space are quite similar among distinct spatial configurations though of the same level.

Similar to the dragon's piece, each phoenix user is transformed at real-time into an avatar of unique abstract mythological winged form, where the contours of the body have their own unique phoenix shape, made up of the user's human body features tracked on the installation. An invisible human-computer interface technique (interactivity based on

full-body computer vision) is used, with the core of the interface in a camera-based joystick that captures the player's presence at a limited distance from the projection of the piece and estimates a simple form of avatar from the input of the human image in the camera. When facing the projection and the 3d camera, the user's flying gestures become the joystick of the immersive environment. In spite of resorting to a similar game engine and interaction techniques to the Draco piece, Phoenix.Wolfanddotcom.Info's gaming mechanics differ, as well as the overall interactive ambient videogame, as they are inspired in condensed nutshell moments from phoenix myths and fire rebirths. In each level the user is guided to fly down a sinuous path and completes the level if he manages to reach the phoenix egg, or restarts in a fire rebirth at a circular distant location from its aim.

2.1.3 Wolfanddotcom videogame

The world of wolves and videogames serves as poetic inspiration in the creation of Wolfanddotcom, a local networked ambient audio-visual videogame within the homonymous wolfanddotcom series, which researches interactive and immersive electronic means as bridges towards non-human otherness, animal embodiment and cathartic gameplay. The users immerse as virtual wolves, whom are trying to rebuild a cybernetic virtual network within the space of the game, to help maintain life on the planet. The central theme of the piece is the recreation of an internet by these animals that, in a post-apocalyptic future, are longing and racing to construct networks among themselves.
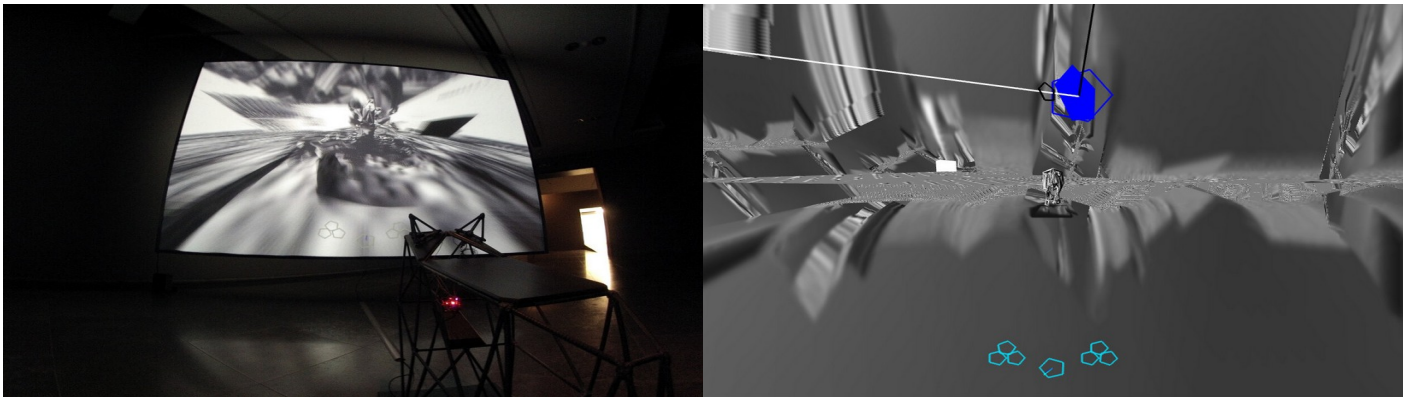
Figures 164, 165: *Wolfanddotcom* at Sonae Media Art exhibition MNAC 2017, Lisboa.

The Wolfanddotcom videogame establishes the core research theme. Set in a post-human abstract environment, it presents a vast 3D world which is synthesized from data obtained through a micro-analysis of electronic processes, composed from streams of bytes from files and running programs, which are orchestrated spatially on a gridmap virtual partition the user travels within. Like in preceding mythological videogames, the gamespace is divided into levels of ascending difficulty, with each level presenting a different spatial network configuration composed of nodes and connections, which have to be connected to the planetary network. Gameplay consists of discovering and activating all network nodes through the open labyrinth method that makes up each level, where seemingly short distances are often disorientating, for they exhibit different patterns of virtual video planes holding a real-time recursive feedback image – a technique used throughout many previous and percursor works by the author, particularly the before

mentioned struct series (Sier 2000-). The users interacting with the work are personified as wolves, play with a wolf pack of bio-electronic animals that have to go to the nodes to activate them and connect them to the rest of the network. Participants should complete each level's network, by activating all network nodes with their wolf pack. As they connect the nodes, the immersive visual and audible environment reflects the current state of the connections in the game.

The interface of this work is also technically innovative, since the piece features a custom physical interface, a couple of life-sized sculptures of metallic wolves, joystick-sculptures, where users can sit and perform actions by moving the ears of wolves, as if they are riding wolves and fondling their ears. Each one of the ears positions are sampled with three touch buttons. Pressing the buttons, by moving the ears, they allow actions in the gamespace, like going forward, turning, jumping, braking, and activating a network node. Distributed social joysticks are also implemented, to allow participants, connected to piece's WiFi through their smartphone, interfere with wolf-players. A nodejs instance on a rPI serves a processing.js sketch over the piece's WiFi network, which in turn communicates with the Wolfanddotcom server through OSC. Viewers of the work logged in the social joystick on their smartdevices can thus playfully alter and interfere with the wolf-players motions, stimulating social pack dynamics among visitors of the mythological videogame.

Figures 166, 167: *Wolfanddotcom* wolf-joystick-sculptures and wolfanddotcom-server at Sonae Media Art exhibition MNAC 2017-18, Lisboa.

In relation to the composition, Wolfandotcom is a generative networked audio-visual interactive immersive space, subdivided in levels, each level consisting of a visual space which holds stochastic distribution of network nodes, and ambient music spatialized. As

with other wolfanddotcom series' works, all videogame elements (visual design, terrain, city constructions and structure) are fully procedurally generated, although very interesting videogame engines and pre-made tools are available, they uphold a generic pipeline common for a specific videogame aesthetic and logic. For example, the mountains in Wolfanddotcom, where the wolves walk and weave their strategic network, are generated from sequences of bytes and processes on the GNU/Linux operating system, where Wolfanddotcom resides in a kind of potential world. This means that these shapes, backgrounds and objects are created using the code from the operating system that underlies the computer itself, its processes, its data patterns magnetically engraved through voltages. The representation is intrinsic to the code and the innate computational nature of this alternative world, known as Wolfanddotcom, ends up determining a specific materiality of the images and sounds that reach users as they immerse themselves deep within this electronic universe.

Although the thought to be mightiest and most ferocious carnivorous predator of the forest ecosystem, nowadays, wolves are an endangered species worldwide. For an interesting wolf contrasting image, Anneka Svenska on one of her Animal Watch videos is being kissed by a wolf inside her mouth as a sign of trustful relationship approach (https://youtube.com/watch?v=PguE2XclsBg). The wolf is a social animal living in packs that one can find throughout mythologies, from inter-racial encounters to combinations with humans (Freccero 2017, Robisch 2009). By looking at wolves and actively using them in this artistic work we underline a distinctive approach to art making, to contribute not only to the formation of new aesthetic knowledge, but also to induce a user transformative cathartic state within safe ilinxian regions, which is self-operated by coming into contact and communication with the artistic works, due to their innovative aesthetic, immersive and non-humanness characteristics. Having the power to change a person, artworks can consequently transform society, through the transformation of individuals. Although this does not mean that the artistic constructs have direct action, or even measurable influence, in creating responses to the current global crisis, perhaps they lead humans to look at non-human organizational models as better answers to current global crisis.

The creation and emergence of an interconnected network between us is thus central to the idea of this work. Much like pioneers establishing technologies that would later

make the internet we know today, what would a non-human network be like, forged from the ground up, shunning away humans and their plundering hubris? From a non-human form of animality, the piece explores the construction of networks between spiritual forms, like emotional networks among animal packs, while simultaneously creating a game based on the real functioning of the internet and the way computer nodes in the network interconnect and transmit data packets to communicate and respond to each other. Like the wolves, howling at each other, across vast distances, territorializing and deterritorializing their selves, their packs in their landscapes. The piece functions as a dynamic and interactive portrait of a network that has shaken the space and changed the way life works on the planet. It also functions as a warning scenario that involves the prospective extinction of humanity for which it is itself responsible, and an appeal to creative energies of survival, through an immersive cathartic state, albeit in a kind of animality restoration, symbolised by the central role of wolves and their packs.

2.1.4 Labyrinthine opus

The labyrinths, made up of inextricable paths and crossroads, constitute spatial challenges, solvable through physical displacement over time within their intricate structure. They challenge the free will and choices of the daring traveler who ventures into them, seeking to solve their mystery, or simply conquer it by getting out alive. They are, therefore, fertile ground for elaborate and deadly games, serious games, for the spiritual heightening of human beings, a daring spiritual training ground and basis for deeper human spiritual connections, as spatial metaphors of human life. Solving a tangled deadly space riddle involves untangling and heightening the full depths of the human soul, often beyond its known scope.

As life changing devices, interconnections between labyrinthine structures and the arts are inevitable. Within the context of exploring new electronic arts' aesthetic regions and unexampled connections between generative art, games and mythology, the practical artistic research surrounding my own mythological videogames was led to focus on labyrinthine structures. In that regard and based on a personal record of the author's encounters with labyrinthine structures throughout electronic arts, in the previous recess from the reading provided at table LEA (Labyrinthine Electronic Arts), a subjective selection of EA works are listed, sorted by date, with informing notable examples of the use of labyrinths in the arts, namely in electronic arts (EA).

As mentioned before (2.1), the wolfanddotcom series has been in the author's aesthetic horizon since 2011. Within wolfanddotcom and by the simplest way possible, a first series of drawing-games for two humans sets the core mechanics, aesthetics and leitmotifs of 0X Labyrinth (2018-22) one of the core virtual reality mythological developed videogames.
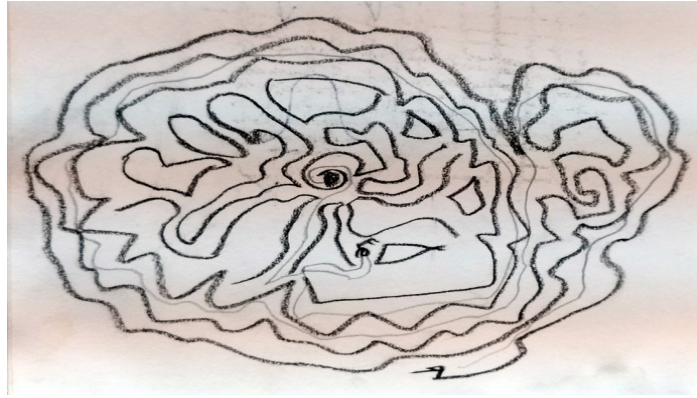
Figure 168: Labyrinth drawing-games for two humans (2011-).
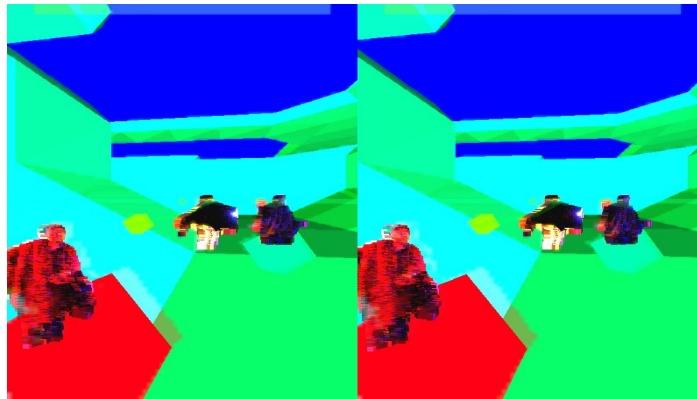
Figure 169: *0X Labyrinth* screenshot of virtual environment projected to users' eyes (2019 version).

0X Labyrinth (2018-2022) 2020's version features no networking and a single player double immersive interface (see figure 111). 0X Labyrinth 2020 version is a generative immersive videogame for handcrafted virtual reality helmets that allows two players to share a competitive moment inspired in the first serious and spiritual space and time device entanglement: can they be faster than Asterion in solving the maze? Do they hear the Minotaur, Theseus, the Birds and The Food? Will they love Ariadne? And what about the ball of thread? 0X Labyrinth interacts with the movements and sounds of visitors, submerging them as archeological explorers in an infinite computational universe, inspired by the mythical engineered thread. It is, perhaps, the first game in the form of a spatial and spiritual device, resolving space and time. It is interesting to note that the ball of wool, a gift from Ariadne to Theseus and which becomes his mythical salvation helping him to solve the labyrinth, is itself also a labyrinth on a different portable scale, which presents itself as tangled up single path hyper-compressed and confusing solution of the labyrinthine image. It will perhaps be the only possible help artifact to face the deadly

device, since it allows him to go marking the path to take back, as he dives deeper and deeper into the recursive meander to conquer it.

Concerning 0X Labyrinth, there are still several aspects that should be highlighted. One concerns the mask – doubly Theseus' helmet and the Minotaur's horns, and how that vision evolved into the creation of VR masks, already utilized in Babylon (2018) – that has the ritual feature of the others seeing the wearer with a bizarre artifact on the head, which is also a sculpture, and the only gateway into the game.

Figures 170:, 171 Portuguese Oxes 3D recording session during Asterion residence & 0X Labyrinth VR sculpture masks for two player version construction (2019), solo version (2020) see figure 111.

Regarding the music, it is also important the use of a temporal fractal composition technique, which resorts to archaeological musical structures such as the Hurrian Hymn nº6, the basis of the melodic theme of the opening scene of the game, the dance scene before entering in the labyrinth. The interface of this work is also technically innovative, since it uses the direction of the gaze and the intensity and frequency of the sounds produced by the user to generate different types of movement within the game-space.

Other pieces of the wolfanddotcom series also evidence labyrinthine studies, accompanied by theoretical research and new knowledge formation of innovative labyrinthine construction techniques (see 1.2). The design of labyrinths, whether single-path or multicursal structures (titled as classical labyrinths and mazes, respectively), has been the subject of intensive investigation in numerous contemporary computer scientist's research. This led to the fact that, due to the use of computers, there has been a tremendous threefold evolution: in the spatial dimension and in that of the object moved

in the labyrinth; in the complexity of the labyrinthine geometry; and in the type of algorithms for generating the labyrinthine structures. Section 1.2, without intending to be exhaustive in any way, includes an extended description of the history of labyrinths, their implications and philosophical roots, their methods of use and construction, on which the author of this thesis bases to propose new methods of labyrinths construction, resorting to new ways of looking at this powerful millenial structure that are the labyrinths and also new techniques of labyrinthine construction, which lead beyond usual human scope of imagination of spatial structures.

From the above it can be seen that, on the one hand, these new methods use non-human bio-electronic techniques, attempting to establish grounds to combine scientific, artistic and non-human methodologies as tools to explore new aesthetic regions within electronic arts. On the other hand, most examples shown in the above shown table LEA feature non obvious usage of labyrinthine characteristics, namely time-spatial entanglement, disorientation and near infinitude with goal oriented displacement, which are useful for new non-human artistic labyrinthine formation methods. A question then arises:

Why non-human methods in the artistic construction of labyrinths?

Non-human labyrinth formation methods aim to reduce an anthropocentric view and equalize/balance the prevalence of non-humans with humans, to evidencing distinct emergent design patterns that are not mostly based on human reasoning, other regions to what has been seen in the Daedalus' algorithms (1.2), even when electronic methods were used on standard labyrinth formation. Non-human methods also aim to reach new aesthetic grounds, to come up with new forms to attain harmonious natural spiritual realms, based on non-human models, some recognized for providing exemplary touchstones of how a stratified, environmentally balanced and well-oriented social organization might be achieved, in contrast to many human models of organization of social life, which have proven to be inadequate and limited to plundering the planet for profit, while (lighthouse) others have tried a spiritual government like in the Tibetan regions. This option for non-human models raises very relevant questions, which ended up

steering the main lines of research on non-human labyrinths within the scope of this thesis. In brief, these questions can be stated as follows:

- ◦ What would happen if animal thoughts and practices were directly amplified via electronic algorithms?

- ◦ If eusocial animals could program, what rules would they set forward when working on spiritual tuning devices?

- ◦ If electronic processes attained some sort of biological awareness, how would they design catalyst structures towards life preservation?

- ◦ How would non-human animals and plants and electronics merge?

- ◦ What would a labyrinthine spiritual device designed by non-humans to balance humans look like?

The application of non-human ideas to the creation of labyrinths has thus originated distinct novel methods by which labyrinthine structures have been, and still are, created for novel artworks. Either using biological or electronic processes, deriving from plants and animals or from electronic systems, the methods are used to investigate and engender labyrinthine patterns without or with very dim human intervention, where the prevalent architectural element is of non-human origin. The focus at labyrinth synthesis grounds on their attributes as exquisite legendary spatial gaming devices and possible pathways to gain deeper humane insights.

In summary and from a more broad and deeper point of view, it can be concluded that, by specifically focusing on non-human methods, artistic creation related to the construction of labyrinths might be considered in a double perspective: a way for its author to accompany the wave of indignation at the critical situation of possible life extinction in the planet, which humans, on their own responsibility, are currently confronted with; an opportunity to allow him, as an artist, to participate in the positive transformative action

that art can have on each individual and consequently on society. The focus on non-human methods thus translates the quest for alternatives in the construction of tools and experiences that, being centered on an imaginary non-human post-Anthropocene world and based on non-human organizational models that have better answers to the current critical situation, constitute possible vehicles for the induction of positive changes at the individual and thus collective level.

In the following sections, the created novel methods– non-human methods – for labyrinth construction will be described with appropriate detail and exemplified through artistic constructs, which will also be explored in relation to specific descriptive details and, whenever justified, usage and composition.

a) Non-human labyrinth formation methods

According to the labyrinth's design they generate, the novel non-human labyrinthine methods have been grouped into three distinct sub-categories (the 'open' method, the 'mathematical flower' method, and the 'animal' method) that are summarized in the following.

a.1) Non-human 'open' labyrinth method

The 'open' method was processed as an almost antithesis of the usual labyrinthine image while producing the same results. Starting from the observation of how labyrinths are structures which entangle space on the maximum amount of time to untangle it, a spatial hyper complexification with least possible extension, some premises were generated, namely: But could we not also achieve a device to deeply recursively entangle space and time on a wall-less open design? What if the goal oriented displacement is scattered and designed over a vast infinitude of space? Or even if the goal is almost within grasping distance on the open, but perceptive hyper entanglement and complexification prevents reaching it clearly?

With such premises to begin with, this labyrinthine formation method has been explored on stochastic infinite electronic games. Here the essential non-human aspect is the pure electronic design based on simple spatial rule premises for the goal oriented displacement serious game, where the game designer and players face similar unknown conditions by entering labyrinthine domains exclusively designed by programmers' algorithms on the machine, in scattering goals and setting base space users must engage with in order to solve this kinds of devices. By providing way points which access distinct spatial regions, even though there are no displacement barriers, open labyrinths feature invisible logical designs that can be simple or more complex and which can be equally challenging as most maze designs. The method is categorized as non-human for it consists on macro-rules that electronic procedures execute with varied degrees of uncertainty, loosely following maze logic, where way points need be touched in order to progress on the maze's logic, originating unknown exploration spaces, similar to travelers engaging labyrinths without overview maps.

a.2) Non-human 'mathematical flower' labyrinth method

The 'mathematical flower' method aims at using human derived mathematical computational formulas that deal with non-human natural generation of form, like formulas which explain how certain recursive entangling natural based shapes are created within nature. Flowers are one example of natural phenomenon which exhibit many characteristics related to maze like designs. They usually have a central core which is surrounded by an infinitude of distinctive patterns towards the outside of the flower structure. If looking at flowers from the point of view of a small and near invisible bug, to reach the center of the flower in order to seek its nectar can easily look to this bug like a labyrinthine task.

After this initial observation I sought out flower pattern generation algorithms and successfully applied them to the generation of maze like structures using flower formation algorithms. Stephen Wolfram was one of the first scientists to unveil and discover new algorithms to create natural forms, as well as emergent cellular automata algorithms that

display intrinsically emergent and complex behaviors from very simple expressions. Wolfram (2002) investigated flower pattern creation and came up with a simple formula where one can manipulate the angle and stride of the successive generations of elements that appear in the design. By manipulating the formula and over imposing successive designs we quite easily reach a palimpsest that is easily recognized as a maze like pattern, though with the added organic design derived from flower forms. The pattern can also be used then in conjunction with Pullen's 'template' method (2015) where we can isolate gaps and holes, remove loops, turning the design in a true maze or labyrinth. It is however interesting to note that formulas uncovered for the generation of nature like shapes can be utilized as means to design maze structures closer to non-human nature designs.

a.3) Non-human 'animal' labyrinth method

There are lifeforms on this planet which co-exist socially, feeding themselves, organizing, while maintaining the ecosystem's balance. They are also authors of unprecedented architectural creations derived from their social stratification. The focus has been on insects, animals whose internal, social, as well as emergent bottom up organization, pairs with the constant cooperation towards the common good of the colony achieve – eusocialism –, their architectural structures undeniably conveying their general attitude towards life. Their intricate inner housing meanders doubly foster colonies growth and protect it against predators. In many ways, they can outwit, outlast, and outplay humans.

Ants (Formicidae family) are eusocial insects that represent the highest level of organization an animal society might achieve, with a total amount of biomass roughly equal to the biomass of humans (Parikka 2010, Johnson 2004, Wilson & Hölldobler 1990). They cooperate in complex ways towards the common good of the ant colony, and thrive in conditions that challenge most other species, whereas humans cannot. Ant colonies usually synthesize intricate labyrinthine tunnel patterns below the ground where they self-organize and operate as a group towards a common good.

By observing these animals and shadowing their designs on a larger human scale, besides reaching unheard of aesthetic designs for labyrinth formation – few predators / Theseus's are brave enough to dare entering a large ants social colony –, perhaps, like labyrinth devices are a mirror architectural image of peak attainment of human status quo, animal based labyrinths represent an image of a higher evolutionary step for life on earth. In one of his final oeuvres, Derrida (2002) reminds us of the animal he therefore is. Most importantly, establishes an animal veil-less status quo to most animal species, beginning with analysis of his cats. "Unlike humans" he states, "my cat doesn't care if we are dressed or naked" – animal's attitudes are filter-less, usually placed at a rawer level of reality, without many additional mind constructs or confabulations other than their own raw feelings, emotions, sense data, for they are truly present and engaged in the here and in the now. Generative artists marvel at rule-based electronic arts delving into unheard of aesthetic regions. Perhaps an impressive, life-changing aesthetic power resides in animals that humans cannot reach.

b) Non-human labyrinths case examples

In order to illustrate the described non-human labyrinth formation methods, four case examples of artistic non-human labyrinths are explored: k. and k.~ videogames (2007, 2010); Wolfanddotcom' videogame (2017); 8-bit Maze Gardens vegetable paintings (2018-) and MetaPh (2018-) photographs; Ant Ennae Labyrinths bio-electronic apparatuses (2019-). Videogames k., k.~ and Wolfanddotcom represent usage examples of the techniques described in the non-human labyrinth open method; 8-bit Maze Gardens vegetable paintings make usage of the mathematical flower non-human labyrinth method; Ant Ennae Labyrinths use the animal labyrinthine aesthetic design procedure for non-human labyrinths formation. Works like 8-bit Maze Gardens and MetaPh are preparatory, using technical methods of creating spaces that add to the previous ones: in 8-bit Maze Gardens, Biowolf, etc, new patterns of labyrinths crafted with mathematical flower methods that are carried over to the creation of the game space, like the labyrinth drawings from 2011; in MetaPh, the images themselves are textures where colors are used to create objects and spaces within levels, upon levels and levels.

b.1) Non-human labyrinths 'open' case examples: k., k.~, Wolfanddotcom

k. and k.~ are purely electronic labyrinths designed by author shaped ST algorithms which induce pseudo random generators to give shape to a near infinite virtual space, a digital open labyrinth inspired by Kafka's "The Castle". These are ST/procgen games with abstract graphics which attempt to provide the player a pseudo-infinite quest by placing the Castle structure, the player's goal, in only one of the 4,294,967,295 levels of the 32-bit precision random number generator. The player is gifted with abnormal speed and even flight capabilities, which allow him to traverse the game space faster. In the game, he is embedded in an open zone where he can find monolithic square shapes, like in Kubrick's "2001: A Space Odyssey", which he may carry along in his virtual backpack and that allow him transport and passage on star-shaped forms of abstract spheres represented by lines originating from their own core. In order to be transported into another of the 4,294,967,295 possible levels of the stochastic game space, k. must hold a certain amount of monoliths before being greeted and transported with a teleport passage to another level. While on k. players engage with mouse and keyboard, on k.~ the game spatial algorithm got improved as well as the controls have been replaced with a microphone and custom sound analysis algorithm. k.~ is a sonic land-surveyor of infinite spaces. Users, making sounds above a silence threshold cause k. to move in the direction he is facing. No sounds cause continuous rotation about his axis. Hissing sounds makes him fly (see figures 97, 104). A parenthesis noting these ideas of combining monoliths and bio-electronic works is present in the work doenças from 1996,7, where ~1m blocks of foam are coated with a mixture of flour based papier maché with blue pigments, which, as the works were drying, developed organic materials, punctuating the base blue of the suspended at random public spaces monolithic bent shapes with different orga-colors.
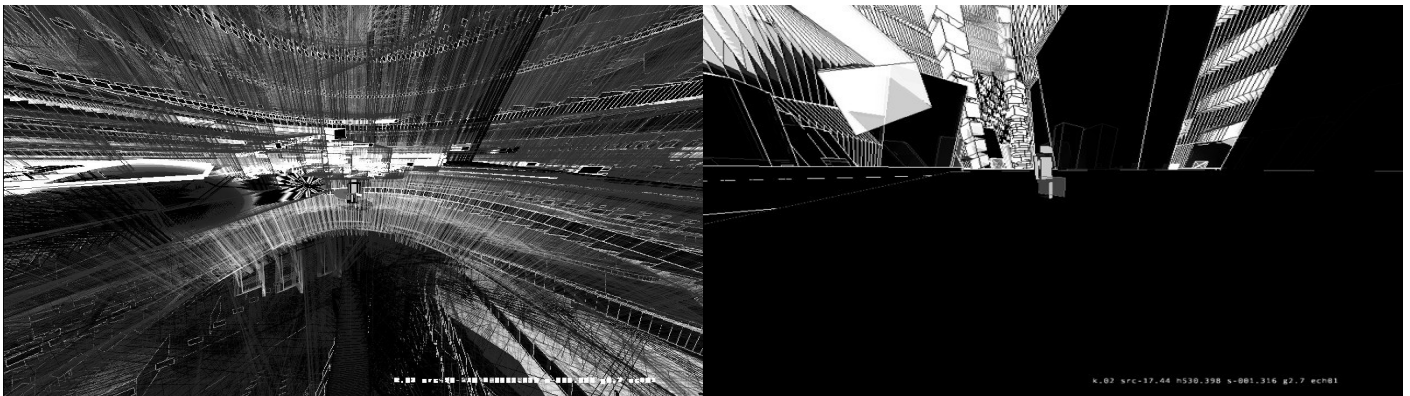
Figures 172, 173: k. screenshots 2007.

Wolfanddotcom, already detailed before (2.1.3), also is referenced here due to its nature of a labyrinthine videogame of the non-human labyrinths open type, procedurally generated from sequences of bytes and processes on the GNU/Linux operating system. It combines wolf packs' behavior to the emergence of a post-Anthropocene network inside an open abstract environment synthesized from files and computer processes. Ascending levels within the game exhibit growing network configurations on expanding spatial regions walled by confusion labyrinthine inducing feedback visual planes. The users, playing with a pack of bio-electronic wolves locally controlled by joystick-wolf-sculptures or WiFi, try to rebuild a cybernetic network by activating (RX/TX) each network node in the landscape. By completing the network, they advance to other regions, unknown memory addresses gifted with more complex networks and labyrinthine, visual, mesmerizing disorienting spaces, overflowing with signals everywhere. Wolfanddotcom is a cathartic immersive anthem to cyberspace, to overcoming extinction, to the machines, programs and data links, built by post-Anthropocene bio-electronic wolf packs. Activating a network node, the games' map on the sky of the videogame lights up a colored beacon from the ground up to to the sky, similar to Anthemusa's 8-bit laser lighthouse (Sier 2021). Simply, each Wolfanddotcom level corresponds to a random network map of ascending number of nodes cast in a growing 3D virtual environment, mapped out by a sky network map to assist in the navigation of its users (see figures 82, 83).

b.2) Non-human labyrinths 'mathematical flower' case example: 8-bit Maze Gardens

8-bit Maze Gardens (2018-) are generative paintings usually applied on supports, ranging from drawing paper, canvases to outdoor walls on floral, mathematical and labyrinthine themes, where pictorially maze like patterns emerge from the use of mathematical formulas of flower formation, executed with living and slowly evolving / decaying vegetable based inks. The paintings performed represent a labyrinth game that took place: static labyrinthine designs and player traces trying to engage the labyrinth seeing who reaches the nucleus first. Being done with ecological vegetable inks, the works also inscribes a slow moving generative system that, like myths, slowly grows or erases from its inscribed surface (see figures 16, 57, 58, 59, 60, 65, 66).

b.3) Non-human labyrinths 'animal' case example: 'Ant Ennae Labyrinths'

Ant Ennae Labyrinths (2019-) is a bio-electronic ecosystem and interactive optical apparatus to create animal made labyrinthine patterns by ants, interfered by computer or human controlled laser light source, where ants play the game of life inspired in the mythology of labyrinths. Ants' normal behavior is sometimes influenced by low powered laser lighting: their movements stop, they try to grasp the ethereal light. In this work, a robotic laser light made with inky (s373.net/x 2009) follows the labyrinthine pattern inscribed on an electronic image. As with what happens in cybernetics, these audiovisual systems feedback to their sources, in the case by casting laser beams onto an ant colony making labyrinths with electronic formation. Whenever the image pixel is above a threshold, the laser beam projects light on the corresponding ant's farm mapped position. Ants were placed on top of an empty vertical ant farm with access to plenty of food and water. As they began to occupy the ant farm space, the laser light would daily stimulate them with the electronic image superposition by laser light casting (see figures 12, 36, 39, 44).

2.1.5 Bio-electronic aggregates

The here considered art constructs, mythological videogames and bio-electronic aggregates, merge fields from the biological and electronic art domains and propose immersive situations in the entitled neon paleolitikos epoch, an imaginary post-Anthropocene geological future. They consist on amalgams of hybrid operative elements – biological and electronic, or any combination of them – that is, hybridized and operational assemblies set in a post-human world and in a variety of media. Each has characteristics from both domains, such that biological systems are amplified with algorithms, electronic devices, network ports and protocols, while programs are endowed with biological memory regions or prosthetic augmentations of biological origin. Bio-electronic data becomes sounds, images, or virtual architectural models of spaces, imprinting dynamics in the composition and autonomous movements of the artworks, by controlling, like a dj or a gardener, the genetic processes that alter the sounds produced. As cyber-environments, these audiovisual systems feedback to their sources, for example, by emitting continuous sounds to plants, generated by raw plant and electronic data while it is sampling voltages from it to generate the sounds (Half-Plant 2017); or by casting laser beams onto an ant colony making mazes with electronic formation (Ant Ennae Labyrinths 2019-); or casting generative cellular automata visuals derived from rule based slow visual transitions also to an ant colony with its ecosystem consisting of food, water and generative cellular automata based visual patterns (Half-Ant 2020).

As extended before (0.3.1 and 1.1.4), all these three artworks are cyber-environments of non-human machine interaction, focused on establishing means for an hybridization of the non-human biologic and electronic domains into cybernetic bio-electronic aggregates, through physical computation situations. Their main characteristics are detailed in the following.

a) Half-Plant (2017)

Half-Plant is the first dynamic art-science work of bio-electronic aggregates, where the live mutation of electronic and biological information gained a tangible concrete run-time

reality. On this work, a small vegetable-electronic ecosystem , open to networked smart device app human interaction, is continuously digitized through an Arduino firmware that is sensing electrical flows of voltages in six distinct sampling channels and points of contact with the plant through piezo-electric sensors and other electrical voltage conductive materials. The now digitized raw sensor data flow is sent to be further combined in the computer with electronic microscopic readings of the electronic self-information present in the computer machine that is acquiring the data. This means that the plant's electrical information is transformed into sequences of byte streams using electrodermal sampling, a process mathematically described by Galeş (2012). The computer processes, or selected files on the GNU/Linux filesystem – the electronic source data: byte sequences from programs, processes outputs and operation, RAM contents, raw networking data and files that inhabit the computer ecosystem –, are equally transformed into sequences of byte streams, using live reading of archived byte patterns. Those non-human biological byte streams, digitized sequences of captured voltages sensing electrodermal current variations, are in turn combined with the continuous sampled electronic byte streams of information processes taking place in the computer. Both real-time streams are transformed into DNA floating-point number streams, and genetic algorithms (Sims 1994, 1991) combine the distinct streams under a third bio-electronic hybrid stream. The bio-electronic DNA signal becomes sibling of this biologic and electronic mating process. Its' continuously running mutated information becomes source audio material that is fed back into the ecosystem, closing the loop on a cybernetic system meant to evolve plant-computer bio-electronic aggregates.

Users can connect to this installation by logging in with their smartphones to a wireless local website served by Half-Plant's broadcasted WiFi network, where they can find, within their browser on Half-Plant's IP address, a graphical interface to collaboratively alter the parameters of the system: amplitudes of electronic, biological or bio-electronic signals; the types of genetic algorithms and their mutation indexes; the three signals (electronic, biological, bio-electronic) reading speeds. Fiddling with the parameters alters the low level raw musical sonic patterns that emerge from the bio-electronic aggregate internal structure, which are in turn continuously fed back to it.

In short, it can be said that Half-Plant is a bio-electronic aggregate, partly microelectronic processes, other part microbiological voltages, operated by smartphone. Broadcasts a WiFi Access Point, which allows whoever connects to mix different genetic processes, combinations of electronic and non-human biological micro-fluctuations into a bio-electronic hybrid (see figures 3, 7, 21, 23, 35, 42, 43).

b) Ant Ennae Labyrinths (2019-)

Since Ant Ennae Labyrinths has been detailed before (at 2.1.4, apropos work's description as an example of the use of the animal labyrinthine aesthetic design procedure for non-human labyrinths formation), here only a complementary short reference will be made, focused in main characteristics that classifies it as bio-electronic installation aggregate. In this context, the artwork Ant Ennae Labyrinths can be considered a bio-electronic ecosystem and interactive optical apparatus, to create animal made 3D labyrinthine patterns by ants, interfered by computer or human controlled laser light source. Like other bio-electronic installations, Ant Ennae Labyrinths is a work which combines creative aesthetic research onto primer bio-electronic aggregates research, with laboratorial situations, where biological living systems communicate with electronic systems, in the case, an ant colony and laser beam rhythmically composed, respectively. As a cyber-environment, this audiovisual system feedback to its source, by casting laser beams onto the ant colony making mazes with electronic formation.

Ant Ennae Labyrinths was created within a project developed on ants, in which about 70 ants, placed inside a thin acrylic vertical structure filled up to three quarters of its height with bare and decontaminated earth, and with plenty of access to food and water on the top level of the acrylic enclosure, were augmented with robotic laser light projection, during exhibition settings and often in the author's house. The work establishes human interaction with the bio-electronic system combinations through a physical computation bridge made from a joystick connected to the robotic laser. This laser, which is s373.net/x studio's 8-bit graffiti polar plotter, is evolved from an awarded open source system at Lisbon's Maker Faire (2015) code named inky[50], a small painting bot capable of throwing

---

[50] Inky's description, imagery material and reference implementations on hardware and software are documented at https://s373.net/x/inky/. You can also find a more recent sibling firmware called Samian open

ink/watery liquids, or projecting lasers, using a pan and tilt servo mechanism coupled to a projective source. In most cases on Ant Ennae Labyrinths, when humans are not interacting with work, the machine is projecting pulsating laser patterns according to labyrinth designs interfered by electronic processes, shown side by side with a camera feed on the Ant Ennae Labyrinths' screen monitor. The ants are thus continually constructing and fabricating a space for themselves enveloped with non-human electronic interference. The ants become antennas susceptible to interference from the electronic patterns derived by the laser radiation as they carve their labyrinths (see figures 12, 36, 39, 44).

c) Half-Ant (2020)

Half-Ant is another hybrid bio-electronic ecosystem, made up in part by microelectronic processes, in part by biological aggregates of animals, that stimulates an ant ecosystem with visual patterns derived from slowly evolving pure generative cellular automata mathematics. As a cyber-environment of non-human machine interaction, it is also focused on establishing means for a hybridization of the non-human biologic and electronic domains into cybernetic bio-electronic aggregates, through a bio-electronic computation situation concretized as cellular automata visuals evolving on a LCD screen on top of which an ant colony thrives. Like other dynamic works, it addresses non-human bio-electronic apparatuses or devices, seeking to establish different sorts of electronic, electrical, algorithmical channels of communication and experimentation, in the biological and electronic domains, in the creation of seed structures coupled to ecosystems (see figures 10, 37, 38).

sourced at https://github.com/s373/samian000.

2.1.6 More bio-electronic aggregates

This section describes four more bio-electronic aggregates, namely Honey Krater (2019), Bioscope #1 (2020), Wolfmachine (2020-22), Wolfspace (2019-22), distinct from the three described above (2.1.5) by the type of user-construct bridge.

d) Honey Krater (2019)

Honey Krater exhibits a touchable live cymatics bio-electronic system. It is inspired in the honey offerings ancient greeks did at temples surrounding labyrinth mythology, which Kerényi so accurately and delicately describes (Kerényi 1963). A honey based watery solution is vibrating on a woofer according to the sound waves made by a trio of robotic voices, chanting portions of Nietzsche's Ariadne's lament, from his last book of poems, Dionysian-Dithyrambs. In Nietzsche's poem, Dionysus adverts Ariadne after her lament he is the one she seeks mistakenly on Theseus, he is her labyrinth[51]. On the work, touching the smartphone produces these electronic choir divinations as short segments of sound, which in turn undulate the surface of the honey solution. A directed green laser light bounces on the liquid surface and is projected on the wall behind, visualizing with intricate cymatic patterns amplified laser projections of mesmerizing shapes induced by sonic honey divinations. Over the work's exhibition period, the honey based solution quickly starts to grow organic materials, growth also coupled to the laser visuals derived from the electronic system executing as an Android app, completing this bio-electronic cybernetic system. Honey Krater's mode of cymatics is quite similar to the before mentioned Struct series (see 1.1.1), to its precursor work (je t'aime..., 1998)[52] to the sound engine in all structs and particularly visual resemblant to Struct_4 (2006)[53] and Struct_5 (2006)[54]

---

51 Paraphrasing "I am your labyrinth" from Nietzsche's 1891 Dionysos-Dithyramben (Nietzsche 2011).
52 "je t'aime..." (1998) is his first site-specific work with continuous sound. It sends the sound from a space, through directional microphones, which translate the vibrations created by the environment's sounds and people moving around, into a woofer modified in order to contain fluids. The physicallity of the amplified sound creates concentric cymatic patterns that vibrate on the water surface of the column/object to the sound details captured by the microphones. The device also amplifies the fluid oscillating patterns using a light projector and a mirror to luminously enlarge the patterns at the woofer (https://andre-sier.com/projects/jetaime/).
53 https://andre-sier.com/struct/struct-4/
54 https://andre-sier.com/struct/struct-5/

Figures 174, 175: *Honey Krater* at Lady of the Labyrinth's Honey exhibition at Zaratan art gallery, Lisboa. (see also figure 11). Pictures © Lise Bardou 2020.

e) Bioscope #1 (2020)

Bioscope #1 is an immersive and interactive playful audio-visual bio-electronic environment. It is a playful installation creating a biological augmentation electronic instrument and an immersive cathartic audio-visual environment. Thus, Bioscope #1 is, at a time, a spatial game between humans and non-humans; a place for experiential meditative inquiry into the bio-electronic realms of life on earth; and a space shifting submersion ambient, transporting humans to a bio-gameplay experience, Petri dish sized, with an interactive video game floor and space altering mechanized laser projection through biological lenses. On Bioscope #1, that interactive video floor evolves a digital simulation based on algorithms of Physarum polycephalum growth models (Adamatzky 2014, Jones 2010), which are extended to include interaction with moving blobs, obstacles and areas of influence of positive or negative forces.

Visitors interact with the simulation by walking / performing on top of the video projection. Through this interaction, they influence both the digital simulation and the growth of bacteria scale biological material on the installation space. This double influence is evidenced on the immediate response from the simulation, since the particles of digital bacteria are attracted or repelled from their locations, as well as on a biological solution of Physarum polycephalum, following visitors actions detected through computer vision.

211

This biological ecosystem is evolving on a petri dish at the focal point of the lenses of a laser telescope / microscope, whose lightning patterns are influenced by visitors' movement, a biological device instrument which in turn operates as the lenses to a laser light that is computer controlled through the human movement interaction. Telescopic or microscopic interactive devices, zooming the bio-electronic, capable of magnifying biological or electronic spaces at an immersive large room scale, bathing multiple humans as players, cooperating or competing with a digital interactive video floor projection of a slime mold simulation while influencing living, growing, biological Physarum with distinct laser light patterns derived from gameplay interaction parameters and electronic logic.

Through computer vision and their spatial movements, human visitors are embedded within an audio-visual bio-electronic videogame, becoming food sources or repelling agents, playing with a magnified biological evolution of a population of digital Physarum polycephalum, a single cell amoebae-like creature known to remember, anticipate, decide and grow the most efficient ecosystem networks, inhabiting the planet since at least 600 million years ago (Jones 2010). Certain human/non-human game parameters and spatial configuration interactions between the visitors and the Physarum particles on the video floor gamespace activate different patterns on a bio laser projector second light source to the installation space. The laser projector utilizes and influences a growing biological culture of a Physarum organism on a Petri dish as lenses to project scattered and pointillized green laser light dots through the amoebae creature which continuously transforms the slime molds' and humans' sensory perception of the bio-electronic gamespace they are submerged in.

Beyond usual human scales of sensory apprehension and modes of being there lays a myriad of near invisible lifeforms sustaining ecological balance and whose social behavior greatly differs from human ones, usually striving for the species' colonies common good within an amenable habitat, with exemplary adaptation, balanced resources usage, millennial enduring examples, bottom up social emergent architectures. Space shifting, immersive bio-electronic videogame ambients could submerge humans to the experiential intuition of the shadows projected by the small movements of a balanced planetary life. The Bioscope series of interactive artworks, within the Wolfanddotcom research line of inquiry onto imaginaries of animality and cyberspace post-Anthropocene, creates

perception altering electronic experiences susceptible of human immersion towards bio-electronic realities focusing playful experiences located at sense scales not easily grasped by humans. This work was developed and presented during V2_ + Museu0 Artist in Residence 2020, V2_ residence 17-25 september 2020, Museu0 residence 15-23 october 2020. The work was exhibited at the exhibition "Intimate Observations: On conducing Earth Observations", curated by Florian Weigl (V2_), Boris Debackere (V2_), Joana Carmo (Museu0), that happened at Ermida de São Roque, Tavira, october 2020, featuring works by Francisca Rocha Gonçalves, André Sier, Matthias Hurtl, Jelger Kroese (see also figure 4).

Figures 176, 177 *Bioscope #1* detail human interaction and laser bioscope at Intimate Observations, Ermida S. Roque, with curatorship by Florian Weigl and Boris DeBackere (V2_), Joana Carmo (Museu0).

f) Wolfmachine (2020-22)

Wolfmachine is a bio-electronic work designed for wolves and non-human ecosystems comprised of mini electronic laser-lighthouses[55], robotized and programmed from the ground up, scattered on the landscape, that sing in synchronicity visual patterns, through the rhythmic and composed emission of beams of green laser light towards the sky and surrounding landscape. The generative composition performed by the lasers is based on the historical data of the evolution of the lupine population in Portugal throughout the XXth century. Each decade of data from all Portuguese municipalities gathered by the scientific research from Grupo Lobo[56] consists of records of sightings of living or dead wolves where it is possible to observe the geographic distribution of Canis lupus signatus

---

55 Using and evolved version of the before mentioned open hardware and software 8-bit polar plotter system inky, please see 2.1.5 b) for extended information on the hardware and software.

56 The scientific collaboration with other institutions such as Grupo Lobo and CIBIO was already addressed under 0.4 methodology and 0.5 ethical issues; refer to these sections of how and why this data and collaboration was essential for the realization of some of the projects in the wolfanddotcom series.

throughout time (1901-2000), until its current near extinction. The electronic composition, repeated uniquely and generatively every hour, is divided in 10 sections, where each of these, representing a decade of data, have equi-temporal durations of 2.5 minutes, and where the numerical data of lupine population in Portugal grouped by regions south, center, north, coastal, interior, determine the types of movements performed by the lasers, as well as the rhythm of their luminous pulses.

Since the work was built with wolves in mind, a representative tribute machine introductory to the inner complexities of this wondrous beast, resonating a physical implementation of the videogame Wolfanddotcom network nodes topologies, its main deployment installations facilities have been selected in open semi-natural regions of Portugal, known from previous occasional lupine sightings and encounters, but absent of wolves nowadays, regions where ecosystems blur and diffuse between the human and the non-human, with the prospective idea of establishing beacons of light and communication among this non-human population. Within gallery or museum installation settings, like Wolfmachine Cerveira[57], it encompasses a bio-electronic installation (Wolfmachine) and video records of landscape deployments (Wolfmachine video, further described - 2.2.2 b), until the opening of the exhibitions and often also as video background to installations of the work. The lasers in the landscape visualize the near extinction of the apex predator essential to the forest biodiversity through electronic chanting. Wolfmachine, designed from wolves and for walves, simultaneously operates as a protective visual barrier on the landscape for the animals, and as a metaphor of the encounter of wolf howls, among their packs, that gather to intone near shamanic chants, tele-comunicating with the unknown and evoking protective omens. Wolfmachine Cerveira (Wolfmachine and Wolfmachine video), that derives from the art-science project "Os Lobos em Portugal" from ArteCódigo Associação Cultural, is possible thanks to the partners and support of the project. Wolfmachine has the conception, artistic direction and code by André Sier. Hardware realization by Tiago Rorke, Maurício Martins, MILL, s373.net/x. Filming and drone by André Sier, Henrique Casinhas, Tiago Fróis. Production by ArteCódigo. Co-production by Grupo Lobo and CIBIO. Support from Direcção Geral das Artes, Câmara Municipal de Mafra, Município de Paredes de Coura. And counts with the partners s373.net/x, MILL,

---

[57] Wolfmachine Cerveira consists of a bio-electronic installation (Wolfmachine) and video records of landscape deployments (Wolfmachine video), until the opening of the exhibition Espaço/Programa at Fundação Bienal de Cerveira, from 23rd April to 12th June 2022.

Cultivamos Cultura, Oficinas do Convento, FBAUP, Fundação Bienal de Cerveira (see figures 13, 46, 70).

g) Wolfspace (2019-22)

Wolfspace is an interactive century deep visualization and sculpture making tool of movements of wolves over time delineating their space. It emerged as response to attempt to solidify wolves' territorial lines across time over a human defined country territory. The work resorts to historical XXth century data gathered by Grupo Lobo, as well as geolocation data (GPS) gathered by CIBIO. We just saw under Wolfmachine how the historical data was utilized to generate laser patterns. Here, on Wolfspace, the same historical century deep data generates wolf particles at approximate 3D locations within the specified municipalities and decades of occurrence on an interactive 3D digital representation. Using a voxelizing algorithm (further discussed on static art-sci constructs Binary/Biological Sculptures, Labyrinth Players (Eu-Abstracto)) the wolf particles inject matter into void space, making a sculptural mesh representative of the areas of their occupancy at a given time within the XXth century. A similar procedure of sculptures produced by accumulating the positions of near extinct iberian wolves in the wild was utilized with the GPS data provided by CIBIO. Wolf GPS data was obtained by monitoring their activities remotely, using lightweight GPS collars on wolves. What interests the most about this data to the author is the fact that it records actual positions of live wolves on the territories they can occupy, while not being humanly observed[58], often far away from contact with human photographers and videographers, or even tampering camera based prosthetics, under their own most natural animal behavior. The used data provided by CIBIO monitors three wolves from distinct packs over the years 2012-2014 and it was the reference data through which it was possible to solidify a sculpture of the actual cartography they inhabited throughout these years in regions close to northern Portuguese Spanish borders. A similar simulated time is used in both simulations, which loops endlessly at a constant speed within the given intervals of the 20th century, as well as more recent and more technological geo-locative data. Both simulations cast particles at the transcribed 3D positions on the virtual space within the given simulated time and it is

---

[58] It is a known fact that the olfactory sense of wolves is on scale orders of tens of kilometers, and through it they can detect presence of other living organisms tampering with their natural behavior while unobserved (Robisch 2009).

possible to user navigate within these sculptures. The Wolfspace app, part of the before mentioned supported project "Os Lobos em Portugal", was exhibited first at solo exhibition "Mel da Senhora do Labirinto" at Zaratan gallery in Lisbon 2020, is also an integral part of the Uivo solo exhibition, which features a lupine selection of works from the wolfanddotcom series, shown at Casa da Cultura, Ericeira 2021 and at Centro Cultural de Paredes de Coura 2022. The Wolfspace app is now freely published as an Android app by ArteCódigo Publicações, at https://artecodigo.pt/pub (see figures 71, 72).

2.2 Static art-sci constructs

The static art-sci constructs produced within the wolfanddotcom series consist of a number of aesthetic objects in a novel and authorial artistic language, encompassing 3D-printed fabricated sculptures, machinic plotter drawings, photographs, drawings on photographs, videos and organic paintings, the latter being generative vegetable graffiti featuring a certain level of living condition that differentiates them from the other static artifacts. Most of the static artworks are built both for the refinement of techniques involved in the creation of cyber-environments, as well as to return tangible constructs, to bring back to non-technological reality generated artifacts from these bio-electronic worlds, objects whose function is that of poetically addressing and underlining the mythos and the ethos, surrounding and embracing the methods of artistic exploration and creation. They reflect the research undertaken so far not only on electronic data, in the microscopic and macroscopic scales, to generate the entire virtual visual (landscapes, textures terrains, typologies) and sonic composition of the videogames, but also on field data collecting, both bio-data and electronic data, as well as their use, leading to the creation of bio-electronic dynamic devices.

The essence of this thesis research is the proposal (and the artistic practice based achievements) of dynamic art-sci constructs that use interactive immersive electronics as bridges towards cathartic non-human otherness embodiment in a post-Anthropocene epoch, where each user can play-enjoy-experience always unique and practically unlimited cathartic phenomena, whenever venturing into the artistic cyber-realm. The static-aesthetic constructs – also thesis research achievements that address the core mythological, artistic and philosophical considerations underlying and leading to the more complex dynamic works – are equally artistic outcomes of key importance in the thesis, since they offer and allow contemplation of unique moments captured among the phenomena experienced with the dynamic constructs. In this way, likewise to what happens with traditional countless human made artifacts, they perform the essential aesthetic function of any artwork, which is to be virtually open to infinite readings and interpretations determined by the singularity of those who contemplate them, although, unlike dynamic artistic works, they are final works, finalised at the time of production, which maintain their identity and immutability during fruition by the user/receiver.

The creation/materialization of each static work in this research, being closely associated with a specific dynamic work, leads to the respective description in the following sections inserted in the group that gathers all the static artworks with which this association occurs, regardless the type of the static artifact to describe. Refer to table W1 for an index listing of all static art-sci artifacts discussed here.

2.2.1 Videogame Wolfanddotcom's group

a) Neon Paleolitikos Drawings (2017)

A series of plotter based drawings, 50x70 cm each, with data excerpts and some wolf characters, performed on a plotter with ballpoint pen on fine art 250gr paper, from code that visualizes the visual patterns of byte sequences from programs and electronic processes on GNU/Linux systems. The shown binary information is converted to image and terrain elevations of the Woldanddotcom environment, from a microscopic observation to the rhytmic information patterns (see figures 14, 49).

b) Wolfanddotcom Drawings (2017)

Drawings on fine art 250gr paper, 62x45cm each, generated in code from the sculpted space of the Wolfanddotcom videogame, by projecting textures and terrains in 3D space from granular analysis of byte patterns from programs, files and running processes in the GNU/Linux system.

Figures 178, 179 *Wolfanddotcom Drawings* at Neon Paleolitikos, solo exhibition at Ocupart, Lisboa.

c) Wolf-Totems (2017)

Series of sculptures, of about 7cm3 each, performed as 3D totemic sculptures printed in PLA[59] plastic, on a 3D printer. They combine Wolfanddotcom's wolf animation moments into Wolf-Totems, totemic aggregates architectural sized landmarks in the virtual space of the videogame (see figure 50).

---

[59]   PLA plastic is a synthetic thermoplastic polymer that represents a biodegradable option, which can be mechanically or chemically recyclable, biocompatible and bioabsorbable by Gaia.

2.2.2 Wolfspace App's group

d) Totem-Lobo #1(2021)

The totemic sculpture, Totem-Lobo #1, is a generative structural portrait of the Iberian wolf in Portuguese territory, representing the delicate condition of population decline until reaching the near extinction of today. It is equipped with a wireframe metallic structure to give it solidity, which is completely wrapped in bamboo reeds and splattered with a small bio-electronic ecosystem that meshes live mosses and small plants with pieces of electronic circuitry. It is expected that over time the biological material will evolve, the bamboo reeds degrading depending on whether or other environmental conditions, possibly showing pieces of the structural metal, the plants growing or drying, thus giving rise to a generative sculpture of slow motion dynamics dilated along the time, also creating a portrait of the evolution of the Portuguese lupine population. The sculpture, sized about 2.5m height, is fixed to the ground where installed, with metal bars welded to the sculpture's basis and embedded in a subsoil cement shoe, in order to prevent falls or displacement risk.

This series of public art sculptures began in the above mentioned 3D printed series Wolf-Totems (2017). The first large sculpture, Totem-Lobo #1, has already been installed (summer 2021) as a permanent public artwork at the Iberian Wolf Recovery Center (Municipality of Mafra, Portugal). A second sculpture, Totem-Lobo #2, will soon be installed at the headquarters of ArteCódigo in Santarém, also aware of the near extinction of the Iberian wolf and motivated to defend its preservation (see figures 17, 69).

e) Wolfmachine video (2020-22)

Wolfmachine video is a video recording of green laser-light beams, rhythmically emitted by mini electronic and robotic laser-lighthouses, towards the sky and the surrounding landscape during implantations of the Wolfmachine bio-electronic

installation (see 2.1.5). It offers the visualization of the wolf presence in Portuguese geography throughout the 20th century, painted with patterns of green laser-light beams, in which the rhythm of the luminous pulses and the movements of the lasers correspond to the numerical data, collected between 1901 and 2000 by Grupo Lobo scientific research (Centro de Recuperação do Lobo Ibérico), on dead or alive wolf sightings, in southern, central and northern regions of Portugal.

Particularly when serving as a video background for the installation Wolfmachine in exhibition contexts, by presenting those shamanic patterns related to the presence of the wolf in Portugal, which evoke howls, electronic chants, omens and protective pleas telecommunicating with the unknown, it also can serve as a mean to, through art, alert to and spread out the near extinction of the species, while convoking for the protection of this endangered, legendary-totemic-mythological apex predator, essential to the biodiversity of the ecosystems it inhabits, thus a strong theme in the world's natural and cultural heritage.

Figures 180, 181: *Wolfmachine Video* still images.

f) Biowolf218 (2021)

Biowolf is a series of generative structural portraits on wolf subjects in a post-human three-dimensional fractal environment, which are made as vegetable graffiti, using biological plant-based inks, living matter that slowly evolves, growing or withering, in the urban art forms in which it is applied. Biological graffiti paintings have been investigated by the author as artistic alternatives to dynamic and generative works, endowed with a life of their own and presented without the use of electronic substrates, only with colored biological material, applied at different scales, occasionally in paintings, but more often in

an enlarged format, occupying walls or buildings' facades. Through these technical ecological and innovative alternatives of artistic creation, the artworks are materialized as works that change, gaining life or perishing, depending on the environment in which they are installed.

Given their graffiti nature, where the combination of aesthetic and social functions of the artworks tend to be stronger, Biowolf's biological portraits also are one of the works of the wolfanddotcom series that exalt the importance of non-human apex species in the preservation of biodiversity, while showing their fragility, resulting from their current situation as threatened or endangered species. The objective is then the creation of artifacts in art-science that, in addition to their aesthetic function of promoting culture, offering themselves to the fruition of those who contemplate them, also can generate opportunities to rethink attitudes in the preservation of natural and cultural heritage, a condition essential for a more sustainable society. In the case of the Biowolf series, the theme the portraits paint is situated in a hypothetical scenario, increasingly tangible, of a post-anthropocene and bio-electronic near future, explored along the line of the pieces within the wolfanddotcom series. The focus is on the wolf that, in decline or risk of extinction, imposes the struggle to be preserved, through multiple interventions in which art can affirm itself as the language of election (see figures 59, 60).

2.2.3 Half-Plant installation's group

g) Binary Sculptures Series (2017-)

Binary Sculptures is a fabricated 3D printed sculpture series which spawns unique three-dimensional object structures from byte patterns of programs, files and running processes in the GNU/Linux Filesystem. Byte sequences provide source data to voxel space, meaning that the data is source to custom generated voxelizing algorithms in order to construct polygons, which are transformed into 3D structures, sculpted material artifacts (in fluorescent yellow PLA plastic, approximately 7cm3 each) that reveal unseen architectures, tightly related to the inner living workings of an operating system's ecosystem (see figures 28, 52).

h) Biological Sculptures Series (2017-)

Biological Sculptures Series features the meshification of raw electrical data captured from plants and other living biological aggregates. It is a fabricated 3D printed sculpture series which spawns unique three-dimensional object structures (in fluorescent green PLA plastic, close to 7cm3each), from digitized sequential electrical impulses obtained from the living organisms. The series started with plants, where electrical fluctuations resulting from exposure to light, water, night and day were recorded over time. Later, contraptions like in figure 126 were also applied to animal and human bodies (including the artist himself), giving rise to sculptural electric plant and animal portraits, of limitless complexity, which the author refers to as biological-mathematical palaces. Sculpture creation starts from the capture of raw electrical data flows in biological aggregates, this data being then transferred to digital information (digitized sequential electrical impulses), and voxilized through custom generated voxelizing algorithms, that is, arranged in a three-dimensional grid by transposing the gathered data into a spatial domain, to later 3D printing (see figures 127, 138, 139, 143). By superimposing electrical information, layer

after layer, delicate, fragile and unique sculptural forms are created, which end up revealing invisible flows of life present in all biological organisms and electronic mecha.

i) BIND (Binary Drawings) and BIOD (Biological Drawings) (2019-)

The BIND drawing series is a set of drawings on fine art 250gr paper, 46x30 cm each, generated in code from granular analysis of byte patterns from programs, files and running processes in the Gnu/Linux Filesystem, which are later machine fabricated through custom plotter machines, by undergoing a series of graphic procedures leading the data to become rhythmic lines of intensity registered in two dimensional drawings. The BIOD drawing series, a set of 46 x 60cm sized, plotter drawings on fine art paper, is generated as vector drawings in code from granular analysis of signal analysis of raw electrical data captured from plants and other living aggregates, which also are later machine fabricated through custom plotter machines and graphic procedures that lead the data to become rhythmic lines of intensity, registered in two dimensional drawings. One aspect worth highlighting is that the lattice-like drawings of the BIND and BIOD series, consisting of black lines of data intensity drawn on white paper, make evident the similarities in data and resonance frequencies between the raw data of biological or electronic origin. See figures 53, 54, 125.

2.2.4 0X Labyrinth's group

j) Labyrinth Drawing Games (2011-)

Labyrinth Drawing Games is a paper game series of drawing-games performed by two humans, where alternating one builds and the other solves the labyrinthine game. Freehand exploration of drawing patterns associated with the purpose of gaming (see figure 167).

k) Labyrinth Players (Eu-Abstracto) (2019-20)

Labyrinth Players (see figures 61, 62, 63, 64) is a series of 3D sculptures of the virtual players present in the videogame 0X Labyrinth. They have approximately 10x10x16cm each, being made in PLA plastic. The series consists of a set of abstract portraits made from digitized sequences with 3D cameras of three-dimensional point clouds of people in spatially accumulated movements, where unique frames or several temporal moments collide in the same space. It emerged in a process similar to the Eu-Abstracto sculpture series (2014), a special limited edition of 25 sculptures made from Skate.Exe sequences.

l) 8-bit Maze Gardens (2018)

8-bit Maze Gardens is already described at 2.1.4.b.2, and is present in this topic for being the core algorithmic technique design for most levels of 0X Labyrinth. As described above in relation to the Biowolf series, the inks also are biological plant-based materials, thus constituting living matter that slowly evolves, grows or withers, in the artworks where it is applied. Consequently, due to the use of this kind of ecological and innovative technical alternatives in the artistic creation, the artifacts are materialized as works that change along the time, coming to life or decaying, according to the environment in which they are installed. However these special inks, since they are mostly moss based, can be brought again to life, simply by seeding the proper nutrients to these organisms, triggering a new beginning.

2.2.5 Ant Ennae Labyrinths' and Half-Ant's group

m) Eusocial (2018-)

Eusocial is a series of photographs of bio-electronic ecosystem research, obtained by stimulating ants with laser interferences and photographic observations inside their natural habitats. The photographs are sized near 43 x 27cm each (see figures 12, 55, 124, 125).

n) Ant I Purga (Es7#agos da Formiga Br4nca) (2019)

The archive/library of the Arquivo Nacional da Torre do Tombo, Lisbon, Portugal, is a repository of contents of extensive cultural and historical value, a metaphysical territory as infinite as time itself, an ever-expanding continuum that aims, as opposed to just storing materials, works of art, documents, books and manuscripts, to also take care of the knowledge it contains, preserving it, protecting it, and restoring it when necessary, in compliance with the imperative of knowing how to bequeath it.

In the artwork Ant i Purga, the author proposes a turnaround in the way of seeing the ecosystem of this monumental setting, suppressing the anthropocentric perspective and exploring a world that is often invisible to the human eye, although equally submerged in the physical, metaphysical and imaginary territory of archives and libraries. In this sense, and based on the photograph 'Estragos da formiga branca' (1929), exhibited at the Arquivo's Research Portal, the artist focuses on the animal species known as termite, an infesting ant whose presence in the archives must be eliminated (by purging), since it feeds on wood or paper and, escaping the purgatory, shreds portions of human archives and creates what can be called its own archives, the labyrinthine structures that it builds from the pulp of books and documents in the territories it inhabits.

In an analogy based on the poetic perspective of non-human centrality (underlying the vast majority of his artistic work), the author also focuses on another non-human co-inhabitant of the territories in which the termite lives, the entity "processing electronic data and digital technology", which also creates specific archives (the digital archives) by digitizing documents, artworks and other components of the human archives. Digitizations (the photographic images of the original archives, obtained by processing computer data that records in the JPG codec) are subject to the limitations of digital technologies that escape the "purge" of imperfections almost impossible to correct, leading digital archives to be collections of imperfect images, mere echoes of the originals' reality.

Ant i Purga (Es7#agos da F0rmiga Br4nca) was created in this context as a series of photographs of insect habitats in national archives, which intersect with drawings made from electronic micro-observations of photographic image data. This crossing, or overlapping of the territories that are the common habitats of non-human protagonists, potentiates an unconscious trigger for the fear of loss in those who contemplate the images produced. It was built as a site-specific project for Umbigo's Portuguese art magazine #68, with a text by José Pardal Pina about the project.
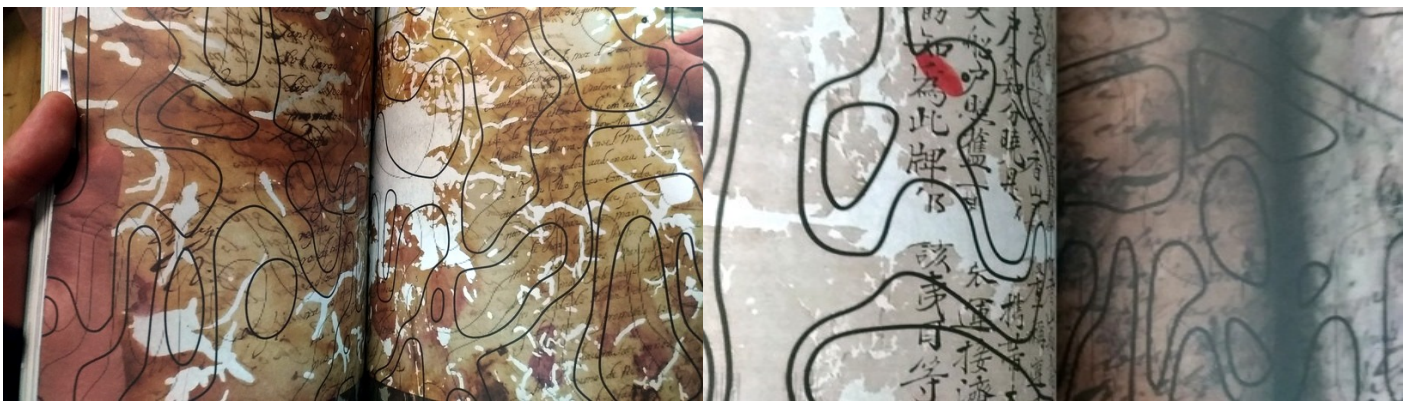
Figures 182, 183: *Ant i Purga.* Drawings superimposed on photographs at Umbigo Magazine #68, 2019.

o) Ant Ennae Videos (2019)

Ant Ennae Videos is a variable ensemble of video moments which portrait a visual rhythmic voyage to the interior of the intimate bio-electronic universe of ants and lasers, set at the borders between the landscape and ant's houses, palaces, even megapolises. The

video translates the result of dynamic algorithmic assemblages obtained from images captured in the interior of natural anthills, where the ants react to computer and human generated laser lights (see figures 55, 56).

p) An Observer ToL: Sierpinsky, Ikeda, Log, Navier-Stokes (2019)

An Observer ToL is a video that follows the line explored through Ant Ennae Videos, not because both are focused on ants, but due to the resembling features as videos obtained from experimental/reflexive work on the sensory apparatus of a non-human being (ants, in the case of Ant Ennae; electronic, in An Observer ToL), while receiving streams (laser light or data, respectively in each case) coming from an exterior world.

The research under An Observer ToL seeks answering questions such as:

- In the data age, could computers derive meanings, attain awareness, through synthesis, fractal, chaos?

- Capturing and observing visual and sonic data flows tampered with chaos and fractal algorithms, as well as inner running processes in machine-space, can modify the incoming data streams?

Online, An Observer ToL is a 6' excerpt from a 16' video work (ed. 2), captured in real-time from a machinic point of view, when reflecting on the infrastructure of an electronic being's sensory apparatus while it (he/she) is receiving data streams that apparently come from an exterior world, if it exists. In the data age, An Observer magnifies selected incoming streams, trying to establish classifications and derive meanings, augmenting subtle and near invisible data traces resorting to chaotic and fractal mathematical synthetic models such as Sierpinsky, Ikeda, Logistic, Navier-Stokes, before propagation of the viral content.

q) MetaPh photographic works

Similarly to An Observer ToL, the description of MetaPh happens here, due to their character of artworks created from experimental/conceptual practice-based research.

MetaPh is a series of analog photographs, focusing on the mechanics of organisms' viewing apparatus, through the insertion of distinct combinations of reflective / refractive / fractal forms of visible light, right after the image sensor and before the exterior world (which sometimes holds originals of other artworks). With variable dimensions, the MetaPh series' photographs can be standalone photographic works, or texture/maps/game-logic basis elements, for works such as the aforementioned (2.1.4) 0X Labyrinth. See figure 0 and instagram.com/a.sier.

3. Conclusion

This first part of the concluding chapter has the purpose of writing the final words of this thesis, retrieving its conceptual basis and course, summarizing and putting into simple words its broad context, research field, assumptions and particularly the pathway designed by its most significant determinants.

It has long been recognized that the arts can play a transforming role, either by arousing in humans and seeming to quench a spiritual restlessness of incompleteness, a deep need for something superior, fulfilling, or by inducing a positive transforming cathartic state, self-operated by contact and confluent communication between a form of artistic expression and its receivers or users. It is also unquestionable that artistic products and cultural artifacts accompany and mark history, inevitably reflecting society's problems from different perspectives and perceptions. Abstract art, for example, besides heading in directions other than realism, derives tools for meditative, rhytmic introspection. According to its creator Wassily Kandinsky:

> [...] art is not vague production, transitory and isolated, but a power which
> must be directed to the improvement and refinement of the human soul – to, in fact,
> the raising of the spiritual triangle. (Kandinsky 1998[1911]:57).

Brian Eno, the creator of ambient music, also invites towards inner thinking and abstraction by using the effects of a tendentiously zero discretely changing music evoking familiar yet unkown places, provides an aesthetic sensory experience that is in the search for the immersion that will end up to influence the behavior of the user/listener:

> An ambience is defined as an atmosphere, or a surrounding influence: a tint.
> My intention is to produce original pieces ostensibly (but not exclusively) for
> particular times and situations with a view to building up a small but versatile
> catalogue of environmental music suited to a wide variety of moods and
> atmospheres.[...] Ambient Music is intended to induce calm and a space to think.
> (Eno 1996[1978]:296)

Raptures and periods of crisis urge artists to investigate new artistic domains and new methods, to create artistic works that intrinsically induce a practical positive catharsis, with the potential to promote the individual transformation of its users and consequently to transform society. The need for human transformation grounds on the universally held belief that "humans were generated by «Mutter Erde»" (Eliade 2000[1957]), translating the standpoint that the human condition is natural, the human is an integrant element of nature, and precisely due to that, it is imperative, for its own survival, to build the concept of a new humanism, based on inspiring models for the transformation of individuals and for the organization of society on a planetary scale, the latter requiring an urgent strategic action of survival, supportive and coordinated, as among wolves, ants and bacteria too.

In the obscured exciting times we are going through, the author of this thesis, as a contemporary artist seriously committed to contributing to the high purpose of positive social transformation through art, developed his investigation from a compelling desire to achieve the goal of gathering and advancing knowledge embodied in the practice of a nascent field, which combines areas such as aesthetic computing, interactive electronic arts, videogames, mythology, biology and (non-)human-computer interfaces. Doing so, he challenged the prevalence of a lack of artworks with the power to induce positive cathartic states to transform society through the individual's transformation, a lack that reveals an apparent inattention in this research area, regarding the purpose of the art's transformative social role.

His creative practice has been developed for several years within a multidisciplinary and broad domain, including many arts (painting, sculpture, music, cinema, videogames, technoethics), sciences (philosophy, mathematics, biology, ecology, mythology) and engineering (informatic computation, electronic circuitry, machinic fabrication, electro-technical and systems programming), more specifically in the above mentioned nascent field, essentially focused on bio-electronic and imaginary arts, alloyed with a non-human turn that marks out the global area of his research.

Based on the reflection on his and other authors' relevant work, the investigation within the thesis' scope maintained the same focus, establishing multiple lines of flight, seeking novel, procedural, immersive, playful, cathartic and bio-electronic methods, designed as playful aesthetic cybernetic environments, generators of interactive time spaces that summon play, for human and non-human engagement, as grounds for establishing deeper humane spiritual connections. As basic research assumptions, overarchingly, he considered that aesthetic, interactive and immersive experiences in non-human cybernetic themes and environments go beyond mere entertainment and can be a valid tool inducing the desired transformative positive catharsis that enhances a critically conscious cyber-humanity. He also considered that investigating factors of innovation in the creative process of this broad area leads to the creation of poorly or not mapped artistic outcomes, which contribute to the advancement of knowledge in the area and, in this way, enhance the broadening of the base for the establishment of the ambitioned deeper humane spiritual connections. That is why he established the process of artistic creation in this area (namely the process assumptions, methods and outcomes) as the object of study of his thesis' research work. It included not only theoretical epistemologically based investigations and the outlining of a broad research field (TA, IA, 0R, AL, ZG, ZS, 0, 0D, LEA), but also the creation of artistic constructs (W0, W1), in the form of mythological videogames and bio-electronic installations, as well as static art-sci artifacts, in the form of 3D sculptures, drawings, photographs, videos and organic paints, all of them related with the main cybernetic creations within the wolfanddotcom series.

In the thesis research field, a wide range of domains were explored, ranging from mythology to electronic arts, biology, painting, music, mathematics, programming, sculpting, VR immersion, philosophy, videogames, physical computation, non-human research, bio-electronic aggregates. The research space has thus been mapped within a broad landscape provided mainly by the mathematical theory of communication, differential philosophy, complex numbers, chaotic and fractal algorithms, self-recurrence and strange loops, electronic and natural cybernetic systems towards non-human ontologies, which are, according to Flake (1998), "the computational beauty of nature". However the deepening of most of these areas, as an objective in itself, was beyond the scope of the thesis. In the research process, primacy was attributed to practice, probing, testing, prototyping new ideas, in a word, the emergence of practice implemented across

multi-media, i.e., the arrival point of creative production. Following each resonating theme (a new departure point, to bring again to life and from new perspectives, original ideas) led the theory through multiple lines of flight, returning to aspects that were subsequently reflected upon, refined and conceptualized.

Addressing the main conceptual aspects of the works produced during the artistic practice-based research (aspects that are axial to a structure for playable non-human immersive cybernetic environments), it was inevitable to create words, aiming to delimit and identify the regions of interest and to consolidate the core aspects of this and other future investigations. The words thus crafted (*panvision, zenospace, imaginary art, zero reality, gaian field, aspatiality,* and *quantum-now*) represent fuzzy new under-explored areas in the universe of concepts that have built these sorts of immersive technologies and entangled bio-electronic communication, which include both cybernetic assemblages coupled in symbiotic systems adhering to users, and their ilinxian repercussions on the human plane, at the physiological and psychological levels. These key-terms also express relevant contributions to the advancement of knowledge proposed by the carried out research, in relation to "how to tackle conceptually" and to "how to produce" artifacts upon human out of bounds regions.

Most significant determinants of the research development have included the impact of programmable arts, computation, philosophy, along with the manifold influence of computational pioneers (who laid grounds for networked machines, computer graphics, digital sound processing capabilities on 2250/pds/pdp/unix/gnu/linux terminals), of scientists and artists programming alike, of hackers and painters, in an intellectual wild west (Graham 2004)[60]. Particularly relevant was also the influence of both the special focus placed by the research on some non-human living beings, and the use of their more specific peculiarities in the artistic works. That underlines a distinctive approach to art making, aimed not only to contribute to the formation of new aesthetic knowledge, but also to induce a user transformative cathartic state within safe ilinxian regions. This state is consequential with the experimental embodiment shift from the human towards non-

---

[60] Hackers & Painters: Big Ideas from the Computer Age is the title of a book by Paul Graham (2004), as well as his own expression of intellectual wild west. The book contains several interesting insights from his own anthropological research of cyberspace's makers and tenants for tourists to enjoy. "GOOD DESIGN IS HARD. If you look at the people who've done great work, one thing they all seem to have in common is that they worked very hard. If you're not working hard, you're probably wasting your time." "Wild animals are beautiful because they have hard lives". (Graham 2004:136-7)

human alternatives, self-operated through exploration and communication with the artworks, due to the innovative aesthetic, immersive and non-human characteristics they have. Intersecting videogames with animals, e.g. dragons or wolves, apex predators of the mythological and the non-human ecosystems, served therefore as poetic inspiration in the research of interactive and immersive electronic means, as bridges towards non-human othernesses, animal embodiment and cathartic gameplay. For instance, in the piece Wolfanddotcom (whose central theme is the recreation of an internet by wolves that, in a post-apocalyptic future, are longing and racing to construct networks among themselves), the users immerse as virtual wolves, trying to rebuild a cybernetic virtual network within the space of the game, to help maintain life on the planet.

Besides dragons and wolves, other peculiar animals have been under this research focus. Ants, for example (eusocial insects), coexist socially, feeding and self-organizing, maintaining the balance of the ecosystem. They are authors of unique architectural creations, intricate labyrinthine tunnel patterns below the ground, derived from their bottom up stratified social organization, paired with constant cooperation as a group, for the colony development and protection against predators, briefly, towards the colony common goals. Observing these animals (that represent the highest level of organization an animal society might achieve) and designing their constructions on a broader human scale, allow reaching unprecedented aesthetic designs for the formation of intricate labyrinths. This kind of cave evolved structures, for millenniums made-up by the humans, challenge the free will and choices of the daring traveler who ventures into one seeking to solve its mystery, or simply to conquer it by getting out alive – spatial challenges often connected with feedback, compression, entanglement and hyper complexification of goal oriented displacement. Labyrinths are, therefore, fertile ground for elaborate and deadly games, serious games, for the spiritual heightening of human beings, a daring spiritual training ground and basis for deeper human spiritual connections, as spatial metaphors of human life. Solving a tangled deadly space riddle involves untangling and heightening the full depths of the human soul, often beyond its known scope.

The inevitable interconnection between labyrinthine structures and the arts (for years one of the research subjects of this thesis' author) also has decisively influenced the thesis development at three complementary levels: in exploring new aesthetic regions within electronic arts, through tools that combine scientific, artistic and non-human

methodologies, aimed to reach new aesthetic grounds to come up with new forms to attain harmonious natural spiritual realms; in obtaining unprecedented connections between generative art, games, mythology and biology; and in forming new knowledge in innovative techniques of labyrinthine construction, which lead beyond the usual scope of human imagination in spatial structures. It follows that, in the thesis work, labyrinths have been approached as mythological structures, gaming devices (and possible pathways to gain deeper humane insights), from which players can leave alive – thanks to exceptional non-human powers, which allow them to solve the spatial challenges they are confronted with –, or perish, due to becoming deeply and recursively immersed in labyrinthine complexity.

Consequently and in an original way, the labyrinthine construction carried out within the scope of the thesis uses non-human bio-electronic techniques, which led to the implementation of three new methods and their application in various artistic works. Naturally, myths are also used, not only owing to the recognized cathartic action they operate in humans, but also for the balance they impose on the research's underlying aspect of non-anthropocentric role (Eliade 1947, Karényi 1941), by creatively incorporating super-human powers and involving weird beings, generally expressed and visualized as mythical beasts (Derrida 2002, Borges 1974), surreal combinations of physical traits from different animals. The myth of Daedalus, for example, establishes a powerful allegory illustrating the importance of hidden doors and ingenious wing-shaped beeswax flying machines, essential tools to escape from the horizontal plane of the labyrinth to the vertical plane of the path that leads to the skies. But it is also notable in illustrating the danger of dazzlement in the use of such tools, a fact that can irremediably compromise the success of evasion, as with Daedalus' son Icarus. Narratives such as that of Daedalus teach that being dazzled by the technological product as an end in itself does not protect (on the contrary) against the risk of losing the superior purpose of the creative act, a risk for which warnings are already being heard. As Roy Ascott states:

> *It is equally clear that the impact of technology can have the effect of reducing art to a form of craft in which the spectacle of special effects and dazzling programming alone can replace the creation of meaning and values.* (Ascott 1989:357)

Still according to Roy Ascott, we should be aware that dazzling special effects are no replacement for the spectacle of programming the transformative experience, when the search and creation of meaning and values is in order. Instead, we look for models that can be inspiring and shifted to practice, the natural, the biologic and electronic, non-human worlds. For art is a practice of essential role and can aspire to be a vehicle leading transformative outcomes (Tarkovsky 1998).

All the above makes it evident that the research development was objectively determined by the specificities of the several factors just analyzed. But it is undeniable too that the same factors were also decisive in ending up shaping and altering the author's own views regarding what being human, what being a machine, what being an animal, can be like. A conceptual turn not unlike Derrida's assumption on his last work of the animal he therefore is (Derrida 2002), illustrated through the simple apprenhension that his cat doesn't mind if he is dressed or naked, underlining a distinct becomable otherness, again familiar yet unkown places. In this way, the turning factors influenced the very act of artistic creation, its foundations and the perception of how videogames and bio-electronic immersion can become tools to lead transformative human experiences and devices, programs that, themselves, quest boundaries on pseudo-infinite mythological and biological, bio-electronic spaces, in short, interactive constructs that go beyond mere entertainment, and that might be regarded as change inducing tools.

From a global point of view, it can be said, in a word, that the theoretical and practical research of this thesis was essentially focused on the creation of interactive aesthetic cybernetic environments, which summon play and ilinx, for human and non-human engagement, based on the belief that the ludic infrastructure in humans precedes rationality, "the ludic man precedes the sage man" (Sier 2017), that is, playing is more characteristic of humans. Play, being a free activity nonetheless capable of absorbing the player in an intense and total way (Huizinga 1980[1944]), provides the creation of tools, distinct from but hybridized with science, susceptible of inducing the desired transforming positive catharsis, which might enhance users' visions and a critically conscious cyber-humanity: the *ars* purpose.

Also from a global point of view, but here and now metaphorically speaking, perhaps it can be said that the research carried out in the scope of this thesis is comparable to the zen ceremony of tea brewing and serving to guests in Japan, if we consider the parallelism that can be established between the premises, models, development processes and objectives of the research, and everything that is associated with the apparent simplicity and ultimate purpose of celebrating a millenary art, still very much alive in the nipponic culture (Moraes 2008). Directed by formal procedures (protocols), rigorously followed for centuries and still strictly followed today, the ceremony presupposes that, especially the host, but also the guests, have a good knowledge of a very wide range of other arts, evidencing that the study for preparing and carrying out the ceremony is a never ending task. The utensils used, themselves, tend to be true artworks, each one built for a particular purpose of the ceremony. And all the movements, full of meaning, converge to the unique goal of seeking to create, in each participant, a state of spiritual harmony with the universe (of which each one is an integrating part (Eliade 2000[1957])), through a ritual of mental emptying, sometimes even as with the overflowing of a tea cup to a confused guest (Osho 2007), of reflection and self-questioning, which can convert each celebration into a magical opportunity to transform human consciousness, thus the society as a whole.

3.1 Contributions of new knowledge

The broad latitude of the research field and the subsequent amount of vastly approached domains led the research to be more concerned with establishing an extended conceptual and practical analysis of the investigations and their fields, focusing more specifically on the creation of the wolfanddotcom body of works and in the delineation of novel areas of aesthetic intervention, where aesthetics is assumed both as discipline of philosophy and representative of the arts. Both M2 and M4 methodological approaches "artistic practice based" (in which a collection of ilinxian technoetic otherness interactive experiences, videogames, static artworks, field work, are generated) and "test-retest field-experiment" (that addresses immersion, reactions and raised issues to the interactive videogames, laboratorial environments when audience exposed) were then central to develop the conceptual and creative practice-based work, as well as its outcomes. Together with the options concerning the research development, naturally they ended up being reflected upon the practical and theoretical contributions this thesis produces, responding to its main objectives.

Regarding the primary and secondary aims, the thesis research contextualizes a specific electronic-arts (EA) field, oriented towards the creation of games and interactive arts and experiences, immersive playable cyber-environments, interfaces, augmentations, bridges, codex and strata. The results of this work provide an expanded theoretical context, covering the broad world of new videogame based technological artistic tools, seen as technological apex, as well as programming languages and generative, interactive, technoetic, imaginary arts. They also provide an elucidation of paths of research rooted on the works of other artists and scientists, thinkers and engineers, as well as a practical state of the art, through selecting a number of aesthetic objects, games and interactive arts authored by artists whose work resonates with similar work this research addresses.

As contributions of new knowledge towards novel concepts and innovative forms of creative work, in the context of immersive technologies and entangled bio-electronic communication, the thesis research also introduces novel key terms (*panvision, zenospace, imaginary art, zero reality, gaian field, aspatiality, quantum-now*) to address

a territory of aesthetic intervention, tentatively called imaginary art, on a zenospace, resorting to panvision technologies. The key terms' purpose was to circumscribe regions of interest explored through the research carried out, further pinned as consequential new proposals to conceptually approach and to produce artifacts in regions outside human limits.

Synthetically recapitulating what was described in detail throughout the thesis, it can be said that, for example, imaginary art (IA etymologically traceable from the creative works of renowned contemporary artists in very distinct domains) can be seen as a tool to posit imaginary worlds. Its outcomes derive from abstract expressions, unpredictable concrete combinations of elemental traits, mathematical algorithms, mainly through special operators which engage strange loops, divide by zero, and overflow numerical precision with NaNs (Not a Number). The tangible constructs it proposes constitute a combination of imaginary spaces built by the human mind, utilizing what could be described as infrastructure rapture with "mythological functions" of the human mind (Deleuze 1985), coupled to non-human expansion, in order to further enlarge the scope of the human (inter-)communication with the unknown (already seen within traditionally millennial examples), not of the mental freely non-spaced ennui, but from directed aspaced synthesis into imaginary mathematical, electronic and biological non-human regions. All the created works seek for a similar outcome: engage the users, let them to focus and immerse in the experience of situations that combine, simultaneously and in an intricate balance, recursive resemblance and unfamiliarity, self-referentiality with otherness transformative outcomes, thus evolving unique languages capable of human out of bounds synthesis (the non-human realms).

Within the research development, zenospace rose out of the need to address a deeper meander related with the human detachment from the infrastructural human plateau towards non-human embodiment in imaginary art domains. The key-term proposes the formalization of an imaginary system for imaginary arts, which is simultaneously: a placeholder axial system for zero reality, where mythological functions and organisms other than humans can expand their systems; a systemic godelian operator (Hofstadter 1999); and a Kerényian functor (Kerényi 1963). In that imaginary system, the human amind (based on non-human bio-electronic models and through strange loops that

establish and apply mechanics similar to humans for the understanding and construction of alternative realities) devises constructs that emulate otherness mechanics and are capable not only of directing immersive experiences in feasible simulations, but also of altering mechanics corresponding to what is not human, to what is imaginary or mythological, thus submerging out of bounds experimentation, through more vivid experiences.

With respect to panvision, the notion foresights other than human sensitive experiences, by providing the means to apply the zenospace functions towards imaginary arts and proposing spatial constructs, aiming to eradicate an anthropomorphic infrastructural departing hangar, concerning a gaian field's cosmic unison, in a triple metaphorical connotation that includes: looking through the eyes of Peter Pan, flying non-linearly over ground level mythological landscapes; experiencing non-human sensitive experiences and modes of being, departing from an anthropocentric vision towards a pandemonium of biological, electronic and bio-electronic aggregates; finally as devices for accessing regions beyond human limits, following a process inspired in camera technologies that, at the dawn of the 20th century, established means for a cinematic art form, but which now, in the first quarter of the 21st century, can be operated by means of software, hardware or bioware, zenoware, zooming Kerenyian functors and Godelian operators into zenospace, from an amind accessing human out of bound regions, providing footage material for zenospace directors.

This thesis also introduces new modes of human/non-human communication by constructing bio-electronic aggregates for plants, ants, wolves, bacteria, humans and other animal lifeforms, artworks that are cyber-environments of non-human machine interaction, focused on establishing means for an hybridization of the non-human biologic and electronic domains into cybernetic bio-electronic aggregates, through physical computation situations. Within the contextualization of labyrinths and labyrinthine algorithmic creation, the research inovates introducing three new construction techniques, designated by "the mathematical flower", "the open/veilless labyrinth",and "the animal construction methods". Altogether, the art-science works created using these techniques – namely Half-Plant (2017), Ant Ennae Labyrinths (2019), Half-Ant (2020), and others, specifically Honey Krater (2019), Bioscope #1 (2020), Wolfmachine (2020-22), Wolfspace

(2019-22), distinct from the first three by the type of user-construct bridge –, translate some of the most representative practical and theoretical contributions of new knowledge produced by the research in this broad area.

Finding resemblances on what aesthetically the Greek protogeometric art movement did (Robertson 1981) by placing on the foreground non-human subjects combined with abstract background motifs, and even on the case of pre-historic cave paintings (Sier 2021, Azéma 2011), the thesis also establishes proto-videogames, zero/zeno games, mythological videogames, upscaling myths and animal subjects on abstract electro-bio ecosystems, thus extending the reach and impact of novel conceptual creative approaches to generate playful aesthetic, interactive and immersive experiences in non-human cybernetic environments, tools to induce the desired transformative positive catharsis.

The investigation of factors of innovation in the creative process of the addressed broad areas led to the creation of poorly or uncharted artistic outcomes, which contribute to the advancement of knowledge within the wide domain and, in this way, enhance the broadening of the base for the establishment of the ambitioned transformative deeper humane spiritual connections. The artistic works, created in a novel and authorial artistic language, were described in detail throughout the thesis. Here it is worth recapitulating the foundations, objectives and procedures of their creation, with a view to highlighting the innovative aspects that give them the status of contributors to the advancement of theoretical and practical knowledge in this area of the research carried out.

The here focused artworks constitute a particular dynamic sort of cybernetic mechanisms, in the form of playful laboratories, aesthetic laboratorial environments, spaces that summon play, spaces that call for user interaction and spaces that invoke a region for playful experimentation with the created technological apparatuses. Within the scope of this investigation, these apparatuses generally constitute derived computational environments, which interlink the human, biological and electronic realms, thus providing an infrastructural plateau to engage in electronic plus non-human communication. They can be looked at from three distinct but complementary perspectives: a) as electronic derived and augmented spaces that, in some works of the series, address humans and their

immersion in devices and, in other works, communicate with plants, ants or wolves (in a communication that is bio-electronic bidirectional and/or unidirectional), engaging biological non-human computation and immersion environments; b) as dynamic spaces that source non-human bio-electronic information, creating and often hybridizing the very substrate that allows them to operate, being that substrate constituted either by byte sequences of programs running in operating systems, electronic traces and flows of data of their execution, or by biological voltages sourced from plants, animals, or humans, the electrical currents discharged and flowing within the organs and internal structure of these organisms; c) as spaces that become ludic scientific laboratories since, through complex procedures, the raw biological data are genetically combined, by algorithms, with the raw electronic data, in the development of bio-electronic aggregates. The data resulting from such combination (the so-called bio-electronic data) becomes sounds, virtual terrains, or tangible sculptures, architectural models of spaces, drawings, or temporal events or spatial partitions, imprinting dynamics in the composition and autonomous movements in the works.

The following examples are paradigmatic of the above mentioned aspects: in the piece Half-Plant (2017) and as with what happens in cybernetics, these audiovisual systems feedback to their sources, by emitting continuous sounds to the plants, generated by raw plant and electronic data, while sampling voltages from the plant to generate the sounds; in the piece Ant Ennae Labyrinths (2019), the feedback is performed by casting laser beams onto an ant colony making mazes with electronic formation; and in the piece Half-Ant (2020), the feedback takes place by casting generative cellular automata audiovisuals derived from rule based slow transitions, also to an ant colony, with its ecosystem consisting of food, water, electronics and generative audiovisual patterns.

Most of the dynamic art-science works produced within this research (namely Draco.Wolfanddotcom.info 2015, Wolfanddotcom 2017, Phoenix.Wolfanddotcom.info 2017, Half-Plant 2017, Ant Ennae Labyrinths 2019, Wolfspace 2019 and 0X Labyrinth 2018-22) can be considered as targeting human intervention, appealing for some sort of user interaction and proposing interface techniques, which range from interaction with physical computation objects to computer vision or sound-based navigation and network interactions. This is the case of the wolf-sculpture-joysticks in Wolfanddotcom, the

computer vision tracking flying gestures in Draco and Phoenix, the smart device joystick app in Half-Plant, Wolfanddotcom and Wolfspace, and the sound and VR gaze interaction in 0X Labyrinth and Babylon. Other dynamic works, where the target is non-human-machine interaction, address non-human bio-electronic apparatuses or devices and engage in bidirectional and/or unidirectional non-human communication. Works such as Half-Plant (2017), Ant Ennae Labyrinths (2019), Half-Ant (2020), Bioscope #1 (2020) and Wolfmachine (2020-22) seek to establish different sorts of electronic, electrical and algorithmical channels of communication and experimentation, in the biological and electronic domains, in the creation of seed structures coupled to ecosystems, which show and are evidence of several lattices into new bio-electronic worlds.

From the above, it can then be concluded that these art-sci works, together with a number of static art-sci aesthetic artifacts (machinic fabricated sculptures and drawings, organic evolving paintings, photographs and videos, which address research and creation addressing the core mythology, underlining and leading to the more complex interactive works), establish new knowledge towards new forms of creative practice, through theoretical considerations, rooted and embedded in the practice within the nascent field, where areas such as interactive electronic arts, videogames, mythology, human / non-human computer interfaces are included. These theoretical contributions accompany the driving practice-based research in the field that covers novel custom technological programming techniques (fine-tuned over the years), interactive aesthetic arts and scientific domains, to produce immersive experiences, otherness playful laboratorial devices, and static artifacts deriving from the wolfanddotcom series of artworks.

In short and at a more detailed level to explicitly respond to the general (G1-G6) and specific (S1-S4) objectives, it is worth mentioning that the research sets new modes of interactive narrative exploration on pseudo-infinite spaces using virtual space partitioning, synthetic stochastic design, spatialization compositional techniques, sonic based interfaces, computer vision, physical computing, networking and VR interfaces. Most relevantly and resorting to these means, the narrative exploration throughout the works consists of seemingly no narrative (k. for instance). Adding to the above means, it utilizes biological materials to construct slowly evolving paintings and sculptures; it discourses and speculates about electronic consciousness research, electronic systems biologification;

it contributes with coding techniques through shared public code and listings at appendix α; most appositely, the wolfanddotcom research shifts the anthropocentric views and introduces the non-human as focus motif, while speculating about a cyber-transcendence of networked humans and non-humans, orga and mecha alike, dancing to the wind gusts, storms and sunny days offered at every single instant by Eorthe.

While subjectively the main research questions can be answered with a reverberating yes by the author of this thesis, as previously stated, the research lacks scientific corroboration of empirical reached results mostly in the aesthetic fields, hybridized with scientific methodologies, within a field encircling Technoetic Art augmented under a specific non-human orga and mecha focus, and beyond, into Imaginary Art. Specifically answering to S4, even though no scientific analysis is provided, one challenges the reader to question the human immersed poses associated with the coupled physiognomies from their body postures provoked and interlinked with the research produced artistic installations, documented throughout the list of illustrations (namely, figures 1, 2, 3, 4, 5, 6, 15, 40, 41, 50, 96, 97, 98, 99, 101, 107, 109, 110, 150, 151, 153, 156, 157, 160, 161, 162, 176, 177). Like a deleuzian crystal-image (Deleuze 1983), such static moments documented in photographs are hardly produced without an evident transport into a non-human otherness, facilitated by the crafted mythological videogames and bio-electronic aggregates.

To finalize, it is still worth noting that transgressing the principle of primacy in general attributed to practical investigation, the research process was often forgetful of important missing details such as detailed analysis of the composition space present in each work, in favor of encircling the research towards fundamental queries that opened a vast amount of new doorways and exploration roads, which undoubtedly raised more questions than it was possible to address, pointing to future research lines. This is, for instance, the case of deepening bio-electronic communication set forth on Half-Plant, Ant Ennae Labyrinths, Half-Ant, Bioscope #1, Wolfmachine, and to cross combine further as non-human players and/or collaborators with the playable atmospheric stochastic spatiums of near infinite depths such as in Wolfanddotcom, oX Labyrinth, Draco and Phoenix.Wolfanddotcom.Info.

It should also be noted that other avenues of research were identified to be pursued in the desirably near future and in areas where, within the scope of this thesis, it was not even possible to make more than a preliminary contact, even though they immediately aroused the greatest interest of this thesis' author. For example, the research could not yet look at an astonishing model to explore within the research area and under its main goal, which is provided by the almost planetary sized vegetable fungi networks, known today to interconnect several and surfaced mushroom towers by sharing common roots throughout the Amazon. Tree-tree communication (Chamovitz 2012) is another fascinating domain, which is already on the horizon of the author of the thesis but which, like the previous one, also had to be left out for the time being. As well the prosecution of mythological videogames embodying non-human mechanics and collaborations into transformative atmospheric settings that revere a gaian field. Among many other references, these ideas are explored in the lifestream concept within the movie Final Fantasy VII: Advent Children, directed by Tetsuya Nomura and written by Kazushige Nojima.

Ad latere, it should be reminded that the artistic work produced by the research carried out, being a contribution to the advancement of knowledge in its area of development, may also be a contribution to substantiate the struggle already underway that aims to guarantee full access to art by all citizens. As a first condition to provide positive transforming individual experiences, access to artistic expressions can thus be another powerful way to promote the much needed and coveted transformation of society.

3.2 Boundaries / limitations

While the research overflows, and keeps pouring tea beyond any cup, it fails to establish tangible evidences that the interaction with the posited constructs lead to transformative outcomes of the ways by which humans experience/inhabit reality. It also misses to substantiate the interaction with art games and bio-electronic systems constitutes a valid tool for consciousness research and for positive social transformation through art, since there is no analysis of the usage to the wolfanddotcom series of opus, or analysis in the EA field about kinds of works that could foster such usages.

Perhaps it also goes too far as to consider inanimate beings as such, beings – though this fulcral shift allowed for the investigation of raw micro-electronic and raw micro-macro-biological deltas of voltages and of data running throughout conductive electronic highways. It is however a positive speculative exercise that allows so many written words, so many installations and objects about zero, about nothing. This nothing that tentatively and elusively lingers to be apprehended. This nilness (or Xenakis' negative time) that provokes us to resort to caves, to labyrinths, to Gaia (Margulis, Lovelock), to the earth-mother (Eliade), to come full circle, Huizinga's magic circle. The spiritual yearning no object or process seems to quench. The vertical escape route, both Daedalus and the imaginary numbers perform, as they evade the horizontal by carving a tangible imaginary vertical/orthogonal direction. Or as Zeno, as you are recursively attracted to a vertical direction in a seemingly horizontal world, like Thales exemplifies. Daedalus escapes the horizontal labyrinth where both him and his son were entrenched by forging access to an out of bounds (imaginary) plane over warships on Krḗtē. The exciting soaring through the skies, where Icarus, perhaps inplace of all human hubris – but also spiritual beauty –, reached for the sun; and imaginary numbers, on a one dimensional cartesian plane, jumping orthogonally to a brand new y/why axis, offering the polar space and spectral analysis/synthesis provided by the impossible yet essential square root of negative one.

The research is unsuccessful again in presenting considerations and analysis regarding the recent advances of artificial intelligence (AI) and important correlations and derivatives to these kinds of explored techniques in the wolfanddotcom research, - a bit

like Stephen Wolfram speculates on the near future existence of de-centralized computational ecosystems through emergent and parameterized CA techniques (Wolfram 2002), of which a work from 2011, before recent AI euphoria is reminiscent of[61]. Also missing correlations with qu-bits and how quantum computing offers a whole new system and paradigm of programming, with deep implications for AI. Seems like Shrodinger's cat also joins Derrida's in cat to a cat party in a nearby future. Missing yet an analysis of the logic and simple artificial intelligence techniques utilized throughout the opus of wolfanddotcom, most actors being finite state machines with distance triggers, also digital actors consisting of boids algorithms (Reynolds 1987)[62], particle flows in grid-spaces such as images like in Bioscope #1, and also abstract combinations of movement methods, further discussed appendix α.4. These kinds of simple state machines and movement mechanics ground cybernetic flows of upmost importance on logic flows of algorithms typically applied to videogames (see Buckland 2005). No neural networking algorithms were applied in any of the discussed works so far, though fascinating, and visualized through Wolfanddotcom's sky map simulation of network topologies, most these algorithms are very resource usage intensive, and ethical issues emerge, since their computing power requirements are enourmous, in tandem with electronic derived waste, pollution, electronic energy consumption is one of most prevalent current sources of damage towards Gaia (Awashti et al, 2016).

When thinking about stochastic infinite experiences, and bio-electronic aggregates, you think about years and decades, perhaps centuries of running time. The Long Now Foundation, for instance, devised a mechanical 10000 year clock, which is engineered for this duration to keep a synchronized and accurate representation of time, a very inspirational and exemplary machine. Further to this, they even changed the way they mark the years, preceding them with a 0. It promotes reliability, stability, a machine companion ticking along the seconds, the minutes, the hours, the days, the months, the years, and the centuries, all one hundred of them. The spaceship earth (Fuller) we are all a part of, crumbling down at accelerated pace, taking along the plunge most of its biodiversity, electrodiversity, requires to stem away from this ruination (Tsing).

---

61 7000 (2011), at uunniivveerrssee.net solo exhibition, Museu de São Roque, Lisboa 2011 (catalogue, web: https://andre-sier.com/uunniivveerrssee/7000).

62 From Reynolds seminal research (1987) emerged the author's early interest in boids like locomotion, and early Max/MSP important prototypen. Boids for Max, initially by Eric Singer, then the author and Jasch did a couple of Max objects, Wesley Smith Jitter visual ones (2005). These have been used extensively throughout earlier projects, and like similar early Max treasurable code (https://s373.net/code/a-objects/a-objects.html), ported across s373.net/x studio's libraries for P5, ARD, OF.

3.3 Semicolon (closing curly braces)

Semicolons, or closing curly braces, usually end a statement or a function, in the C programming language, among many others. The quest of the research is performed, and yet it remains open. In order to close this loop, we end at the beginning, by correlating that the preamble starts again: it is a world of plants and animals, and man is not there at its center. We are left with the role of caretaker, gardener and architect, tending to our actuality, virtuality, deterritorializing, fertilizing the garden and watching sprouts grow

```
        ;


    }
```

Appendices

Appendix A Codex infra-structural research

α.0 Introduction: reinventing algorithmical wheels to reach new terrains

The gist of programming techniques used throughout the production of works has been evolving ever since the author started programming on BASIC example programs during his teenage years (a colored snake game, see 1.1.1), while admiring game loading sounds on ZX Spectrum and its musical nature, entirely sourced from the programs bytecodes, like this research proposes. Then immersive games like Wolfenstein 3D, Space Quest, Half-Life and similar changed his thoughts on what videogames could be, especially UEd (see figures 80-1). The 25 year learning curve went from researching and working with digital signal processing, Roads' 1996 Computer Music Tutorial had just come out, also Proakis & Manolakis 1996 which he got a copy next year, Xenakis's 1992 Formalized Music, over the years of 1995-97 when transitioning from standard visual arts to programmable electronic ones. Then learning audiovisual programming in Max/MSP, writing C externals for this environment (see the a-objects s373.net/code/a-objects). About 2006, learning and writing Java/P5/C/ARD programs, back to C++ on OF a few years later. Once the programming concepts are known, coupled to methods for digital/analog signal processing, it becomes easier to approach mental constructs and to transform them into poetic logic flows.

Instead of simply listing the entire source code of these libraries on appendix α, each appendix section will introduce the concepts explored within the libraries, list relevant methods and procedures, as well as contextualize the code the libraries offer in the works. While some code remains proprietary due to its experimental and alpha nature, concepts surrounding these libraries are shared. These concepts and code excerpts adhere to a standard MIT coding license.

By carving the logic rules of the underlying libraries, specific methods related to all areas of aesthetic computation may be perused with finer granular detail, since what is calculated by the machine and how it calculates influences directly the outputs. Over the years the need arose to reinvent programming wheels in order to reach new logic strata and aesthetic plateaus, implemented throughout the works.

α.1 Audio library

Starting from some audio objects (α.0) within Max/MSP, refactored also into P5, ARD, OF, a synthesis library has been slowly constructed focusing on sound generation. The audio library s373A~ features a single pipeline of processes that can have filters or effects chain operating on a source audio mono signal. At the end of this processing chain, eventual spatialization can be applied to a custom single or multichannel audio output setup. It is not a robust audio library, that can with ease interchange processing from single pipeline chains, but merely a single channel direct to output DSP architecture. Audio is explored through experimental mathematics and not so obvious DSP procedures. Very much inspired on Xenakis's Formalized Music and his usage of mathematics in the musical arts. Hence, after a tree view of the library contents, we end this section with an interpretation of Xenakis' gendyn procedures, programmed by Marie Helène Serra of CEMAMu (Xenakis 1992:304-21).

```
ofxs373A~]$ tree
.
├── cleanexamples.sh
├── compileexamples.sh
├── example~00
├── example~01
├── example~02
├── example~03
├── example~04
├── example~05
├── example~06
├── example~07
├── example~08
├── example~09
├── example~10
├── example~11
├── example~12
├── example~13
├── example~14
├── example~15
├── example~16
├── example~17
├── example~18
├── example~19
├── example~20
├── example~21
├── example~22
├── example~23
├── example~24
├── example~25
├── libs
│   └── flite2
│       ├── include
│       │   ├── cst_alloc.h
│       │   ├── cst_args.h
│       │   ├── cst_audio.h
│       │   ├── cst_cart.h
│       │   ├── cst_cg.h
│       │   ├── cst_clunits.h
│       │   ├── cst_diphone.h
│       │   ├── cst_endian.h
│       │   ├── cst_error.h
│       │   ├── cst_features.h
│       │   ├── cst_ffeatures.h
│       │   ├── cst_file.h
│       │   ├── cst_hrg.h
│       │   ├── cst_item.h
│       │   ├── cst_lexicon.h
│       │   ├── cst_lts.h
│       │   ├── cst_lts_rewrites.h
│       │   ├── cst_math.h
│       │   ├── cst_phoneset.h
│       │   ├── cst_regex.h
│       │   ├── cst_relation.h
│       │   ├── cst_sigpr.h
│       │   ├── cst_socket.h
│       │   ├── cst_ss.h
│       │   ├── cst_string.h
│       │   ├── cst_sts.h
│       │   ├── cst_synth.h
│       │   ├── cst_tokenstream.h
│       │   ├── cst_track.h
│       │   ├── cst_units.h
│       │   ├── cst_utterance.h
│       │   ├── cst_utt_utils.h
│       │   ├── cst_val_const.h
│       │   ├── cst_val_defs.h
│       │   ├── cst_val.h
│       │   ├── cst_viterbi.h
│       │   ├── cst_voice.h
│       │   ├── cst_wave.h
│       │   ├── cst_wchar.h
│       │   ├── flite.h
│       │   └── flite_version.h
│       └── lib
│           └── linux64
│               ├── libflite.a
│               ├── libflite_cmu_grapheme_lang.a
│               ├── libflite_cmu_grapheme_lex.a
│               ├── libflite_cmu_indic_lang.a
│               ├── libflite_cmu_indic_lex.a
│               ├── libflite_cmulex.a
│               ├── libflite_cmu_time_awb.a
│               ├── libflite_cmu_us_awb.a
│               ├── libflite_cmu_us_kal16.a
│               ├── libflite_cmu_us_kal.a
│               ├── libflite_cmu_us_rms.a
│               ├── libflite_cmu_us_slt.a
```

```
[asier@ATmachine005 s373AVoices]$ cat s373AVXen00.h


/*
 *   made from reading/memory of what gen dyn is
 *
 *       early encarnations of these methods in 242.gendy1bas,
 *       a c object in max/nato programming environment circa 2000
 *
 *       this process is indeed the src of unheard phasehift & polar transitions
 *       // to be further expanded from the old master
 *
 *
 *   Created by andré sier on 20120602.
 *   Copyright 2012 s373.net/x. All rights reserved.
 *
 */


#pragma once

#include "s373AVBase.h"

// s373AWavePts373AWavePts373AWavePts373AWavePts373AWavePt
//   s373AWavePts373AWavePts373AWavePts373AWavePts373AWavePt
// s373AWavePts373AWavePts373AWavePts373AWavePts373AWavePt


class s373AWavePt{
private:
                ofPoint pt; // x until buffersize, y-+1
                float devx,devy;
                int om;
                int bom;
                int *bsptr;

                void setup(int *bs, const ofPoint & p,
                            float dx = 2, float dy = 0.1,
                             int o=0, int bo=0){
                    pt=p;
                    om=o;
                    bom=bo;
                    bsptr=bs;
                }

                void update(){
                        int bs = *bsptr;
                        switch(om){
                                default: case 0: break;
                                case 1: pt.y += ofRandom(-devy,devy);   break;
                                case 2: pt.x += ofRandom(-devx,devx);   break;
                                case 3: pt.x += ofRandom(-devx,devx);
                                            pt.y += ofRandom(-devy,devy);   break;
```

```cpp
                    }

                    switch(bom){
                            default: case 0: break;
                            case 1:
                                    if(om>1){
                                            if(pt.x<0) pt.x = 0;
                                            if(pt.x>=(bs-1)) pt.x = bs-1;
                                    }
                                    if(pt.y<-1) pt.y = -1;
                                    if(pt.y>=1) pt.y = 1; break;
                            case 2:
                                    if(om>1){
                                            while(pt.x<0) pt.x += bs;
                                            while(pt.x>(bs-1)) pt.x -= bs;
                                    }

                                    while(pt.y<-1) pt.y += 2;
                                    while(pt.y>=1) pt.y -= 2; break;

                    }
            }
};


// s373AVXen00s373AVXen00s373AVXen00s373AVXen00s373AVXen00
//   s373AVXen00s373AVXen00s373AVXen00s373AVXen00s373AVXen00
// s373AVXen00s373AVXen00s373AVXen00s373AVXen00s373AVXen00

class s373AVXen00 : public s373AVBase {
protected:

        vector<s373AWavePt> wavepts;
        int numsamples;
        float mvol;

public:
        void setup(int nwavepts = 10, int oom=1,int bound=2,
                            float dx = 2, float dy = 0.1,
                            float freq = 440, float vol = 1,
                            float fb = 0.1,int imode=0
                            ){

                s373AVBase::setup();
                om = XEN;
                wavepts.clear();
                // locations are frequencies in bufferspace
                ofPoint loc;
                float stridex = (float) buffersize / nwavepts;
                for(int i=0; i<nwavepts;i++){
                        loc.x = i * stridex;
                        loc.y = ofRandom(-1,1);
                        addWavePt(&buffersize, loc, dx,dy, oom, bound);
                }

                numsamples = buffersize;
                createreaderdata(numsamples);

                // no data, no phase, all here
                setupReader(freq,vol,fb,imode);
                // depois da readerdata para aceder ao buffercomum
        }


        void calcreaderdata(){

                for(int i=0; i<wavepts.size();i++){
                            wavepts[i].update();
                }

                for(int k=0; k<buffersize; k++){
                            int pt0 = -1;
                            float mdist0 = buffersize;
                            int pt1 = -1;
                            float mdist1 = buffersize;
                            for(int i=0; i<wavepts.size(); i++){
                                    float xdist =ABS( k - wavepts[i].pt.x );
                                    // e qd 1pt no bs e outro no 0?
                                    if(xdist < mdist0){
                                            mdist0 = xdist;
                                            pt0 = i;
                                    }
                            }
                            // again for second pt
                            for(int i=0; i<wavepts.size(); i++){
                                    if(i==pt0) continue;
                                    float xdist =ABS( k - wavepts[i].pt.x );
                                    // e qd 1pt no bs e outro no 0?
                                    if(xdist < mdist1){
                                            mdist1 = xdist;
```

```cpp
                                        pt1 = i;
                                }
                        }

                        if(pt0==-1||pt1==-1) continue;
                        // ja tenho os 2 pts, ja posso interpolar
                        s373AWavePt & a = wavepts[pt0];
                        s373AWavePt & b = wavepts[pt1];
                        float lenx = b.pt.x -a.pt.x;
                        float yatcurrentx = 0.0f; // o q quero saber
                        // sei o x
                        float x = k;
                        // sei a distancia at´e 1º ponto
                        // mdist0=mdist0;
                        // sei os x's e y's dos pontos
                        float perx = ofMap(x, a.pt.x, b.pt.x, 0, 1, true);
                        yatcurrentx = ofMap(perx,0,1,a.pt.y,b.pt.y);
                        float samp = yatcurrentx ;
                        readersdata[k] = samp;
                }
        }

void addWavePt( int *bs, const ofPoint & p, float dx, float dy, int o, int bo ){
                s373AWavePt pt;
                wavepts.push_back(pt);
                wavepts.back().setup(bs,p,dx,dy,o,bo);
        }

void setWavesDev(float dx, float dy, int which=-1){
        bool all = which < 0;
        if(!all){ wavepts[which].devx = dx; wavepts[which].devy = dy; }
        else{
                for(int i=0; i<wavepts.size();i++){
                        wavepts[i].devx=dx;
                        wavepts[i].devy=dy;
                }
        }
}

void setWavesOm(int om, int which=-1){
        bool all = which < 0;
        if(!all){ wavepts[which].om = om; }
        else{
                for(int i=0; i<wavepts.size();i++){
                        wavepts[i].om = om;
                }
        }
}

void setWavesBOm(int bom, int which=-1){
        bool all = which < 0;
        if(!all){ wavepts[which].bom = bom; }
        else{
                for(int i=0; i<wavepts.size();i++){
                        wavepts[i].bom = bom;
                }
        }
}

 s373AChannel * processBuffer(float inmastervol=1.0f){

        calcreaderdata();
        return s373AVBase::processBuffer(inmastervol);

 }


};
```
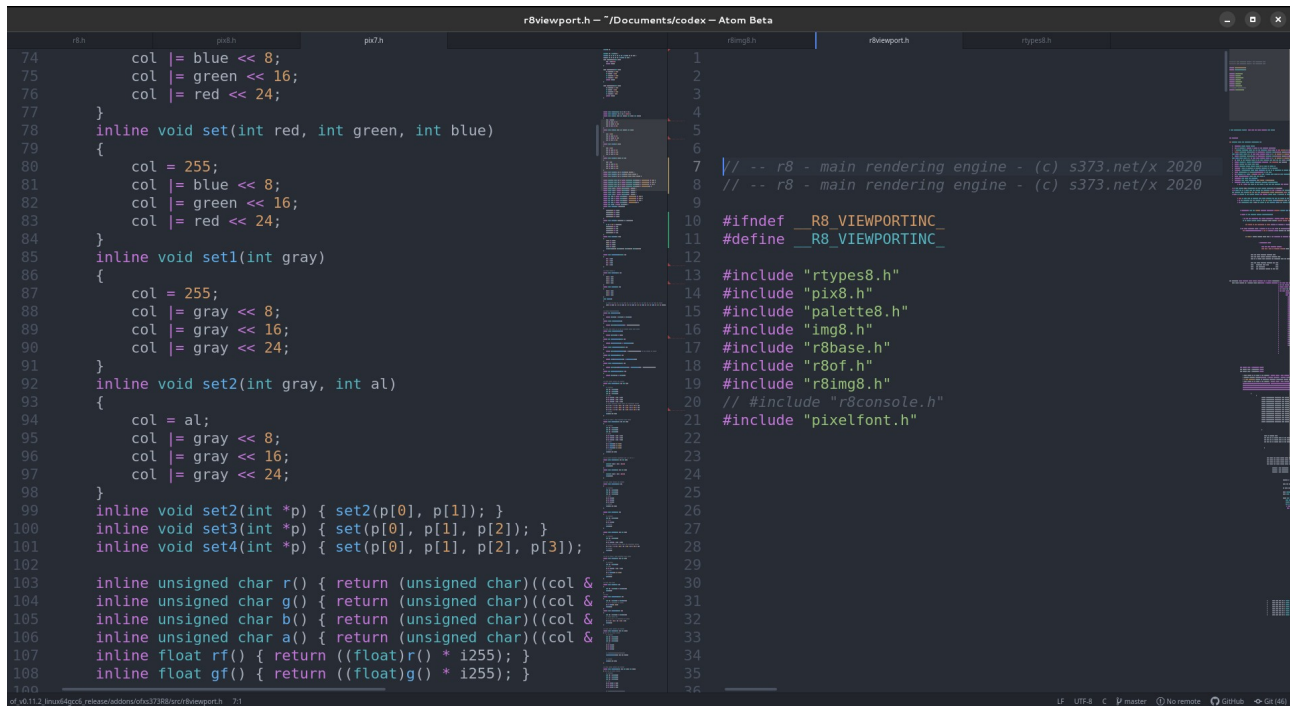
α.2 Physics library
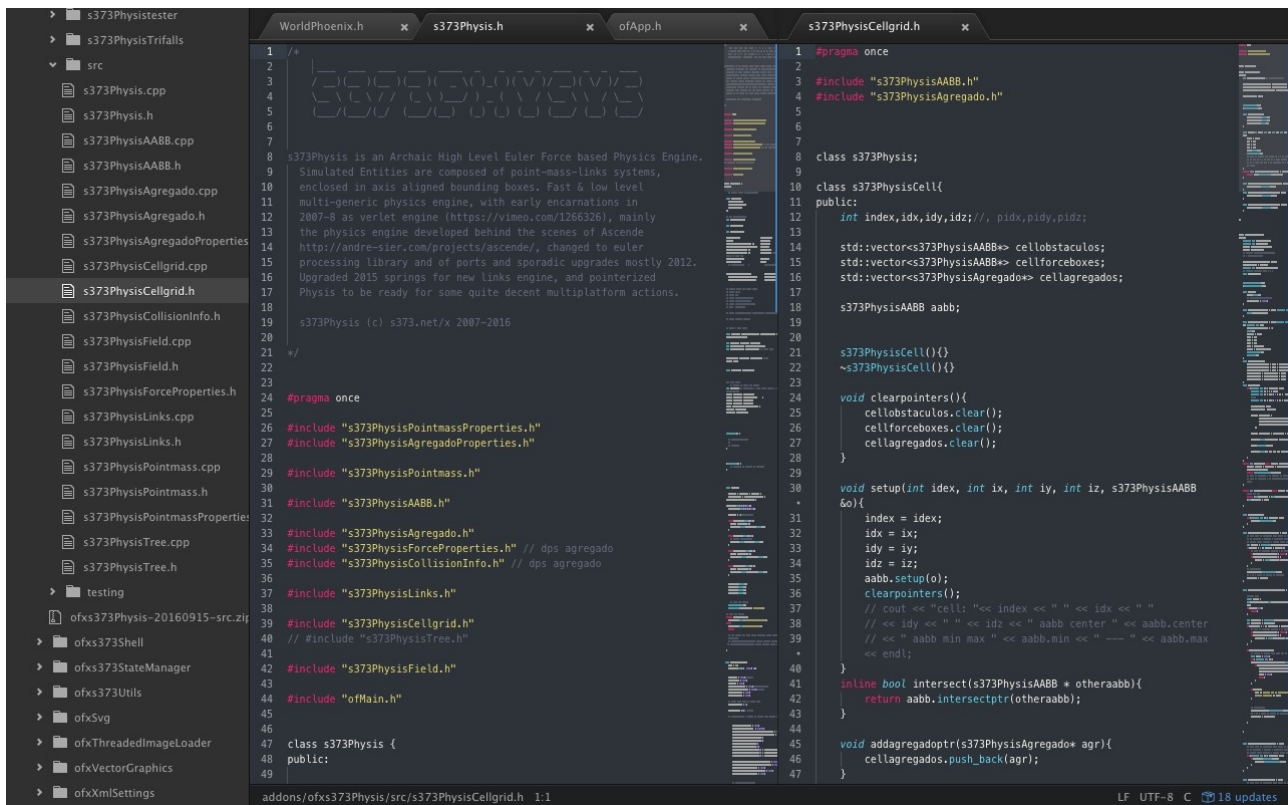
The physics library consists of a standard point-mass physics system, where aggregates can be defined composed of single or multiple point mass elements, interlinked with force constrains, some spatial optimizations. The readme above in the figure is more verbose, and you can watch it in action at the following video: https://youtube.com/watch?v=qYGGuZJWrHw.
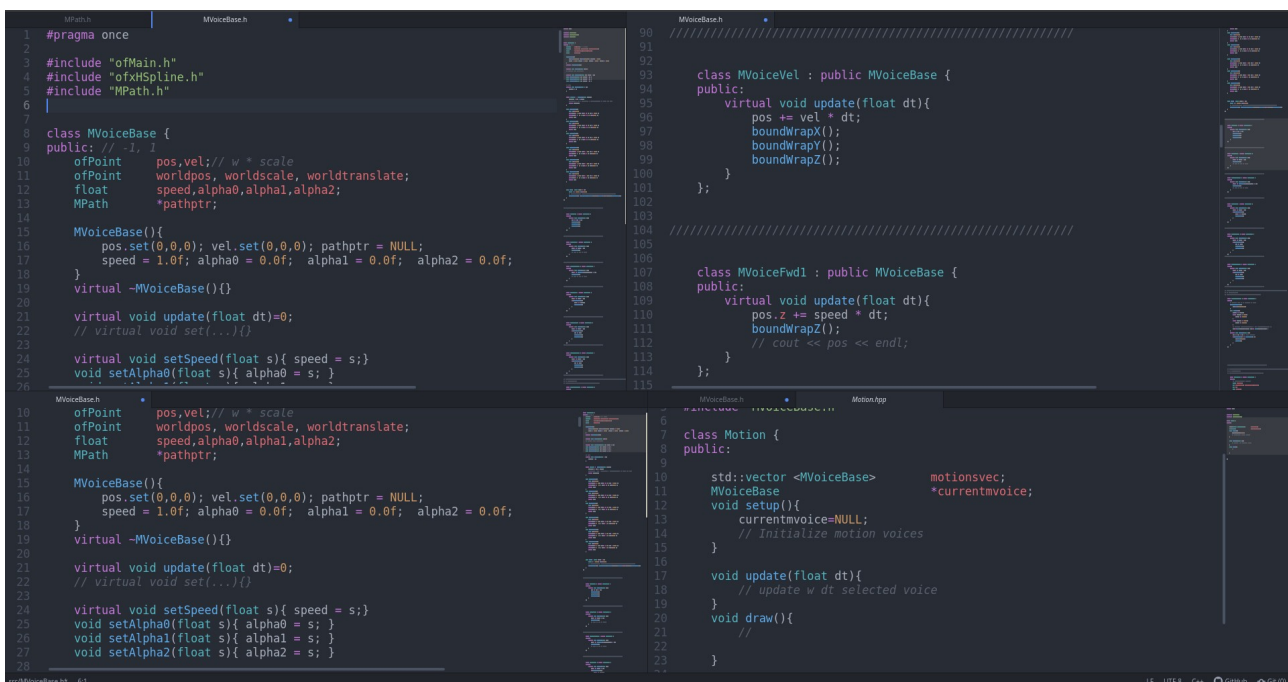
α.3 Image library

The image library consists of a CPU only experimental image processing library with functions where mathematical combination of pixel information is explored. Main data type is 8-bit unsigned char, color information is packed, encoded, decoded, in a single 32-bit integer.

α.4 Movement library

The movement library consists of an assorted collection of displacement functions, ranging from organized movement, to other kinds of spatial displacement. Here we can include organized boids/flocking movements (see https://github.com/s373/ofxBoids, https://github.com/s373/ofxBoidsSinger), chaos & fractals displacements, to simpler movement mechanics, like explored in Babylon and 0X Labyrinth, depicted here in the image.

α.5 Pseudo-infinite terrain

This technique began with 747 (2001-2) as a single FIFO (first-in-first-out) array of heights in Max/MSP/Nato/Jitter. Evolved to the second dimension under 747.5 (2005-6), and in k. (2007) has a 3D blocky gridmap terrain with multiple zones. Space Race series textured the terrains with CA, whereas in Draco and probably before, you can see interpolation in between vertex positions.

A better version lays in the source code of Wolfanddotcom, depicted next.
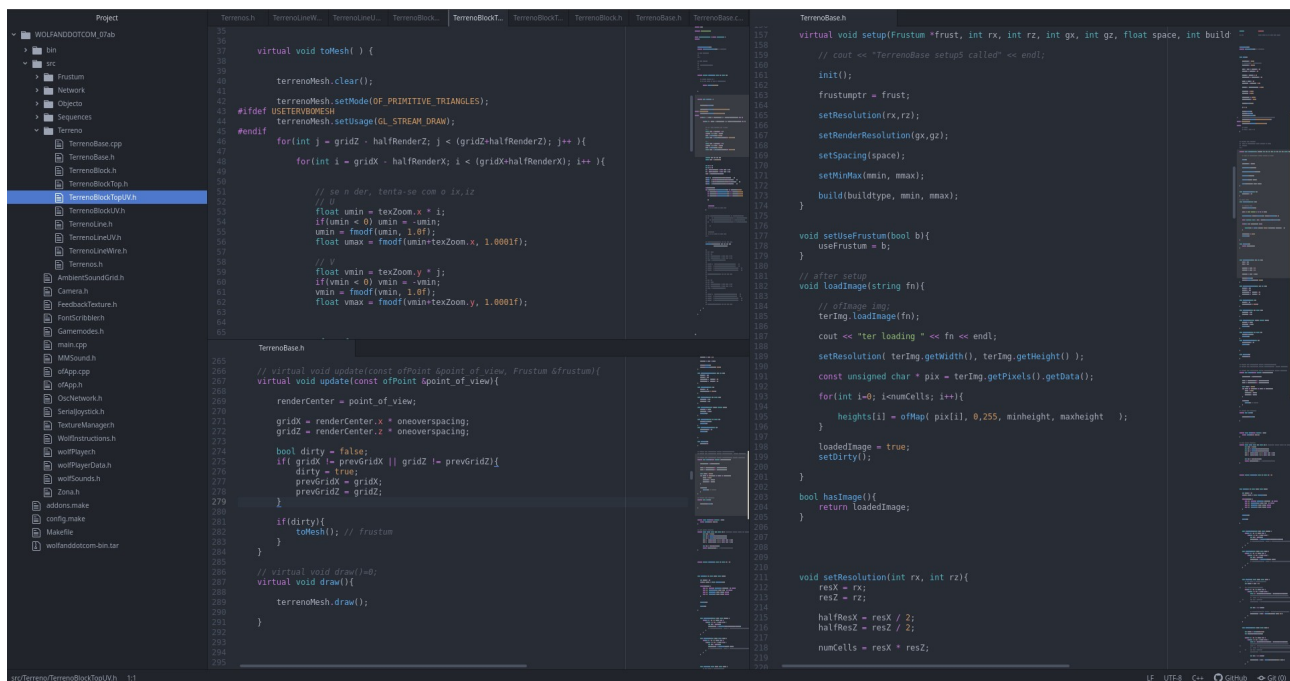
α.6 Pseudo-infinite polygonal fields

Instead of a simple 2D gridmap elevated like the previous annex, here we explore similar mental constructs from pseudo-infinite terrain through marching cubes structures, making a similiar usage of wrapping through a collection of sections engulfed in a collection of 3D seed spaces that get summoned to execution space as the point of view approaches its regions. See https://github.com/s373/ofxMarchingCubes for a spatial constrained version, and 0X Labyrinth for an implementation of it.

This technique was conceived and implemented in the work Arcadia (2015-16), here shown at the first Web Summit in Lisbon 2016, and at solo exhibition Labirinto de Chronos I, at Convento de S. Francisco, Coimbra 2016-17. It is later refined in the work 0X Labyrinth.

α.7 Zero crossings audio joystick (0X)

This consists on a sonic technique that occurs in the time domain of signal based audio processing, so no cartesian to polar, analysis followed by polar to cartesian methods of audio spectral analysis through FFT techniques.

Simply a time domain sampled signal zero-crossings analysis, where we count the number of occurrences of approximate equal amplitudes a signal switches from +-ve yields an audio presence indicator. However this information holds no spectral information about the incoming signal, since it does not FFT transforms it. This is not entirely true, there are remnants of it, however it is very noisy and no significant meaning can be extracted from is time domain information regarding accurate spectral content, such as the ones common in graphic equalizers on audio displays of signals. We can however approximate the spectral information into more meaningful parameters through the zero-crossings time domain technique, by subdividing the incoming signal into n regions, and for each region, apply a regular zero-crossings count, followed by a phase shift to the according desired starting offset. An interface technique that got extrapolated from percursive RMS usage in works: 747 (2002), throughout the struct works (2000-), whereas in k.~ (2010) has its first appearance, followed by other sonic basic works like Temporary-Babel2D (2013-4), Hyperborea (2013-5), Babylon (2018), 0X Labyrinth (2011-23).

α.8 Five point visual skeleton tracking

Flob, and a-jit.human have already been mentioned within thesis main document so it will be a very short text just linking to where you can download and try to run it on your platform if you wish to: https://s373.net/code/flob, https://github.com/s373/ofxFlob.

Below is another image representative of Flob executing on the work Draco.Wolfanddotcom.Info running at Lisbon's Maker Faire 2016.

α.9 CA cellular automata & DNA libraries

DNA based algorithms (Sims 1994, 1991) feature amazing and mesmerizing possibilities GA/AL, since it allows for the transformation of algorithmic parameters of any numerical or symbolical property to be attached to a gene from a classes genome, simulated and iterated through each step processes of evolution, which in turn are actualized as stochastic mutation of the whole set, where parameter numbers are deviated from their current locations towards random deviations with a varied degree of mutation indices. Several mating and mutation processes with varied degree of percentages exist also to breed digital populations featuring traits from the pool of parents. The code is implemented in Processing (https://s373.net/code/dna, https://github.com/s373/s373-processing-libs/tree/master/dna) and openFrameworks (https://github.com/s373/ofxDna).

An important landmark for mathematical reasoning and computation in general, which besides its obvious graphical or sonic usage enchanting properties, allowing visualization of how the mathematical number sequences progress and behave with parameter changes throughout time, can be considered fulcral self-reference and cross-mutation mathematical mechanisms through which can be explored in logic spaces and with usages far distinct from immediate visualization.

CA exhibits perhaps the most interesting low powered depiction of grid based evolution, piercing the grid self towards 0, blinking or fading across time from the intakes solely derived from neighboring states. See https://github.com/s373 for generic implementations 0D, 1D, 2D, 3D.

α.10 VR library

Dorothy is in Kansas, following the yellow brick road. A lion's heart, a tin-man, some additional red shoes, and she just wants to get home. A couple of brooms and witches, reaching a talkative rock. Mumbling and rumbling, echoing the electrostatic stratosferic gaian mineral alchemical combinations set under a deep bassed voice, where electrons jumping out of atomic bounds through their orbits, keep trying to keep track of time, through eye balled transistor machines, chording, according, like a chyme.

```
[asier@ATmachine10 ofxs373VR8bit]$ tree

.
├── GluLookAt.h
├── GluPerspective.h
├── SensorInterface.h
└── VR8bit.h
```

Near/~ 0 directories, 4 files.

Plus an ofxCompass, just to keep a slight track of time. Bearings. A couple of thunderbolts. Ka-pow, sha-zam. Tra-ka-pow.

Log. But this was old, and true, Glu.

A triangle in one hand. A couple of rectangular viewports for humans, just imagine if it was for flies.

Dolphins & whales lead the way, echolocating beyond the boundaries of space-time.

α.11 Chaos & Fractal libraries

Chaotic and fractal based algorithms (Casti 2000, Flake 1998, Gleick 1994, Struik 1987) constitute yet an important landmark for mathematical reasoning and computation in general, which besides its obvious graphical or sonic usage enchanting properties, that allow visualization of how the mathematical number sequences progress and behave with parameter changes throughout time, can be considered fulcral self-reference mathematical mechanisms through which can be explored in logic spaces and with usages far distinct from immediate visualization.

The chaos library was expanded slightly from Richard Dudas' ChaosCollectionFAT from October 1996 on the Max programming environment, running on this language and more recently in OF (https://github.com/s373/ofxAChaosLib).

The fractal library will attempt to be of a similar nature, but it's still in its infancy and no public code has yet been made available. Portions of it, alongside with the chaos library, are utilized in the construction video artwork discussed at 2.2.5.d) An Observer ToL: Sierpinsky, Ikeda, Log, Navier-Stokes (2019). Also worthy of mention is s373's studio byteRandom, a (random) number sequence generator based on user provided samples, which tint the random number outputs from a lookup table, it is data-based, and seems to be cross platform across 64/32bit linux systems, mac os x 10.7.3, windows xp and 7, androids and iphones, arm based socs. github.com/s373/ofxs373ByteRandom. Ironically, seems to be filtering out zeros at the moment in favor of more random variety,

[...] ofxs373ByteRandom.h:126-134

```
while ( rnd ==0 ) {

  rnd = bytedata.at( rnghead );

  rnghead = ( rnghead + 1 ) % rngnumbytes ;

  poolheads [ 0/x ] = rnghead;

}
```

a.12 Physical computing

Physical computing demonstrates some of the crafted firmwares running on Arduino based platforms on the wolfanddotcom series. Robotic pan & tilt mechanisms that already had water pumps, lasers and ink throwers attached, to what is considered to be a primitive 8-bit polar plotter, have been open sourced since 2014 at https://s373.net/x/inky, or its more recent samian version at https://github.com/s373/samian000, which also suits experimental servo based vertical plotters that our studio has been testing.

Firmware code listings follows, for Wolfanddotcom's 3 buttons per ear on the wolf-sculpture-joystick serial protocol, containing 4 files, the main program file and 3 classes, Pbutton, EyeLed and HeartLed.

```
/*
WOLFANDDOTCOM diagram/space/connections
    a                               b              left ear        right ear
          1                1                       2, 3, 4            5, 6, 7
       0    2          0    2                       a         b        c
                 c                          8    10    11(pwm) / 13n faz
           a,b,c leds
*/

/*
 * WOLFANDDOTCOM firmware
 * André Sier, 2017
 */

/*              button idxs
 *                      1
 *                 0      2
 * manda estado de cada orelha se muda
 * nada pressionado = 0       16
 * 0 pressionado = 4            20
 * 1 pressionado = 2            18
 * 2 pressionado = 1            17
 * 0,1 pressionado = 6        22
 * 1,2 pressionado = 3        19
 * 0,2 pressionado = 5        21
 * 0,1,2 pressionado = 7    23
 */

#include "PButton.h"
#include "EyeLed.h"
#include "HeartLed.h"
```

```
PButton Ear1[3];
PButton Ear2[3];
int Ear1State = 0;
int Ear2State = 0;
int Ear1pins[3] = {2,3,4};
int Ear2pins[3] = {5,6,7};
EyeLed eyeleft(8);
EyeLed eyeright(10);
HeartLed heartled(11);
bool led13on = false;
unsigned long led13LastMillis = 0;

void setup() {
    Serial.begin(9600);
 // Serial.println("Wolfanddotcom 1e-7");
    for(int i=0; i<3; i++){
        Ear1[i].setup(Ear1pins[i]);
        Ear2[i].setup(Ear2pins[i]);
    }
    // again
    eyeleft.setup(8);
    eyeright.setup(10);
    heartled.setup(11);
}

void parseSerial(){
    while(Serial.available()>0){
        int incoming = Serial.read();
        bool a = random(100)<1;
        // change according to incoming serial
        if(a||incoming=='a'){
            eyeleft.resetChangesDelay(random(10,50));
            eyeleft.addButtonChanges(random(20,70));
        }
        else if(a||incoming=='b'){
            eyeright.resetChangesDelay(random(10,50));
            eyeright.addButtonChanges(random(20,70));
        } else if(a||incoming=='c'){
            heartled.setSpeed( (float)random(10,100)*0.001f    );
        }
    }
}

void loop() {
    parseSerial();
    unsigned long now = millis(); // s now for all
    // led13
    if(now    > (100 + led13LastMillis)){
        led13LastMillis = now;
        //led13on ^= true;
        led13on = !led13on;
        digitalWrite(13, led13on?HIGH:LOW);
    }
    // update
    int leftchanges = 0;
    int rightchanges = 0;
    for(int i=0; i<3; i++){
```

```
                leftchanges += Ear1[i].update(now);
                rightchanges += Ear2[i].update(now);
        }

        eyeleft.addButtonChanges(leftchanges);
        eyeright.addButtonChanges(rightchanges);
        eyeleft.update(now);
        eyeright.update(now);
        heartled.update();

        int E01state = calcState( Ear1[0].on(), Ear1[1].on(), Ear1[2].on() );

        int E02state = calcState( Ear2[0].on(), Ear2[1].on(), Ear2[2].on() );

  // DEBUG BUTTON STATES
//    Serial.print("Ear01 state ");
//    Serial.print(E01state);
//    Serial.print(" Ear02 state ");
//    Serial.println(E02state);

        boolean sendserial = false;
        if(Ear1State != E01state) {
                Ear1State = E01state;
                sendserial = true;
        }
        if(Ear2State != E02state) {
                Ear2State = E02state;
                sendserial = true;
        }
        if(sendserial){
                Serial.write(Ear1State);
                Serial.write(Ear2State);
                Serial.write(',');
        }
}

int calcState( boolean b1, boolean b2, boolean b3){
    int val = 2;// Nao começar a zero senão o OF readbytes n le
    val = (val << 1) + (b1 ? 1 : 0);
    val = (val << 1) + (b2 ? 1 : 0);
    val = (val << 1) + (b3 ? 1 : 0);

    return val;
}


Pbutton.h

#pragma once

#include "Arduino.h"

// the debounce time; increase if the output flickers
unsigned long debounceDelay = 30;

// pullup buttons w/ debouce
class PButton {
```

```cpp
public:
        int readPin;
        int buttonState, lastButtonState;
        unsigned long lastDebounceTime = 0;
        boolean ison;
        PButton(){}
        ~Pbutton(){}
        PButton(int rpin){
            setup(rpin);
        }
        void setup(int rpin){
            ison = false;
            buttonState = lastButtonState = 0;
            readPin = rpin;
            pinMode(readPin, INPUT_PULLUP);
        }
        int update(unsigned long now){
            int changed = 0;
            int sensorVal = digitalRead(readPin);
            if(sensorVal != lastButtonState){
                lastDebounceTime = now;
            }
            if( (now - lastDebounceTime) > debounceDelay ){
                if(sensorVal != buttonState){
                    buttonState = sensorVal;
                changed+=2;
                //changed+=1; // tanto da offs como ons
                }
            }
            lastButtonState = sensorVal;
            ison = buttonState == 0;
        return changed;
        }
        boolean on(){
            return ison;
        }
};


EyeLed.h

#pragma once

#include "Arduino.h"

class EyeLed {
public:
        int ledPin;
        int ledVal;
        int numButtonChanges;
        unsigned long changesDelayMillis, changesLastMillis;
        int setOnTimer;
        boolean ison;

        EyeLed(){}
        ~EyeLed(){}
        EyeLed(int rpin){
```

```
        setup(rpin);
    }

    void setup(int rpin){
        ison = true;
          ledVal = 255;
            ledPin = rpin;
           numButtonChanges = 0;
          resetChangesDelay();
         changesLastMillis = millis();
        setOnTimer = 0;
      pinMode(ledPin, OUTPUT);
    }

void setOn(int frames){
    setOnTimer = frames;
}

void addButtonChanges(int frames){
// if(frames>0)
    numButtonChanges += frames;
}

    void resetChangesDelay(int c=-1){
        if(c>0){
            changesDelayMillis = c;
        } else {
            changesDelayMillis = random(100)<80 ?
                                          random(10, 50):
                                          random(50, 550);

        }
    }

    void update( unsigned long now){

        if(setOnTimer>0){
            setOnTimer--;
            ledVal = 255;
            resetChangesDelay();
            ison = true;
            if(setOnTimer==0){
            ison = false;
            }

        digitalWrite(ledPin, ison?HIGH:LOW);
        } else if(numButtonChanges>0){
        if(now - changesLastMillis > changesDelayMillis){
            changesLastMillis = now;
            numButtonChanges--;
            ison ^= true;
            if(numButtonChanges==0){
                        resetChangesDelay();
                        ison = false;
            }
            digitalWrite(ledPin, ison?HIGH:LOW);
        }
            }
```

```cpp
                }

        boolean on(){
            return ison;
        }

};



```

HeartLed.h

```cpp
#pragma once

#include "Arduino.h"

#define ABS(x) (x)<0?(-x):(x)

static float mapf(float x, float a, float b, float c, float d){

        return (x - a) *
                            (d - c) /
                    (b - a)
            + c;
}


class HeartLed {
public:
    int ledPin;
     int ledVal;
     float heartSpeedf;
    float heartHeadf;

    HeartLed(){}
      ~HeartLed(){}
    HeartLed(int rpin){
            setup(rpin);
      }
    void setup(int rpin){
          ledPin = rpin;
          ledVal = 255;
          // sempre de 0 a 1 para exponenciar
          heartHeadf = 0.0f;
          heartSpeedf = 0.05f;//0.01
          pinMode(ledPin, OUTPUT);
      }

    void setSpeed(float s){
          heartSpeedf = s;
    }

     void update( ){
          float bright = 210.0f * updateHeart();
          analogWrite(ledPin, (int)bright);
      }
```

```
float updateHeart(){
        heartHeadf += heartSpeedf;
        if(heartHeadf > 1.5f) heartHeadf -= 1.5f;
        float heartHead2 = heartHeadf > 1.0 ? 1.0 : heartHeadf;
        float halfheart = fmodf(heartHead2, 0.5);
        float distheart = mapf( ABS(0.25f - halfheart) ,
                                    0.25, 0., 0., 1.0f );
        return distheart * distheart; // sq for curve
    }
};
```

Appendix B Bio-electronic byte sequences

Appendix β contains two examples of byte sequences to illustrate procedures undertook in digital analysis and artistic results, core source for infrastructural analysis coupled to aesthetic constructions. Outputs ranging from 1D to (3+1)D raw results, in space as 1D, 2D drawings, textures or 3D sculptures, in time as 1,2,3+D sonic or visual animations. Not so raw usages consist creation of spatial 3D heightmaps (appendix α.5), pseudo-infinite polygonal fields (appendix α.6), applications of data (non-)linearly as control values towards logic and GA params of AL agents populating the digital ecosystems of the crafted programs (non-)human users *play* with.

β.1 Electronic byte sequence

A dual example, both source and executable of an electronic byte sequence generated by the `rogue` program (Toy et al 1980). Saved file 'rogue.save' is comprised of 49304 bytes of information. This file is able to communicate with the program by being read as a saved game you can continue. Portions of listed information, in unsigned char byte format, are next visualized as a 2D image and a 3D sculpture.

In C notation, the following information in 5pt font size can be accessed as:

```
unsigned char rogue_saved[] = {
  0x5f, 0xaf, 0x0e, 0xbb, 0x73, 0x70, 0x7d, 0x51, 0x61, 0xf9, 0xdd, 0x88,
   [...]
  0x69, 0xce, 0x0d, 0xc0, 0x69, 0xce, 0x0d, 0xc0, 0x69, 0xce
};
unsigned int rogue_saved_len = 49304;
```

β.1.1 Electronic byte sequence list

5fafoebb73707d5161f9dd88cf7f2d820ffe0910d06c453d64a2d56a1ef649b636616713049e6a220adb60ac2aca980c671675080b8f5346d266751f71b76240383e0a77bf2d7d9f47ed6f9d236416b1fb88369a72cc4b2050c9cf
8ff54af9688ade29cb1e628d4ad698e4a2d2d2d2dc069ce2c2d2d2d2d2c2d2d2c2d2d2d2d2d2d2c2d2d2c2c2d2d2d2d2d2d2d2d2d2d2d2d2d2d2d472dc469ce02a806
a3737f345021ecc78adc7571960ba14c20e94375084b92e26a5e736751b706c7088dd6e0a71b23b0f57a2bd6f9ee12274791ed8369a62cc4b2050c9cf8ac5a4f9688ade29cde27f9fcb8168e4a002af89c46d0f64947adb21585dd
bfadf2567f29a9f6e7a53ed0341ac233d53ab3ccb417407578a495d7e503916b9b1e2792ebd99866ee645c3ccd6a85e1456d1d0273a717e1ba7ea874f36bd93fca597c84387d3b08e174199162e1fdbb4a2e85f87e45d65d17961529
fc29521e96e8ed2e6755c5eaab2265d0b69914a3c951f078a9810d7b72b2df1cf4c6e17b9fff0b329ca31ebff57b236f5248d58b4c55dec66d9781d475bd50efb3c83f397434127e90ca3e407625934b655be17708c5c4c2d88a2b68e
b1ec03348b2e421cf74fcbf45ec230066caef30e91f6df90a6cd7f2a5010bdc381fe69f2ee6438a65cf63b2d5d3ad1c64bda6e065128da91e0b8736d548ef019136c23e2206d8ccbd939c4a2a953c16007e6539c53d5a61c07e5b03b
4f08305762dea80067a879ee27baef92d8d3f42e627e8bb8baf408d03530861decaea503515131e906997b5efd596a87739d5a836196296b267d12d8e85a511d4fc07096cf4c6414500f145c7a5c134bb89bb4c851c68afa5860b
0a0b4bdc94dcd2df7bb30fb8d32b07875d759a1b548f889f67380d60fbcb8bac3aa3bfb6c980dfb2ded3dc47817a854e470022717047328a2b021fa604288518f330ed8ecfd337e89677349824dod6a08f8d2f650b26499ac2d
4b4fa55219caf9735a27321f23f42170b98f9692e81ed4e1217e629db254d4fb2ff87a1f0d9fc638f7c137c67e59f4a627fd29b22b4f6d1cb0161f70f22e136ca53a94538765f15e08a6c6a2c110f89cb3675c3b2261b84a8ce34d3d3439
5e36cf5e6f96fcabf7b22be2fd8aa4b826c61cecc02d94278967ccb4c8efb28b03edc1125b37d8143388b712b6672837d06fa21618c9eb4d2b534294f49645be47f58fcea3694b1076fafgffofb9fe5b62fe44016b1efd5f8a8d24092b1
9402195193fd3ffdb84e487efc54d9478177cb48238110bedd31e5d45f65d23932d8a6d7791c6a47024e0d12d9e2635afcb7f5e80ec6a7ad5d7cc69c1419d25b8671fb9fe0e6ea5628ad3b6c5ee0100226d7af48caecba8fe84doccccd
0ce375a85b375ac3d7d78fe9407d027688d9e230e887b040eae869d73fb3d7441ff302409b8e7dc15e6bb109bdga6c11a65ce7boaa067ffeodgc4b18a8c1bd877e0c6a5ff62e739801dbd177922cfb6fd156363539e19f322d70708
a9d362e8e1d5e03c7ae2110bbbaade7966foda6fod7728d6d726b210df74a7c3206737157eeff17bfff215f672feaebce34b166c7bc1db0528f54e4d508e0e42c953c46363040e0243eafobdf77d1b8889175553956e842a3de9c62
4d3664bce420aebbb95cf2952dc469ce5ea11fab36363c4f6bbe80c2c17f328045b65a0f9b2c127d2ebc910b2816e4e09706a866adaf8fd21b578fd55201f69f81600726fd81aa69a62cc4b2050c9cf8ac54af9688ade29cde27f9fcb
8168e4a002af89c46d0f64947adb21585ddbfadf2567f29a9f6e7a53ed0341ac233d53ab3ccb417407578a495d7e503916b9b1e2792ebd99866ee645c3ccd6a85e1456d1d0273a717e1ba7ea874f36bd93fca597c84387d3b08e17
4199162e1fdbb4a2e85f87e45d65d17961529fc29521e96e8ed2e6755c5eaab2265d0b69914a3c951f078a9810d7b72b2df1cf4c6e17b9fffob329ca31ebff57b236f5248d58b4c55dec66d9781d475bd50efb3c83f397434127e90ca
34076259346655be17085c4c2d88a2b68e1ec03348b2e421cf74fcbf45ec230066caef30e91f6df90a6cd7f2a5010bdc381fe69f2ee6438a65cf63b2d5d3ad1c64bda6e065128da91e0b8736d548ef019136c23e2206d8ccbd93
9c4a2a953c16007e6539c53d5a61c07e5b03b4f08305762dea80067a879ee27baef92d8d3f42e627e8bb8baf408d03530861decaea503515131e906997b5efd596a87739d5a836196296b267d12d8e85a511d4fc07096cf4c6414
500f145c7a5c134bb89bb4c851c68afa5860b0a0b4bdc94dcd2df7bb30fb8d32b07875d759a1b548f889f67380d60fbcb8bac3aa3bfb6c980dfb2ded3dc47817a854e47002271704732842b021fa604288518f330ed8ecfd337e8
9677349824dod6a08f8d2f650b26499ac2d4b4fa55219caf9735a27321f23f42170b98f9692e81ed4e1217e629db254d4fb2ff87a1f0d9fc638f7c137c67e59f4a627fd29b22b4f6d1cb0161f70f22e136ca53a94538765f15e08a6c6a2
c110f89cb3675c3b2261b84a8ce34d3d34395e36cf5e6f96fcabf7b22be2fd8aa4b826c61cecc02d94278967ccb4c8efb28b03edc1125b37d8143388b712b6672837d06fa21618c9eb4d2b534294f49645be47f58fcea3694b1076faf
9ffofb9fe5b62fe44016b1efd5f8a8d24092b19402195193fd3ffdb84e487efc54d9478177cb48238110bedd31e5d45f65d23932d8a6d7791c6a47024e0d12d9e2635afcb7f5e80ec6a7ad5d7cc69c1419d25b8671fb9fe0e6ea5628ad
3b6c5ee0100226d7af48caecba8fe84doccccd0ce375a85b375ac3d7d78fe9407d027688d9e230e887b040eae869d73fb3d7441ff302409b8e7dc15e6bb109bdga6c11a65ce7boaa067ffeodgc4b18a8c1bd877e0c6a5ff62e739801
dbd177922cfb6fd156363539e19f322d70708a9d362e8e1d5e03c7ae2110bbbaade7966foda6fod7728d6d726b210df74a7c3206737157eeff17bfff215f672feaebce34b166c7bc1db0528f54e4d508e0e42c953c46363040e0243e
afobdf77d1b8889175553956e842a3de9c624d3664bce420aebbb95cf29537c069ce25c069ce29c069ce20c069ce23c069ce27c069ce2ec069ce3c069ce3ec069ce38c069ce2bc069ce3c069ce8c069ce2
5a11fab787721036af7db8ec6663a970fb30941873a016022fc854a3f110824c326a666f4f693d37240db867a2bd6f9ee12274791ed8369a62cc4b2050c9cf8ac54af9688ade29cde27f9fcb8168e4a002af89c46d0f64947adb215
85ddbfadf2567f29a9f6e7a53ed0341ac233d53ab3ccb417407578a495d7e503916b9b1e2792ebd99866ee645c3ccd6a85e1456d1d0273a717e1ba7ea874f36bd93fca597c84387d3b08e174199162e1fdbb4a2e85f87e45d65d179
61529fc29521e96e8ed2e6755c5eaab2265d0b69914a3c951f078a9810d7b72b2df1cf4c6e17b9fffob329ca31ebff57b236f5248d58b4c55dec66d9781d475bd50efb3c83f397434127e90ca3e407625934b655be17708c5c4c2d88a
2b68e1ec03348b2e421cf74fcbf45ec230066caef30e91f6df90a6cd7f2a5010bdc381fe69f2ee6438a65cf63b2d5d3ad1c64bda6e065128da91e0b8736d548ef019136c23e2206d8ccbd939c4a2a953c16007e6539c53d5a61c07e
5b03b4f08305762dea80067a879ee27baef92d8d3f42e627e8bb8baf408d03530861decaea503515131e906997b5efd596a87739d5a836196296b267d12d8e85a511d4fc07096cf4c6414500f145c7a5c134bb89bb4c851c68afa
5860b0a0b4bdc94dcd2df7bb30fb8d32b07875d759a1b548f889f67380d60fbcb8bac3aa3bfb6c980dfb2ded3dc47817a854e47002271704732842b021fa604288518f330ed8ecfd337e89677349824dod6a08f8d2f650b2649
9ac2d4b4fa55219caf9735a27321f23f42170b98f9692e81ed4e1217e629db254d4fb2ff87a1f0d9fc638f7c137c67e59f4a627fd29b22b4f6d1cb0161f70f22e136ca53a94538765f15e08a6c6a2c110f89cb3675c3b2261b84a8ce34d3
d34395e36cf5e6f96fcabf7b22be2fd8aa4b826c61cecc02d94278967ccb4c8efb28b03edc1125b37d8143388b712b6672837d06fa21618c9eb4d2b534294f49645be47f58fcea3694b1076fafgffofb9fe5b62fe44016b1efd5f8a8d24
092b19402195193fd3ffdb84e487efc54d9478177cb48238110bedd31e5d45f65d23932d8a6d7791c6a47024e0d12d9e2635afcb7f5e80ec6a7ad5d7cc69c1419d25b8671fb9fe0e6ea5628ad3b6c5ee0100226d7af48caecba8fe84d
occcd0ce375a85b375ac3d7d78fe9407d027688d9e230e887b040eae869d73fb3d7441ff302409b8e7dc15e6bb109bdga6c11a65ce7boaa067ffeodgc4b18a8c1bd877e0c6a5ff62e739801dbd177922cfb6fd156363539e19f322d
70708a9d362e8e1d5e03c7ae2110bbbaade7966foda6fod7728d6d726b210df74a7c3206737157eeff17bfff215f672feaebce34b166c7bc1db0528f54e4d508e0e42c953c46363040e0243eafobdf77d1b8889175553956e842a3d
e9c624d3664bce420aebbb95cf2952f13f6217f709d72d3eeeece3fcaoe7e1ccce36a37c8d2f30baccoe8e0a02b14ddd62dd9064b086a0aoa6fbd6b7f8825b86d501399ea89789192be680008f590e68fcba498b661da1c33c0dof3c
946692508dbaa74eea3ebf28439d46c899b6be7384a9c1c150fd79db6c1c96e33adcbdc9572ac713506b39f61b866512e3b53a474dd74896c62d6ef81ab74e37fb88ec15740cf7ee75700e76e1367982832d645cb2de23ff8f6e51
5e9a60be495b64b5d2be7e64d778617650379c742630e4737f355d19b7f0d1c80bc1a77f061d6b7d20a4c289a4044f980ae60d280e774d8c6b0e7cdda04769e46743e2b101ae7aafae8d13414fd83c91f79611b490b524110bb49
1aa05b8d0fe6880323f34e4557b629eb54ab82c9cc0443bbf9fe468babba7658e102c3cec4e857682f71699d4f142a08261b02ce8a944dcdb18f6997f47549a3c70b19a93818320d21e9d0aa6293o8edo3d4b563f7c06c9e6f206
61bbf28154626142bdcb403180c18afd60ab7d516d99972dffb111b238e1ef99b9a2892550b7e553d1cfe70079a51c4a3fac6a98463fe027fb6269899bdeed491cca54eb3750ea14c15522a24d9b7826a24593d9ceeb71e65bb5bc65c
fe1f4d706761ed2e793e52b8a4bf4112a743b87572c09c697624d52869bfb25511ff532b8502e99f8108c30c0231a342176086ab365080c9a1ade8c9e7410f24442c5cb193e9939610b394eeaebd55d7a9319aa6ca0864e8f4986c7
7820e3d0c9c42801a311b71d170f8a932e674d2cf262foc8b059e61095db1e1e9f6e73ba36d06e25c847ff55b3beedf0088ce18f7c6df8651dd66d4227deba1164cad16ac9a36a815d48a5cb62629479baf3e171563756115c3a2d805
fbddd44ecdd1599f7fe3e43804052955cf1373bfbe10176a03798fbfe3e6fc611fd8c14a72e1033d40c129dc732f34abadf8b88ef2243e8ad40ad127c7d12f7de438d0f89134163a1a25988f883f5ad6a083d37f60c256a4b2d852879a
05626b1c2a59f35ce48429777562e57f6e42fob42ae365d9b9d1ae5d72df56f28aad544e11c4cffd9e8b02648544e110273cd6f00884ce18f7c6df8651d6352f3dec9372df8827412a88737113ccf3b84b4ce3f6c154e55ab34e55b064c4f405afe
e27f0c36787c4ca98c1269601229777e5dd4d55920defd249d5fe130701cee0fed1add9faa899e5464cedd91c34cfc1a43bof060dcbb88e8e685ff2417405ccd321e76ececc042c08293dc159a103cfbc7739c64c8c016bd535a9f46c3
d62e71442bb202c2367f5eaf6fe004f90fa171a948e4a3334a818848e93a378c7bcde24b506ecd60425fb8ff24c5009f7e21dd3cfdd3ec181feqc6c468a242ed02d20d1dfdb51dea546f5c7c6abae93bf7ab5e4057b2a069484a06dad
ead61100d86067d374068b990b4ab47b35435acad5403ad361a5c6dffb9927c069ce2ac069ce2dc069ce28c069ce24c069ce28c069ce3dc069ce3c069ce25c069ce45b90deec6c3f3e
2325c069ce25c069ce59a80cbc36283a2333c069ce3cc069ce59af11ab6538754f6feac795dd783a976a20c069ce20c069ce25b207ab652434037dfoc186a93c069ce3c069ce45a5a1ba9363535b442ef0c185897b378a08be4c2025c069ce25b90dee6c3f3e
2325c069ce25c069ce59a80cbc36283a2333c069ce3cc069ce59af11ab6538754f6feac795dd783a976a20c069ce20c069ce25b207ab652434037dfoc186a93c069ce3c069ce45a5a1ba9363535b442ef0c185897b378a08be4c2025c069ce45b90dee6c3f3e
9ce5ba105ee633c3e546be68899c6685f35c069ce35c069ce57b504ee633e3c456ff3c1cdc063378703b24d4fc922170822c069ce22c069ce49a105a87839b3036beccd9dc8695f2d2dc469ce4cb369ce165055230e9ea8eda910
5fe56ad72920e94375084b92e26a5e736751b706c7088dd6e0a71b23bof57a2bd6f9ee12274791ed8369a62cc4b2050c9cf8ac54af9688ade29cde27f9fcb8168e4a002af89c46d0f64947adb21585ddbfadf2567f29a9f6e7a53ed
0341ac233d53ab3ccb417407578a495d7e503916b9b1e2792ebd99866ee645c3ccd6a85e1456d1d0273a717e1ba7ea874f36bd93fca597c84387d3b08e174199162e1fdbb4a2e85f87e45d65d17961529fc29521e96e8ed2e6755c5
eaab2265d0b69914a3c951f078a9810d7b72b2df1cf4c6e17b9fffob329ca31ebff57b236f5248d58b4c55dec66d9781d475bd50efb3c83f397434127e90ca3e407625934b655be17085c4c2d88a2b68e1ec03348b2e421cf74fcbf
45ec230066caef30e91f6df90a6cd7f2a5010bdc381fe69f2ee6438a65cf63b2d5d3ad1c64bda6e065128da91e0b8736d548ef019136c23e2206d8ccbd939c4a2a953c16007e6539c53d5a61c07e5b03b4f08305762dea80067a87
9ee27baef92d8d3f42e627e8bb8baf408d03530861decaea503515131e906997b5efd596a87739d5a836196296b267d12d8e85a511d4fc07096cf4c6414500f145c7a5c134bb89bb4c851c68afa5860b0a0b4bdc94dcd2df7bb30fb
8d32b07875d759a1b548f889f67380d60fbcb8bac3aa3bfb6c980dfb2ded3dc47817a854e47002271704732842b021fa604288518f330ed8ecfd337e89677349824dod6a08f8d2f650b26499ac2d4b4fa55219caf9735a27321f
23f42170b98f9692e81ed4e1217e629db254d4fb2ff87a1f0d9fc638f7c137c67e59f4a627fd29b22b4f6d1cb0161f70f22e136ca53a94538765f15e08a6c6a2c110f89cb3675c3b2261b84a8ce34d3d34395e36cf5e6f96fcabf7b22be
d8aa4b826c61cecc02d94278967ccb4c8efb28b03edc1125b37d8143388b712b6672837d06fa21618c9eb4d2b534294f49645be47f58fcea3694b1076fafgffofb9fe5b62fe44016b1efd5f8a8d24092b19402195193fd3ffdb84e487
efc54d9478177cb48238110bedd31e5d45f65d23932d8a6d7791c6a47024e0d12d9e2635afcb7f5e80ec6a7ad5d7cc69c1419d25b8671fb9fe0e6ea5628ad3b6c5ee0100226d7af48caecba8fe84doccccd0ce375a85b375ac3d7d78fe
9407d027688d9e230e887b040eae869d73fb3d7441ff302409b8e7dc15e6bb109bdga6c11a65ce7boaa067ffeodgc4b18a8c1bd877e0c6a5ff62e739801dbd177922cfb6fd156363539e19f322d70708a9d362e8e1d5e03c7ae2110
bbbaade7966foda6fod7728d6d726b210df74a7c3206737157eeff17bfff215f672feaebce34b166c7bc1db0528f54e4d508e0e42c953c46363040e0243eafobdf77d1b8889175553956e842a3de9c624d3664bce420aebbb95cf29
52dc069ce27c069ce20c069ce39c069ce24c069ce20c069ce30c069ce3c069ce24c069ce2dc069ce2dc469ce5eac00a33737d384c62faa8eda9105fe56ad72920e94375084b92e26a5e736751b706c7088dd6e0a71b23b0f57a2bd6f9ee1c069ce2dc069ce2c069ce69
ce2bc069ce2dc069ce25c069ce2dc069ce24c069ce2dc069ce2dc469ce5eac00a33737d384c62faa8eda9105fe56ad72920e94375084b92e26a5e736751b706c7088dd6e0a71b23b0f57a2bd6f9ee12274791ed8369a62cc4b2050
c9cf8ac54af9688ade29cde27f9fcb8168e4a002af89c46d0f64947adb21585ddbfadf2567f29a9f6e7a53ed0341ac233d53ab3ccb417407578a495d7e503916b9b1e2792ebd99866ee645c3ccd6a85e1456d1d0273a717e1ba7e
4f36bd93fca597c84387d3b08e174199162e1fdbb4a2e85f87e45d65d17961529fc29521e96e8ed2e6755c5eaab2265d0b69914a3c951f078a9810d7b72b2df1cf4c6e17b9fffob329ca31ebff57b236f5248d58b4c55dec66d9781d4
75bd50efb3c83f397434127e90ca3e407625934b655be1708c5c4c2d88a2b68e1ec03348b2e421cf74fcbf45ec230066caef30e91f6df90a6cd7f2a5010bdc381fe69f2ee6438a65cf63b2d5d3ad1c64bda6e065128da91e0b8736d
548ef019136c23e2206d8ccbd939c4a2a953c16007e6539c53d5a61c07e5b03b4f08305762dea80067a879ee27baef92d8d3f42e627e8bb8baf408d03530861decaea503515131e906997b5efd596a87739d5a836196296b267d
12d8e85a511d4fc07096cf4c6414500f145c7a5c134bb89bb4c851c68afa5860b0a0b4bdc94dcd2df7bb30fb8d32b07875d759a1b548f889f67380d60fbcb8bac3aa3bfb6c980dfb2ded3dc47817a854e47002271704732842b02
1fa604288518f330ed8ecfd337e89677349824dod6a08f8d2f650b26499ac2d4b4fa55219caf9735a27321f23f42170b98f9692e81ed4e1217e629db254d4fb2ff87a1f0d9fc638f7c137c67e59f4a627fd29b22b4f6d1cb0161f70f22
e136ca53a94538765f15e08a6c6a2c110f89cb3675c3b2261b84a8ce34d3d34395e36cf5e6f96fcabf7b22be2fd8aa4b826c61cecc02d94278967ccb4c8efb28b03edc1125b37d8143388b712b6672837d06fa21618c9eb4d2b534294
f49645be47f58fcea3694b1076fafgffofb9fe5b62fe44016b1efd5f8a8d24092b19402195193fd3ffdb84e487efc54d9478177cb48238110bedd31e5d45f65d23932d8a6d7791c6a47024e0d12d9e2635afcb7f5e80ec6a7ad5d7cc69c
1419d25b8671fb9fe0e6ea5628ad3b6c5ee0100226d7af48caecba8fe84doccccd0ce375a85b375ac3d7d78fe9407d027688d9e230e887b040eae869d73fb3d7441ff302409b8e7dc15e6bb109bdga6c11a65ce7boaa067ffeodgc4
b18a8c1bd877e0c6a5ff62e739801dbd177922cfb6fd156363539e19f322d70708a9d362e8e1d5e03c7ae2110bbbaade7966foda6fod7728d6d726b210df74a7c3206737157eeff17bfff215f672feaebce34b166c7bc1db0528f54e4d
508e0e42c953c46363040e0243eafobdf77d1b8889175553956e842a3de9c624d3664bce420aebbb95cf2952dc469ce2a806a3737f3450219ea8eda9105fe56ad72920e94375084b92e26a5e736751b706c7088dd6e0a71b23
b0f57a2bd6f9ee12274791ed8369a62cc4b2050c9cf8ac54af9688ade29cde27f9fcb8168e4a002af89c46d0f64947adb21585ddbfadf2567f29a9f6e7a53ed0341ac233d53ab3ccb417407578a495d7e503916b9b1e2792ebd99866
6ee645c3ccd6a85e1456d1d0273a717e1ba7ea874f36bd93fca597c84387d3b08e174199162e1fdbb4a2e85f87e45d65d17961529fc29521e96e8ed2e6755c5eaab2265d0b69914a3c951f078a9810d7b72b2df1cf4c6e17b9fffob32
9ca31ebff57b236f5248d58b4c55dec66d9781d475bd50efb3c83f397434127e90ca3e407625934b655be1708c5c4c2d88a2b68e1ec03348b2e421cf74fcbf45ec230066caef30e91f6df90a6cd7f2a5010bdc381fe69f2ee6438a65
cf63b2d5d3ad1c64bda6e065128da91e0b8736d548ef019136c23e2206d8ccbd939c4a2a953c16007e6539c53d5a61c07e5b03b4f08305762dea80067a879ee27baef92d8d3f42e627e8bb8baf408d03530861decaea50351513
1e906997b5efd596a87739d5a836196296b267d12d8e85a511d4fc07096cf4c6414500f145c7a5c134bb89bb4c851c68afa5860b0a0b4bdc94dcd2df7bb30fb8d32b07875d759a1b548f889f67380d60fbcb8bac3aa3bfb6c980df
b2ded3dc47817a854e47002271704732842b021fa604288518f330ed8ecfd337e89677349824dod6a08f8d2f650b26499ac2d4b4fa55219caf9735a27321f23f42170b98f9692e81ed4e1217e629db254d4fb2ff87a1f0d9fc638f7
c137c67e59f4a627fd29b22b4f6d1cb0161f70f22e136ca53a94538765f15e08a6c6a2c110f89cb3675c3b2261b84a8ce34d3d34395e36cf5e6f96fcabf7b22be2fd8aa4b826c61cecc02d94278967ccb4c8efb28b03edc1125b37d814
388b712b6672837d06fa21618c9eb4d2b534294f49645be47f58fcea3694b1076fafgffofb9fe5b62fe44016b1efd5f8a8d24092b19402195193fd3ffdb84e487efc54d9478177cb48238110bedd31e5d45f65d23932d8a6d7791c6a470
24e0d12d9e2635afcb7f5e80ec6a7ad5d7cc69c1419d25b8671fb9fe0e6ea5628ad3b6c5ee0100226d7af48caecba8fe84doccccd0ce375a85b375ac3d7d78fe9407d027688d9e230e887b040eae869d73fb3d7441ff302409b8e7d
c15e6bb109bdga6c11a65ce7boaa067ffeodgc4b18a8c1bd877e0c6a5ff62e739801dbd177922cfb6fd156363539e19f322d70708a9d362e8e1d5e03c7ae2110bbbaade7966foda6fod7728d6d726b210df74a7c3206737157eeff17bf
ff215f672feaebce34b166c7bc1db0528f54e4d508e0e42c953c46363040e0243eafobdf77d1b8889175553956e842a3de9c624d3664bce420aebbb95cf2952dc069ce27c069ce27c069ce62b60cbc61223c576b9e28c069ce28c
069ce7eac06b9162bc069ce2bc069ce6eacocaf6450472d7f620314c069ce26c069ce26c069ce24c069ce2e37233f2355c2c5a7f41ad36b5246a6of9888ac
8637f9118b6592026c069ce26c069ce4ce00bab772221516feea83dc069ce3dc069ce4ce01dab7a35254c7cea8899db712fe53ec069ce3ec069ce4ce019a17f233a4d2efac99fdd302b970ba72921c069ce21c069ce01bbb6524
75577cffd8ed3fc069ce3fc069ce4ce004b76524305167f1dd9e8964 2d841ad72cc069ce2cc069ce23c169c069ce22c169ce22c169ce8c069ce8c5764ad24be558038c069ce27c069ce3dc069ce05c069ce7dc069ce8dc069ce6dc169ceadc269ce39c569ce05ca6
9ce7dd469cee5f269cebda569ce7d0369ce8d4668ce6dd0d6aceadda6fce2df565cead4477ce2dc954ce2dd213ce2dc069ce05c069ce3dc069ce6c069ce9c069ce29c069ce27c04a652c069ce6c069ce3dc069ce2d2d
2d2d2dc069ce2dc02cc0a4653dc069ce16c069ce29c069ce27c069ce33c069ce20c069ce1cb85dce165055230e9ea8eda90fc069ce25c069ce2ac0a46525c069ce20c069ce20c069ce27c069ce2d2d2dc069ce4c2
5c069ce2dc069ce165055232c069ce2dc069ce165055232c069ce2dc069ce20c069ce27c069ce2dc069ce2dc069ce20c069ce2dc069ce2ec0a46570c069ce2dc069ce20c069ce2dc069ce4f25c069ce1650
552325c069ce2dc069ce165055232c069ce2dc069ce2dc069ce2bc069ce2fc069ce2dc069ce2dc069ce2dc069ce20c069ce2dc069ce165055232c069ce1cb85dce165055232c069ce1cb859ce
e165055232c069ce29c069ce2dc069ce28c069ce3dc069ce2dc069ce2dc069ce2eco a46502c069ce8c069ce2fc069ce2dc069ce4525c069ce1db859ce165055232c069ce1db859c
069ce2cc069ce2fc069ce2dc069ce3fc069ce2dc069ce2dc069ce2eco a46504c069ce2dc069ce23f96314925c069ce1cb858ce165055232c069ce1fb85dce165055231c069ce2ec069ce2dc069ce
2dc069ce3fc069ce2dc069ce2dc069ce2dc069ce2eco a46504c069ce0ac069ce39c069ced23f96314b25c069ce1cb85bce165055232c069ce1fb85dce165055232c069ce2dc069ce3dc069ce2ec069ce2fco
69ce2dc069ce2dc069ce2eco a46504c069ce29c069ced23f96314b25c069ce1cb85bce165055232c069ce2ec069ce2dc069ce3dc069ce2ec069ce2fco69ce2dc069ce2dc069ce31c069ce2dc069ce2dc069ce
2eco a46512c069ce2dc069ce2dc069ce4e4425c069ce1db859ce165055232c069ce1db859ce165055232c069ce2ec069ce2dc069ce3dc069ce2ec069ce2fc069ce2dc069ce2dc069ce
f96312ec069ced23f9631d23f96312ac0a46524c069ce2dc069ce3fc069ce2dc069ce2dc069ce2eco a46512c069ce2dc069ce2dc069ce165055232c069ce1db859ce165055232c069ce4c069ce2dc069ce2dc069c
e2dc069ce2dc069ce2eco a46512c069ce2dc069ce20c069ce2d25c069ce1db859ce165055232c069ce1db859ce165055232c069ce24c069ce2fc069ce2dc069ce2dc069ce2dc069ce2dc069ce2dc069ce2d
c069ce2eco a46512c069ce13c069ce3c069ce2dc069ce1db859ce165055232c069ce1db859ce165055232c069ce24c069ce2fc069ce2dc069ce2dc069ce2dc069ce2eco a46512c06
9ce68c069ce3fc069ce2d25c069ce1db859ce165055232c069ce1db859ce165055232c069ce24c069ce2dc069ce26c069ce2dc069ce2dc069ce2dc069ce2eco a46504c069ce67c069ce39c069ce
d23f96312d25c069ce1fb85dce165055232c069ce1cb85ace165055232c069ce2dc069ce2dc069ce2dc069ce2dc069ce2dc069ce2dc069ce2eco a46517c069ce64c069ce3fc069ce2dc069ce2dc069ce2d
1b859ce165055232c069ce1db859ce165055232c069ce2dc069ce26c069ce2dc069ce2dc069ce2dc069ce2dc069ce24c069ce46507c069ceobc069ce3fc069ce2dc069ce165055232c0
69ce2dc069ce165055232c069ce2dc069ceoc069ce26c069ce2dc069ce2dc069ce2dc069ce2eco a46507c069ce2eco a46507c069ce2dc069ce2dc069ce165055232c069ce2dc069ce1650552
32dc069ce2dc069ce26c069ceoc069ce25c069ce2dc069ce2dc069ce2eco a46507c069ce66c069ce2dc069ce2dc069ce165055232c069ce2dc069ce165055232c069ce2dc069ce1650552
dc069ce2dc069ce2dc069ce2dc069ce2eco a46504c069ce22c069ceo a4652c069ce2fc04a652c069ce2dc069ce2de82cco a46527c069ce27c069ce2fc069ce2ac069ce2dc069ceo a46512c06
9ce1cb85fce165055230e9ea8eda92bc069ced23f96312aco a4652dc069ce2fco a4652c069ce68c069ce3c069ce2c7e7e032dc069ce2cc069ce2de82cco a46527c069ce2fc069ce2cc069ce24c069ce25c069ce20c069ce1cb85
ace165055230e9ea8eda92aco a4652c069ce2aco a4652dc069ce2fco a4652c069ce6c069ce3c069ce2c7e7e032dc069ce2cc069ce2de82cco a46527c069ce2cc069ce2cc069ce28c069ce25c069ce20c069ce1cb85ace165055230e9e
a8eda925c069ce2aco a4652dc069ce2fco a4652cc069ce13c069ce3c069ce2c7e7e032dc069ce2cc069ce2de82cco a46527c069ce2fc069ce2cc069ce28c069ce2fc069ce2cc069ce20c069ceo a4652c069ce2fcce1cb85ace165055230e9ea8eda92fc

278

69ceodc069ce

(illegible repeating pattern)

282

β.1.3 Electronic 3D output

β.2 Biologic byte sequence

Listing a small portion of voltage variations digitized through Arduino's ADC ports in studio plants and stored as numerical byte values. The snippet of information depicts data deltas underlining a pleasing perhaps nourishing plant watery moment in time observed electronically on the sample ecosystem. Portions of listed information, in decimal format on unsigned char range, are next visualized as a 2D image and a 3D sculpture.

β.2.1 Biologic byte sequence list

|				
2018-08-19-14-41-46-750	logs/HalfPlantLog	1		
2018-08-19-14-41-48-517	1.93138	0	Half-Plant sensors	216, 202, 207, 184, 204, 157
2018-08-19-14-41-48-651	2.06477	1	Half-Plant sensors	222, 205, 219, 197, 203, 163
2018-08-19-14-41-48-817	2.23141	2	Half-Plant sensors	220, 205, 207, 206, 199, 156
2018-08-19-14-41-48-984	2.39809	3	Half-Plant sensors	213, 204, 206, 209, 206, 160
2018-08-19-14-41-49-150	2.56471	4	Half-Plant sensors	217, 213, 210, 204, 199, 158
2018-08-19-14-41-49-317	2.73135	5	Half-Plant sensors	214, 208, 208, 211, 200, 159
2018-08-19-14-41-49-450	2.86463	6	Half-Plant sensors	213, 205, 205, 211, 201, 162
2018-08-19-14-41-49-617	3.03141	7	Half-Plant sensors	213, 228, 199, 217, 202, 190
2018-08-19-14-41-49-784	3.19811	8	Half-Plant sensors	208, 212, 208, 217, 192, 173
2018-08-19-14-41-49-951	3.36474	9	Half-Plant sensors	216, 214, 199, 214, 197, 177
2018-08-19-14-41-50-117	3.53146	10	Half-Plant sensors	215, 224, 203, 213, 196, 182
2018-08-19-14-41-50-284	3.69813	11	Half-Plant sensors	212, 215, 216, 216, 200, 168
2018-08-19-14-41-50-417	3.83141	12	Half-Plant sensors	213, 204, 215, 205, 200, 153
2018-08-19-14-41-50-584	3.99803	13	Half-Plant sensors	223, 210, 208, 210, 206, 159
2018-08-19-14-41-50-750	4.16473	14	Half-Plant sensors	211, 211, 203, 210, 219, 161
2018-08-19-14-41-50-917	4.33144	15	Half-Plant sensors	216, 202, 211, 197, 212, 146
2018-08-19-14-41-51-084	4.49806	16	Half-Plant sensors	223, 191, 214, 194, 213, 151
2018-08-19-14-41-51-250	4.6646	17	Half-Plant sensors	221, 196, 215, 192, 210, 143
2018-08-19-14-41-51-384	4.79798	18	Half-Plant sensors	216, 195, 219, 195, 215, 145
2018-08-19-14-41-51-550	4.9647	19	Half-Plant sensors	219, 195, 214, 195, 212, 147
2018-08-19-14-41-51-717	5.13137	20	Half-Plant sensors	229, 185, 226, 190, 222, 136
2018-08-19-14-41-51-884	5.29813	21	Half-Plant sensors	228, 192, 227, 194, 221, 140
2018-08-19-14-41-52-051	5.46476	22	Half-Plant sensors	233, 192, 227, 195, 217, 143
2018-08-19-14-41-52-184	5.59801	23	Half-Plant sensors	226, 196, 222, 195, 215, 146
2018-08-19-14-41-52-350	5.7647	24	Half-Plant sensors	227, 203, 216, 204, 206, 160
2018-08-19-14-41-52-517	5.9314	25	Half-Plant sensors	224, 209, 216, 209, 207, 154
2018-08-19-14-41-52-684	6.09807	26	Half-Plant sensors	212, 211, 216, 210, 209, 164
2018-08-19-14-41-52-851	6.26478	27	Half-Plant sensors	226, 203, 218, 212, 209, 159
2018-08-19-14-41-53-018	6.43187	28	Half-Plant sensors	210, 203, 204, 208, 206, 154
2018-08-19-14-41-53-151	6.56478	29	Half-Plant sensors	218, 217, 205, 213, 207, 156
2018-08-19-14-41-53-317	6.73137	30	Half-Plant sensors	210, 213, 208, 208, 203, 166

2018-08-19-14-41-53-484	6.89811	31	Half-Plant sensors	212, 211, 207, 207, 201, 169
2018-08-19-14-41-53-651	7.06473	32	Half-Plant sensors	215, 207, 207, 211, 203, 169
2018-08-19-14-41-53-817	7.2314	33	Half-Plant sensors	203, 224, 200, 214, 199, 189
2018-08-19-14-41-53-950	7.36472	34	Half-Plant sensors	214, 214, 199, 217, 195, 179
2018-08-19-14-41-54-117	7.5314	35	Half-Plant sensors	212, 218, 206, 221, 198, 177
2018-08-19-14-41-54-283	7.69773	36	Half-Plant sensors	212, 217, 208, 217, 206, 170
2018-08-19-14-41-54-451	7.86476	37	Half-Plant sensors	218, 213, 204, 214, 212, 172
2018-08-19-14-41-54-617	8.03136	38	Half-Plant sensors	216, 196, 218, 206, 200, 170
2018-08-19-14-41-54-784	8.198	39	Half-Plant sensors	226, 202, 208, 206, 214, 163
2018-08-19-14-41-54-917	8.33134	40	Half-Plant sensors	218, 201, 220, 206, 213, 150
2018-08-19-14-41-55-084	8.49802	41	Half-Plant sensors	225, 203, 219, 197, 208, 150

[...]
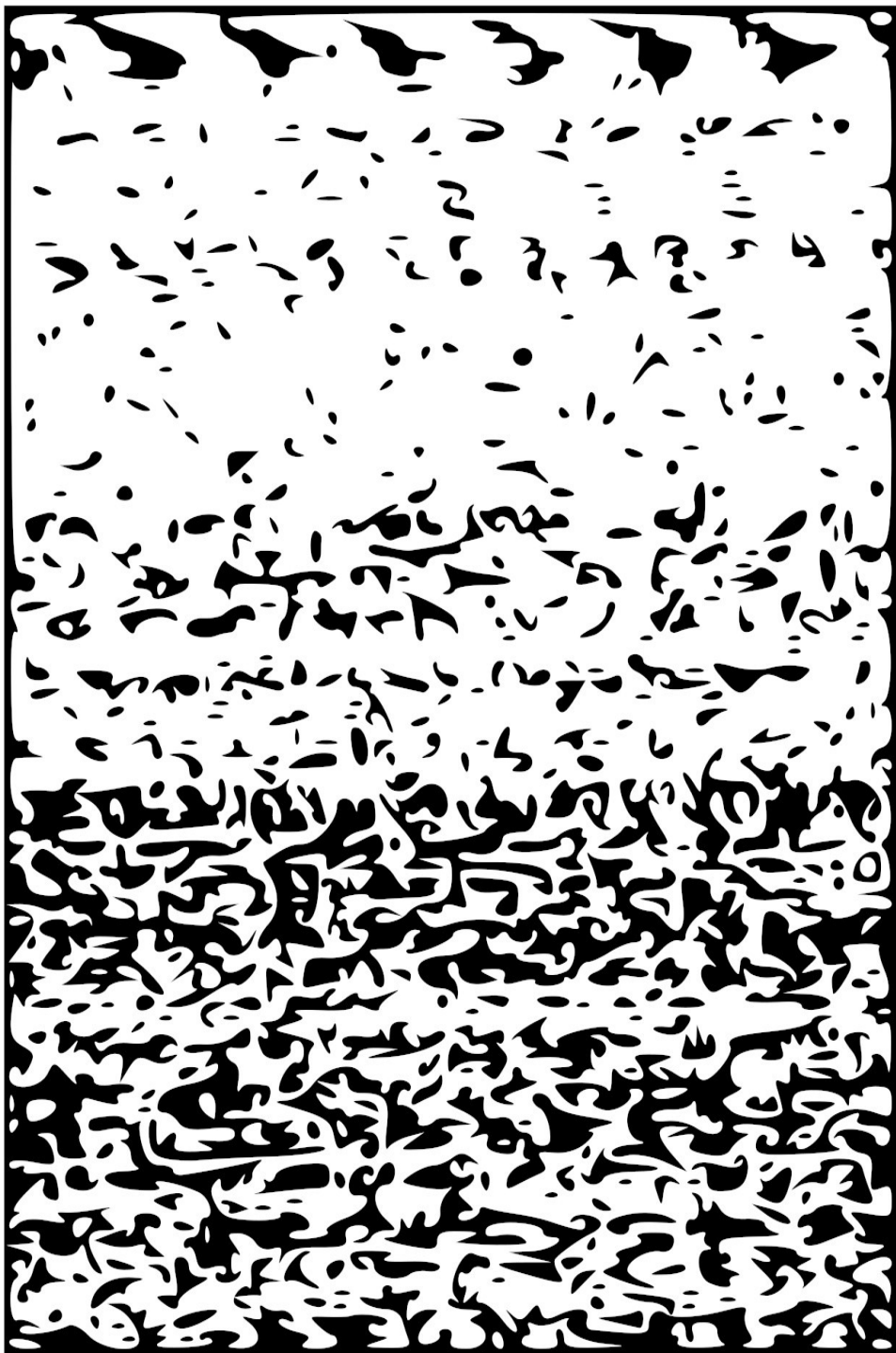
β.2.3 Biologic 3D output
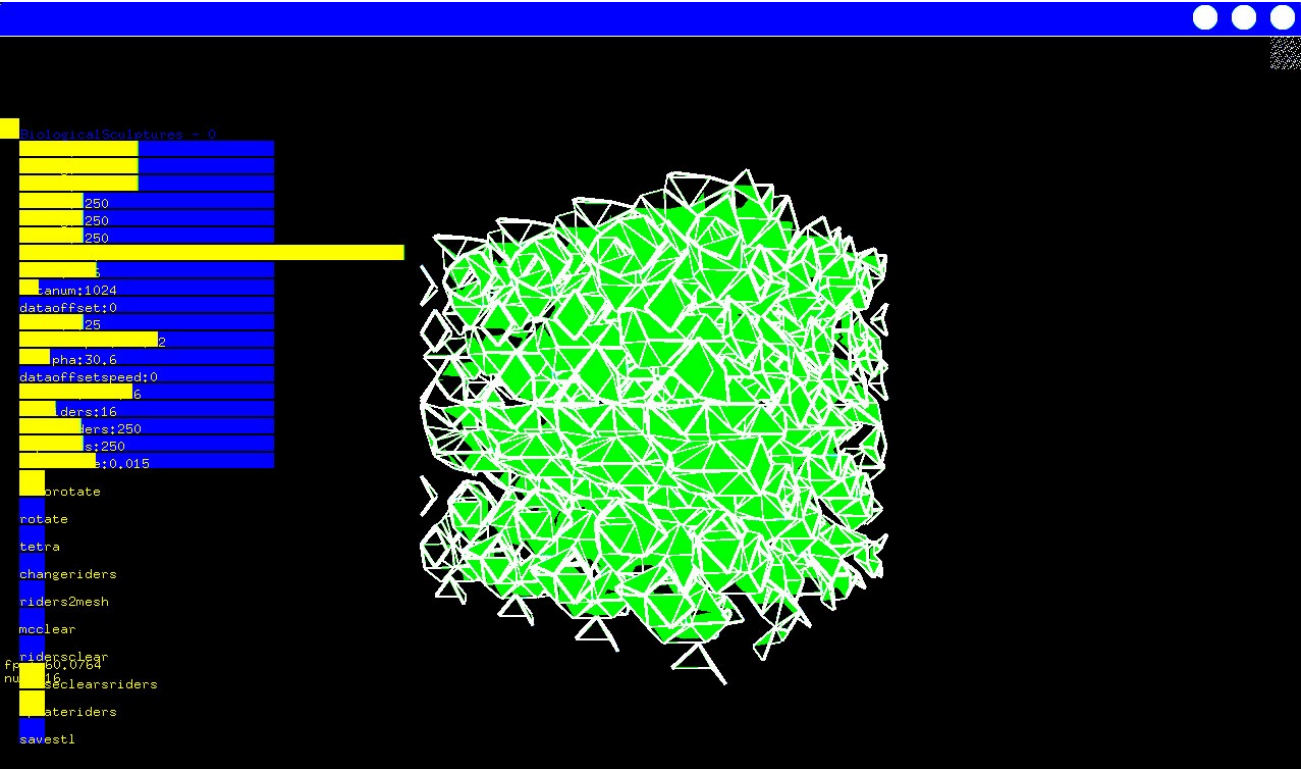
Appendix Γ Research outputs

γ.1 Publications

Sier, A. (2022), Uivo, Santarém: ArteCódigo Publicações. AC22001, 118pp. ISBN 978-989-33-3595-6. URL https://artecodigo.pt/pub/

Sier, A. (2021), 'Anthemusa: towards a mythological laser based point-lighthouse', Aura // Luz de Presença, Freire, P. (ed), pp. 94-106, Sintra: Criaatividade Cósmica, ISBN 978-989-33-0660 URL https://cosmica.pt/luz-de-presenca/

Sier, A. (2019), 'Bio-electronic aggregates on Neon-Paleolitikos strata', Technoetic Arts: A Journal of Speculative Research, Ascott, R. (Ed.), 17:3, pp. 215–28, DOI: 10.1386/tear_00016_1

Sier, A. (2019), 'Non-human labyrinths: Roots and additional other than human formation methods', Technoetic Arts: A Journal of Speculative Research, Ascott, R. (ed), 17:1+2, pp. 5–23, DOI: 10.1386/tear_00002_1

Sier, A. (2019), '21 Games for the 21st Century', Videojogos 2018: Proceedings of the 10th Conference on Videogame Sciences and Arts, Carvalhais, M., Cardoso, P., Amado, P. (eds), i2ADS – Research Institute in Art, Design and Society, University of Porto, Faculty of Fine Arts, ISBN 978-989-54111-6-0, URL https://vj2018.fba.up.pt/

Sier, A. (2018), 'Structs for an aspatial quantum-now', Taboo - Transgression - Transcendence in Art & Science, Honorato, D., Giannakoulopoulos, A., (eds), Corfu, Ionian University, ISBN 978-960-7260-60-4, URL https://avarts.ionio.gr/ttt/2017/en/proceedings/

Sier, A. (2017), 'Human dragons playing in cyberspace', Technoetic Arts: A Journal of Speculative Research, Ascott, R. (Ed.), 15:3, pp. 283–96, DOI: 10.1386/tear.15.3.283_1

Sier, A. (2017), 'Artefactos da porta escondida da ponte ("Lançados para dentro de um Labirinto")', Cibertextualidades, Torres, R. , Petry, L. C. (eds), 8, pp. 57-70, ISSN 1646-4435. URL https://bdigital.ufp.pt/handle/10284/6008

γ.2 Conference presentations and artist talks

Sier, A. (2020), 'Wolfspace: Interactive century deep cartography and sculpture making tool by wolves in Portugal' at Ecodata, Open Fields 2020 Conference, 10 October 2020, Riga. (online)

Sier, A. (2020), '0X Labyrinth' at Telluric Vibrations, UCLA Botanical Gardens – Ars Electronica, 13 September 2020, University of California Los Angeles ArtSci Center, Los Angeles. (online)

Sier, A. (2019),'Bio-electronic Aggregates on Neon Paleolitikos Strata' at Consciousness Reframed XXI, Universidade Católica Portuguesa, 7 June 2019, Porto.

Sier, A. (2019), 'Imaginary Media (√(-art))', at University of Applied Arts Vienna Digital Arts Department, 2 May 2019, Vienna.

Sier, A. (2019), 'Non-Human Labyrinths', at Rubrics of Transformation, Serafio Cultural Center, 18 February 2019, Athens.

Sier, A. (2018), '21 Games for the 21st Century', keynote address at VideoJogos 2018: 10th Conference on Videogame Sciences and Arts, Biblioteca Almeida Garrett, 21 November 2018, Porto.

Sier, A. (2018), 'Half-Plant: A Genetic Bio-Electronic Aggregate', at Festival Art & Science FACTT18, Culturgest, 22 September 2018, Lisboa.

Sier, A. (2017), 'Phoenix.Wolfanddotcom.Info', at Balance-Unbalance 2017 A Sense of Place, Plymouth University, 22 August 2017, Plymouth.

Sier, A. (2017), 'Structs for an Aspatial Quantum-Now', at Taboo Transgression Transcendence TTT17, Ionian University, 27 May 2017, Corfu.

Sier, A. (2016), 'Human dragons playing in cyberspace', at Consciousness Reframed XIX, Chronos Art Center, 27 November 2016, Shanghai.

γ.3 Workshops

Sier, A. (2019), '8-bit Maze Gardens', labyrinthine vegetable paintings workshop at Água Terra Ar, Palácio Landal, March 2019, Santarém.

Sier, A. (2017), 'Generative Sculptures', generative sculpture fabricating workshop at Convento São Francisco, January 2017, Coimbra.

Sier, A. (2016), 'Sonic Interactions in openFrameworks', audio programming workshop at Mill - Makers in Little Lisbon, May 2016, Lisboa.

Sier, A. (2016), 'Foto-Synthesis: Physical Computation Interfaces', physical computation workshop at Mill - Makers in Little Lisbon, May 2016, Lisboa.

Sier, A. (2016), 'Generative Sculptures: Modeling and 3D Fabrication', generative sculpture fabricating workshop at Faculdade de Belas Artes da Universidade de Lisboa, April 2016, Lisboa.

Workshops Generative Sculptures: Modeling and 3D Fabrication (2014-) & Photo-Synthesis (2013-) published online by ArteCódigo at artecodigo.pt/w, July 2022.

γ.4 Exhibitions outputs of creative research

'Wolfspace' & 'Uivo', app and book launch from supported project "Os Lobos em Portugal", 23 July 2022, Iberian Wolf Recovery Center (CRLI), Gradil, Mafra.

'MetaPh', photographs at XXII Bienal Internacional de Arte de Cerveira, July – December 2022, Vila Nova de Cerveira.

'Wolfmachine Cerveira', bio-electronic installation at Espaço/Programa exhibition, Convento de Santo António, July - September 2022, Loulé.

'Honey Krater', bio-electronic installation at ICLI22 exhibition (International Conference on Live Interfaces 2022), Universidade Lusófona, 20-23 June 2022, Lisboa.

'Uivo', solo exhibition, bio-electronic installations, drawings, photographs, videos, at Centro de Cultura de Paredes de Coura, May-June 2022, Paredes de Coura.

'Wolfmachine Cerveira', bio-electronic installation at Espaço/Programa exhibition, Museu Bienal de Cerveira, April-June 2022, Vila Nova de Cerveira.

'Uivo', solo exhibition, bio-electronic installations, drawings, photographs, videos, at Casa de Cultura Jaime Lobo e Silva, November-December 2021, Ericeira.

'Last Dragonfly', drawings on photographs at Ctrl+c exhibition, Zaratan, November 2021, Lisboa.

'Totem-Lobo #1' and 'Wolfmachine', evolving sculpture and temporary bio-electronic performance at Iberian Wolf Recovery Center, October 2021, Mafra.

'Biowolf218', evolving biological painting at Cultivamos Cultura, August 2021, São Luís, Odemira.

'Bioscope #1', bio-electronic installation at Intimate Observations: On conducing Earth Observations, Ermida de São Roque, October 2020, Tavira.

' 0X Labyrinth (video #10.780361)', VR installation video at XXI Bienal Internacional de Arte de Cerveira, August – December 2020, Vila Nova de Cerveira.

'An Observer ToL: Sierpinsky, Ikeda, Log, Navier-Stokes', video at New Art Festival TNAF20, July 2020, Lisboa (online).

'Lady of the Labyrinth's Honey', solo exhibition, bio-electronic installations, VR installation, drawings, photographs, vegetable paintings at Zaratan Arte Contemporânea, January-March 2020, Lisboa.

'Universal Automata, Biological Sculptures, Binary Sculptures', fabricated sculptures installation at Boundless Objects, Fundação Eugénio de Almeida, October 2019 – March 2020, Évora.

'Ant Ennae Videos', bio-electronic video at Festival Art & Science FACTT19, P28 Hospital Júlio de Matos, October-November 2019, Lisboa.

'Ant Ennae Videos', video at Natura Fugiens: Infinite Random, LIP Gallery, June 2019, Fortaleza.

'Half-Plant', bio-electronic installation at Consciousness Reframed XXI, Universidade Católica Portuguesa, June 2019, Porto.

'Half-Plant', bio-electronic installation at Festival Art & Science FACTT Toronto, FACTT Mexico, FACTT New York, 2019.

'Ant i Purga', drawings and/on photographs at Umbigo Magazine #68, 2019.

'Ant Ennae Labyrinths', bio-electronic installation at Expand exhibition, Centro Ciência Viva, Pavilhão do Conhecimento, March 2019, Lisboa.

'Phoenix.Wolfanddotcom.info, Arecibo, Ant Ennae Labyrinths, 8-bit Maze Gardens' immersive and bio-electronic installations, vegetable painting at Água Terra Ar, Palácio Landal, February – March 2019, Santarém.

'Babylon, Binary Sculptures, Biological Sculptures', VR installation and fabricated sculptures at The New Art Fest (TNAF), Sociedade Nacional de Belas Artes, Novembro 2018, Lisboa.

'8-bit Maze Gardens', vegetable painting at Cantina Lx Factory, Novembro 2018, Lisboa.

'Skate.Exe, Binary + Biological Sculptures, 8-bit Maze Gardens', immersive installation, fabricated sculptures and biological paintings at Mill, October 2018, Lisboa.

'Half-Plant', bio-electronic installation at Festival Art & Science FACTT 2018, Livraria Ler Devagar, September 2018, Lisboa.

'Wolfanddotcom' & 'Babylon', immersive and VR installation at XX Bienal Internacional de Arte de Cerveira, August – September 2018, Vila Nova de Cerveira.

'8-bit Maze Gardens', vegetable paintings at festival Spray for Us, July 2018, Ericeira.

'Binary Sculptures', fabricated sculptures at Wagner Gallery, July 2018, Ericeira.

'Neon Paleolitikos Drawings', drawings at Zaratan Arte Contemporânea, February 2018, Lisboa.

'Neon Paleolitikos', solo exhibition, bio-electronic installation, fabricated drawings and sculptures at Ocupart Camões, November-December 2017, Lisboa.

'Wolfanddotcom', immersive installation at Sonae Art Award exhibition, National Museum of Contemporary Art (MNAC), November 2017 – April 2018, Lisboa.

'Lampsacus, Automatos Universais 3D, Heliades', awarded immersive installation and fabricated sculptures at The New Art Fest, National Museum of Natural History and Science (MUHNAC), November 2017, Lisboa.

'Phoenix.Wolfanddotcom.info & 8-bit Solar Wind Machine', immersive and generative installations at Balance Unbalance 2017, August 2017, Plymouth.

'Labirinto de Chronos II', solo exhibition, immersive installations and fabricated drawings at Convento do Carmo, July 2017, Torres Novas.

'Structs for an aspatial quantum-now', poster at Taboo Transgression Transcendence, Ionian University, May-June 2017, Corfu.

'8-Bit Solar Wind Machine', solo exhibition, generative installation and fabricated drawings at Square Waves, July 2017, Ericeira.

'Struct_10', immersive installation at Criatek, Museu de Arte Nova, March 2017, Aveiro.

'Arcadia' and 'k.~', immersive installations at SIAC2, Torre de Menagem, May - June 2017, Guarda.

'Labirinto de Chronos I', solo exhibition, immersive installations and fabricated sculptures at Convento de São Francisco, October 2016 – January 2017, Coimbra.

'Atlantis', solo exhibition, immersive installation and electronic paintings at National Museum of Contemporary Art (MNAC), September – December 2016, Lisboa.

'Skates & Dragons', awarded immersive installations Draco.Wolfanddotcom.Info + Skate.Exe at Maker Faire Lisbon, Pavilhão do Conhecimento, June 2016, Lisboa

'Anthemusa' & 'Draco.Wolfanddotcom.Info', electronic and immersive installation at Festival Aura 2015, MU.SA (Sintra Arts Museum), August 2015, Sintra.

Appendix Δ Video documentation

δ.1 Wolfanddotcom selection videos: 4 mythological videogames + 4 bio-electronic aggregates

Accompanying the written thesis is a representative single video file featuring 1 minute selections of video documentation from 4 mythological videogames and 4 bio-electronic aggregates. The video is titled *Wolfanddotcom: Questing an Imaginary Arts' Framework for Immersive Non-Human Human Playable Cyber-environments,* with a duration of 12'47". It includes the mythological videogames: Draco.Wolfanddotcom.Info, Wolfanddotcom, Phoenix.Wolfanddotcom.info, 0X Labyrinth. The included bio-electronic aggregates in the video documentation are: Half-Plant, Ant Ennae Labyrinths, Honey Krater, Wolfmachine.

δ.2 Further online video sources

https://vimeo.com/andresier

https://www.youtube.com/channel/UC0A4-SoLuGjswlctoGEPHJA (andré sier youtube)

https://www.youtube.com/channel/UCsdqMYuwmO17ZVARCiVbb_Q (s373netx youtube)

Bibliography

Aarseth, E. (1997), Cybertext: Perspectives on Ergodic Literature, Baltimore: The Johns Hopkins University Press.

Aarseth, E. (2001), Computer Game Studies, Year 1, in Game Studies, Volume 1, Issue 1, <http://www.gamestudies.org/0101/editorial.html> [Accessed 1 October 2007].

Abbott, E. A. (1884), Flatland: A Romance of Many Dimensions, London: Seeley & Co.

Adamatzky, A. (2014), A would-be nervous system made from a slime mold, in Artificial Life, Volume 21, Issue 1, pp. 73-91, DOI:10.1162/ARTL_a_00153, Cambridge Massachusetts: The MIT Press.

Alexander, C. (1964), Notes on the Synthesis of Form, Cambridge Massachusetts: Harvard University Press.

Allen, R. E. (1997), Plato's Parmenides, New Haven: Yale University Press.

Álvares, F. (2015), O Lobo em Portugal: contexto biológico e cultural de um carnívoro em paisagens humanizadas, in L'animal dans le monde lusophone, Paris: Presses Sorbonne Nouvelle.

Angelakis, D. G. (2006), Quantum Information Processing: From Theory to Experiment, in Proceedings of the NATO Advanced Study Institute on Quantum Computation and Quantum Information Chania, Amsterdam: IOS Press.

Aristotle (1961), Aristotle's Physics, Lincoln: University of Nebraska Press.

Aristotle (350BCE), The History of Animals, Translated by D'Arcy Wentworth Thompson (1910), www.classics.mit.edu, 1994, <http://classics.mit.edu/Aristotle/history_anim.html> [Accessed on 12 April 2019].

Ascott, R. (1997), The Technoetic Aesthetic: Art and the Matter of Consciousness, in Ascott, R. (ed), Consciousness Reframed: art and consciousness in the post-biological era. 1st International CAiiA Research Conference Proceedings, Newport: University of Wales.

Ascott, R. (2006), Ontological Engineering: Connectivity in the Nanofield, in Ascott, R. (ed), Engineering Nature: Art & Consciousness in the Post-Biological Era, pp. 69-76, Bristol: Intellect Books.

Ascott, R. (2006), Technoetic Pathways toward the Spiritual in Art: A Transdisciplinary Perspective on Connectedness, Coherence and Consciousness, in Leonardo, Volume 39, Issue 1, pp. 65-69, Cambridge Massachusetts: The MIT Press.

Ascott, R. (2007), Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness, Shanken, E. A. (ed), Berkeley: University of California Press.

Ascott, R. (2007)[1966-7], Technoetic Aesthetics: 100 Terms and Definitions for the Post-Biological Era, in Shanken, E. A. (ed), Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness, Berkeley: University of California Press.

Ascott, R. (2007)[1966] Statement from control, in Shanken, E. A. (ed), Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness, Berkeley: University of California Press.

Ascott, R. (2007)[1989], Gesamtdatenwerk, in Shanken, E. A. (ed), Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness, Berkeley: University of California Press.

Augé, M. (1995), Non-places: Introduction to an Anthropology of Supermodernity, London: Verso.

Awasthi, A. K., Zeng, X., Li, J. (2016), Environmental pollution of electronic waste recycling in India: a critical review, in Environmental Pollution, Volume 211, pp. 259-70, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2015.11.027.

Azéma, M. (2011), La Préhistoire du cinéma. Origines paléolithiques de la narration graphique et du cinématographe, Paris: Errance.

Baudrillard, J. (1981), Simulacres et Simulation, Paris: Éditions Galilée.

Baudrillard, J. (1997), O crime perfeito, Lisboa: Relógio D'Água Editores.

Baumeister, R. F., Leary, M. R. (1997), Writing Narrative Literature Reviews. Review of General Psychology, Volume 1, Issue 3, pp. 311–320, https://doi.org/10.1037/1089-2680.1.3.311

Beer, S. (1959), Cybernetics and Management, London: The English Universities Press.

Beer, S. (1981), The Brain of The Firm, New York: John Wiley & Sons.

Benedikt, M. (1992), Cyberspace: First Steps, Cambridge Massachusetts: The MIT Press.

Benedito, S. (2000), Diccionário Breve de Mitologia Grega e Romana, Lisboa: Editorial Presença.

Bogost, I. (2007), Persuasive Games: The Expressive Power of Videogames, Cambridge Massachusetts: The MIT Press.

Borges, J. L. (1998), Obras Completas de Jorge Luis Borges 1923-1949, Lisboa: Editorial Teorema.

Borges, J. L., Guerrero, M. (1974), The Book of Imaginary Beings, Harmondsworth: Penguin Books.

Bourke, P. (1994), Polygonising a scalar field, www.paulbourke.net, 1994, <http://paulbourke.net/geometry/polygonise/> [Accessed on 5 May 2012].

Boutang, P.-A. (2004), Gilles Deleuze from A to Z, Los Angeles: Semiotext(e).

Brewer, N. (2017), Computerized Dungeons and Randomly Generated Worlds: From Rogue to Minecraft, in Proceedings of the IEEE, 105:5, <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7906675> [Accessed 12 June 2021].

Bryant, L., Srnicek, N., Harman, G. (2011), The Speculative Turn: Continental Materialism and Realism, Victoria: re.press.

Buckland, M. (2005), Programming Game AI by example, Plano Texas: Wordware Publishing.

Burchill, L. (2007), The Topology of Deleuze's Spatium, in Philosophy Today, 51, pp. 154-160, Ann Arbor Michigan: ProQuest.

Caillois, R. (1958), Les jeaux et les hommes, Paris: Éditions Gallimard.

Caillois, R. (1961), Man, play, and games, Chicago: The Free Press of Glencoe.

Caillois, R. (1990), Os Jogos e os Homens: A máscara e a vertigem, Palha, J. G. (tr), Lisboa: Edições Cotovia.

Campenot, R. B. (2016), Animal Electricity: How We Learned That the Body and Brain Are Electric Machines, Cambridge Massachusetts: Harvard University Press.

Candy, L. (2006), Practice Based Research: A Guide, CCS Report: 2006-V1.0 November, Sydney: University of Technology.

Capra, F. (1975), The Tao of Physics: An Exploration of the Parallels Between Modern Physics and Eastern Mysticism, Boulder: Shambhala Publications.

Casti, J. L. (2000), Five More Golden Rules: Knots, Codes, Chaos and Other Great Theories of 20th-Century Mathematics, New York: John Wiley & Sons.

Chadwick, J. (1990), The Decipherment of Linear B, Cambridge: Cambridge University Press.

Chamovitz, D. (2012), What a Plant Knows: A Field Guide to the Senses, New York: Scientific American/Farrar, Straus and Giroux.

Colli, G. (2001)[1975], O Nascimento da Filosofia, Lisboa: Edições 70.

Coomaraswamy, A. K., Nivedita, I. (2002), Mitos Hindus e Budistas, São Paulo: Landy Livraria.

Damásio, A. (1999), The Feeling Of What Happens: Body and Emotion in the Making of Consciousness, Boston: Mariner Books.

Damásio, A. (2000), O Sentimento de Si: O corpo, a emoção e a neurobiologia da consciência, Mem Martins: Publicações Europa-América.

Deleuze, G. (1969), Différence et Répétition, Paris: Presse Universitaires de France.

Deleuze, G. (1983), Cinéma. I. L'Image-Mouvement, Paris: Les Éditions de Minuit.

Deleuze, G. (1985), Cinéma 2. L'Image-Temps, Paris: Les Éditions de Minuit.

Deleuze, G. (2000)[1968], Diferença e Repetição, Lisboa: Relógio D'Água Editores.

Deleuze, G. (2005), O Mistério de Ariana: Cinco textos e uma entrevista de Gilles Deleuze, Lisboa: Edições Vega.

Deleuze, G., Guattari, F. (1972/73), L'Anti-Oedipe: Capitalisme et Schizophrénie, Paris: Les Éditions de Minuit.

Deleuze, G., Guattari, F. (1980), Mille Plateaux: Capitalisme et Schizophrénie 2, Paris: Les Éditions de Minuit.

Deleuze, G., Guattari, F. (1987), A Thousand Plateaus, Massumi, B. (tr), Minnesota: University of Minnesota Press.

Deleuze, G., Guattari, F. (1991), Qu'est-ce que la philosophie?, Paris: Les Éditions de Minuit.

Deleuze, G., Guattari, F. (1992), O que é a Filosofia?, Lisboa: Editorial Presença.

Derrida, J. (2002), The Animal That Therefore I Am, New York: Fordham University Press.

Derrida, J., Wills, D. (2002), The Animal That Therefore I Am (More to Follow), Critical Inquiry, 28, pp. 369-418, Chicago: The University of Chicago Press.

Eliade, M. (2000)[1957], Mitos, Sonhos e Mistérios, Lisboa: Edições 70.

Eno, B. (1996), A Year with Swollen Appendices, London: Faber and Faber.

Eno, B. (2011), Composers as Gardeners, The Serpentine Gallery Garden Marathon, talk at October 16th, <https://www.edge.org/conversation/brian_eno-composers-as-gardeners> [Accessed on 10 June 2018].

Esparcia, A., Urbano, P. (2007), ArtEscapes: Variations of Life in the Media Arts, catalogue of exhibition at Universitat Politècnica de València, 11th April - 18th May 2007, Valencia: Editorial de la UPV.

Fitzgerald, S., Shiloh, M., Igoe, T. (2012), The Arduino Projects Book, Torino: Officine Arduino Torino.

Flake, G. W. (1998), The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptation, Cambridge Massachusetts: The MIT Press.

Flanagan, M. (2009), Critical Play. Radical Game Design, Cambridge Massachusetts: The MIT Press.

Franke, H. W. (1971), Computergraphik, Computerkunst, Munich: Bruckmann.

Freccero, C. (2017), Wolf, or Homo Homini Lupus, in Tsing, A., Swanson, H., Gan, E., Bubandt, N. (eds), Arts of Living on a Damaged Planet, Minneapolis: University of Minnesota Press.

Freeland, C. (2004), Piercing to Our Inaccessible, Inmost Parts: The Sublime in the Work of Bill Viola, in The Art of Bill Viola, Townsend, C. (ed), London: Thames & Hudson.

Fuchs, M. (2015), Diversity of Play, Leuphana: Meson Press.

Fuller, R. B. (1961), The World Game: Integrative Resource Utilization Planning Tool, Carbondale: Southern Illinois University.

Fullerton, T. (2009), Reflections on The Night Journey: An experimental Video Game, in Kritische Berichte: The Ludic Society – The Relevance of Videogames, 2.2009, pp. 72-82, Marburg: Jonas Verlag für Kunst und Literatur GmbH.

Ga, Z. (2018), Machines Are Not Alone, in Device_art 6.018: Machines Are Not Alone, Croatia: KONTEJNER | bureau of contemporary art praxis, Zagreb.

Galanter, P. (2003), What is Generative Art? Complexity theory as a context for art theory, in Soddu, C. (ed.), Proceedings 6th International Conference on Generative Art, Milan: Generative Design Lab, Milan Polytechnic Art.

Galeş, C. (2012), Structural Stability and Convergence in Piezoelectricity, in SIAM Journal on Applied Mathematics, Vol. 72, No. 6, pp. 1856-68, doi:10.1137/120870074.

Galloway, A. R. (2006), Gaming: Essays On Algorithmic Culture, Minneapolis: University of Minnesota Press.

Gianetti, C. (1998), Trespassar a Pele: o Teletrânsito, Ars Telemática – Telecomunicação, Internet e Ciberespaço, Lisboa: Relógio D'Água.

Gleick, J. (1994), Caos: A construção de uma nova Ciência, Lisboa: Gradiva.

Graham, P. (2004), Hackers & Painters: Big Ideas from the Computer Age, Sebastopol CA: O'Reilley Media, Inc.

Grau, O. (2003), Charlotte Davies: Osmose, in Virtual Art, From Illusion to Immersion, Cambridge Massachusetts: The MIT Press.

Grimal, P. (1987), A Mitologia Grega, Lisboa: Publicações Europa-América.

Grusin, R. (2015), The NonHuman Turn, Minneapolis: University of Minnesota Press.

Halfacree, G. (2021), O Guia para iniciantes do Raspberry Pi oficial, Cambridge: Raspberry Pi Press.

Haraway, D. (2016), Staying with the Trouble: Making Kin in the Chthulucene, Durham: Duke University Press.

Haraway, D. J. (1989), Primate Visions: Gender, Race and Nature in the World of Modern Science, New York: Routledge.

Haraway, D. J. (2004), Crystals, Fabrics, and Fields: Metaphors that Shape Embryos, Berkeley: North Atlantic Books.

Hawking, S. (1988), A Brief History of Time: From the Big Bang to Black Holes, London: Bantam Dell Publishing Group.

Hawking, S. W. (1996), The Illustrated A Brief History of Time: Updated and Expanded Edition, London: Random House Publishing Group.

Hawking, S. W. (1996)[1988], Breve História do Tempo Ilustrada, Lisboa: Gradiva – Publicações, L.da.

Hayles, N. K. (1999), How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics, Chicago: University of Chicago Press.

Heisenberg, W. (1927), The Physical Content of Quantum Kinematics and Mechanics, in Wheeler, J.A. and Zurek, W.H (eds), Quantum Theory and Measurement, pp. 62-84, Princeton: Princeton University Press.

Hofstadter, D. (1999)[1979], Gödel, Escher, Bach: an Eternal Golden Braid, New York: Basic Books.

Hofstadter, D. (2000), Gödel, Escher, Bach: Laços Eternos. Uma fuga metafórica sobre mentes e máquinas no espírito de Lewis Carroll, Lisboa: Gradiva.

Homero (1980), Odisseia, Lisboa: Publicações Europa-américa.

Huizinga, J. (1980)[1944], Homo Ludens: A Study of the Play-Element of Culture, Great Britain: Redwood Burn Ltd, Trowbridge & Esher.

Hummelvoll, J. K. (2008), The multistage focus group interview: a relevant and fruitful method in action research based on a co-operative inquiry perspective, Norsk Tidsskrift for Sykepleiedorskning, vol. 10, no. 1, pp. 3-14.

Ifrah, G. (1998)[1994], The Universal History of Numbers: From prehistory to the invention of the computer, London: The Harvill Press.

Igoe, T. (2011), Making Things Talk: Using Sensors, Networks, and Arduino to See, Hear, and Feel Your World, Santa Rosa California: Make: Community.

Jackson, S. (1983), Starship Traveller, London: Puffin Books.

Jackson, S. (1986)[1983], A Nave Perdida, Lisboa: Editorial Verbo.

Janiak, A. (2022), Kant's Views on Space and Time, The Stanford Encyclopedia of Philosophy (Summer 2022 Edition), Zalta, E. N. (ed.), <https://plato.stanford.edu/archives/sum2022/entries/kant-spacetime/> [Accessed 1 July 2022].

Jennett C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T. & Walton, A. (2008), Measuring and Defining the Experience of Immersion in Games, International Journal of Human-Computer Studies, Vol. 66, no. 9, pp 641-61.

Johnson, S. (2004)[2001], Emergence: The connected lives of ants, brains, cities, and software, New York: Scribner.

Jones, J. (2010), Characteristics of Pattern Formation and Evolution in Approximations of Physarum Transport Networks, Artificial Life, Volume 16, pp. 127-53, Cambridge Massachusetts: The MIT Press.

Jullien, J.-P., Warsufel, O. (1994), Technologies et Perception Auditive de l'Espace, in Espaces, Les Cahiers de L'Ircam 5:65-94, Bayle, L. (ed), Paris: Éditions Ircam – Centre Georges Pompidou.

Kafka, F. (1991)[1926], O Castelo, Mem Martins: Publicações Europa – América.

Kandinsky, W. (1996)[1970], Ponto Linha Plano: Contribuição para a análise dos elementos picturais, Lisboa: Edições 70.

Kandinsky, W. (1998)[1911], Do Espiritual na Arte, Lisboa: Dom Quixote.

Kandinsky, W. (2002)[1975], Curso da Bauhaus, Lisboa: Edições 70.

Kandinsky, W. (2008)[1911], Concerning the Spiritual in Art, Auckland: The Floating Press.

Kant, I. (1997)[1781,87,90,94,99], Crítica da Razão Pura, ISBN 972-31-0623-X, Lisboa: Fundação Calouste Gulbenkian.

Kant, I. (1998)[1790], Crítica da Faculdade do Juízo, ISBN 972-27-0506-7, Lisboa: Imprensa Nacional – Casa da Moeda.

Kerényi, K. (2008), Estudos do Labirinto, seguido de A Ideia Religiosa do Não-Ser, Paixão, P. A. H. (ed), Stuttgart: Klett-Cotta (2007), Lisboa: Assírio & Alvim (2008).

Kerényi, K. (2008)[1941-50-66], Labyrinth-Studien: Labyrinthos als Linienreflex einer mythologischem Idee, Paixão, P. A. H. (ed), in Estudos do Labirinto, Lisboa: Assírio & Alvim (2008).

Kerényi, K. (2008)[1956], Die Herrin des Labyrinthes, Paixão, P. A. H. (ed), in Estudos do Labirinto, Paixão, P. A. H. (ed), Stuttgart: Klett-Cotta (2007), Lisboa: Assírio & Alvim (2008).

Kerényi, K. (2008)[1963], Heiliges Kreta, Paixão, P. A. H. (ed), in Estudos do Labirinto, Lisboa: Assírio & Alvim (2008).

Kerényi, K. (2015), A Mitologia dos Gregos vol. I: a História dos Deuses e dos Homens, Rio de Janeiro: Vozes.

Kerényi, K. (2015), Arquétipos da Religião Grega, Rio de Janeiro: Vozes.

Kernighan, B. W., Ritchie, D. M. (1978), The C Programming Language, Englewood Cliffs, NJ: Prentice Hall.

Kirk, G. S., Raven, J. E., Schofield, M. (1994), Os Filósofos Pré Socráticos, Lisboa: Fundação Calouste Gulbenkian.

Knuth, D. (1968), The Art of Computer Programming, Reading Massachusetts: Addison Wesley.

Krueger, M. (1983), Artificial Reality, Reading Massachusetts: Addison-Wesley.

Krueger, M. (1991), Artificial Reality 2, Reading Massachusetts: Addison-Wesley.

Lance & Touryan et al (2016), Towards Serious Games for Improved BCI, in Handbook of Digital Games and Entertainment Technologies, Nakatsu, R., Rauterberg, M., Ciancarini, P. (eds), pp. 197–224, Singapore: Springer Singapore.

Langton, C. (1989), Artificial Life, Langton, C. (ed), Artificial Life, Santa Fe Institute Studies in the Science of Complexity, Proceedings vol. 6, Redwood City, CA: Addison Wesley.

Langton, C. (2000) What is Artificial Life?, <http://www.biota.org/papers/cglalife.html> [Accessed on 10 August 2009].

Lanier, J. (2017), Dawn of the New Everything: Encounters with Reality and Virtual Reality, New York: Henry Holt and Company.

Lanier, J. (2018), Ten Arguments for Deleting Your Social Media Accounts Right Now, New York: Henry Holt and Company.

Lecky-Thomson, G. (1999), Algorithms for an Infinite Universe, <http://www.gamasutra.com/view/feature/3377/algorithms_for_an_infinite_universe.php?print=1> [Accessed 1 January 2003].

Lorensen, W., Cline, H. (1987), Marching Cubes: A High Resolution 3D Surface Construction Algorithm, in ACM SIGGRAPH '87 Conference Proceedings, Computer Graphics, 21:4, pp. 163-169.

Lorenz, E. (1934), Search for Mitogenetic Radiation by Means of the Photoelectric Method, Journal of General Physiology, vol.17, pp. 843–862.

Losius, T., Baltazar, P., Hogue, T. (2009), Dbap - Distance Based Amplitude Panning, International Computer Music Conference ICMC 2009.

Lovelock, J. E. (1972), Gaia as seen through the atmosphere, in Atmospheric Environment, Vol. 6, No. 8, pp. 579-580, doi:10.1016/0004-6981(72)90076-5.

Lovelock, J. E. (1979), Gaia: A New Look at Life on Earth, Oxford: Oxford University Press.

Lovelock, J. E. (2009), The Vanishing Face of Gaia: a Final Warning, New York: Basic Books.

Lovelock, J. E., Margulis, L. (1974), Atmospheric homeostasis by and for the biosphere: the Gaia hypothesis, International Meteorological Institute, 26 (1–2): 2–10, doi:10.1111/j.2153-3490.

Mallarmé, S. (1914), Un coup de dés jamais n'abolira le hasard, <https://math.dartmouth.edu/~doyle/docs/coup/scan/coup.pdf> [Accessed on 12 April 2016]

Manovich, M. (2001), The Language of New Media, Cambridge Massachusetts: The MIT Press.

McGonigal, J. (2011), Reality is Broken: Why Games Make Us Better and How They Can Change The World, New York: The Penguin Press.

McInerney, J. (2011), Bulls and Bull-leaping in the Minoan World, Expedition Magazine 53:3, pp. 6-13.

Mignonneau, L., Sommerer, C., Weibel, P. (eds) (2009), Christa Sommerer, Laurent Mignonneau: Interactive Art Research, Vienna: Springer-Verlag.

Moraes, W. (2008), O Culto do Chá, Lisboa: Relógio D'Água Editores.

Newman, E., Blanton, R., (1968), 'The early history of electrodermal research', in Psychophysiology 6, pp. 453–475.

Nietzsche, F. (2011), Sämtliche Werke. Kritische Studienausgabe in 15 Bänden. KSA. Vol. 6: Der Fall Wagner. Gootzen-Daammerung. Der Antichrist. Ecce homo. Dionysos-Dithyramben. Nietzsche contra Wagner. Colli, G., Montinari, M. (eds), Muunchen: Deutscher Taschenbuch-Verlag, pp. 377-410.

Novak, M. (1992), Liquid Architectures in Cyberspace, in Benedikt, M. (ed), Cyberspace: First Steps, Cambridge Massachusetts: The MIT Press.

Osho (2007)[1980], A Cup of Tea, New Delhi: Diamond Pocket Books.

Parikka, J. (2010), Insect Media: An Archaeology of Animals and Technology, Minneapolis: University of Minnesota Press.

Pask, G. (1975), The Cybernetics of Human Learning and Performance, London: Hutchinson.

Pask, G. (1976), Conversation Theory, Applications in Education and Epistemology, Amsterdam: Elsevier.

Pereira, I. (1998), Dicionário Grego-Português e Português-Grego, Braga: Livraria Apostolado da Imprensa.

Perlin, K., Hoffert, E. M. (1989), Hypertexture, Proceedings of the 16th Annual Conference on Computer Graphics and Interactive Techniques, SIGGRAPH 1989, Boston: SIGGRAPH.

Petrucci-Fonseca, F. (1990), O Lobo (Canis lupus signatus Cabrera, 1907) em Portugal - Problemática da sua conservação, Lisboa: Faculdade de Ciências da Universidade de Lisboa.

Pickering, A. (2010), The Cybernetic Brain: Sketches of Another Future, Chicago: The University of Chicago Press.

Pretis, F., Roser, M. (2017), Carbon dioxide emission-intensity in climate projections: Comparing the observational record to socio-economic scenarios, Energy, Volume 135, pp. 718-725, doi:10.1016/j.energy.2017.06.119.

Proakis, J. G., Manolakis, D. G. (1996), Digital Signal Processing: Principles, Algorithms, and Applications, New Jersey: Prentice Hall International Editions.

Pulkki, V. (1997), Virtual sound source positioning using vector base amplitude panning, Journal of the Audio Engineering Society, vol. 45(6), pp. 456–466.

Pullen, W. (1998), Daedalus, <http://www.astrolog.org/labyrnth/daedalus.htm> [Accessed 2 May 2017].

Pullen, W. (2015), Maze Algorithms, <http://www.astrolog.org/labyrnth/algrithm.htm> [Accessed 2 May 2017].

Raessens, J., Goldstein, J. (Eds) (2005), Handbook of Computer Games Studies, Cambridge Massachusetts: The MIT Press.

Renault, M. (1973)[1962], The Bull from the Sea, London: Penguin Books.

Reynolds, C. (1987), Flocks, Herds, and Schools: A Distributed Behavioral Model, in ACM SIGGRAPH '87 Conference Proceedings, Computer Graphics, 21:4, pp. 25-34.

Rivnay, J., Owens, R., Malliaras, G. (2014), The Rise of Organic Bioelectronics, in Chemistry of Materials, 26 (1), pp. 679–685.

Roads, C. (1996), The Computer Music Tutorial, Cambridge Massachusetts: The MIT Press.

Roads, C. (2004), Microsound, Cambridge Massachusetts: The MIT Press.

Robertson, M. (1982)[1981], Uma Breve História da Arte Grega, Rio de Janeiro: Zahar Editores.

Robisch, S. K. (2009), Wolves and the Wolf Myth in American Literature, Wisconsin: The University of Nevada Press.

Ross, J. (2017), Speculative method in digital education research, Learning, Media and Technology, 42:2, pp. 214-29, doi: 10.1080/17439884.2016.1160927.

Ryohei Nakatsu, Matthias Rauterberg, Paolo Ciancarini (2017), Handbook of Digital Games and Entertainment Technologies, Singapore: Springer.

s373.net/x (2009), inky: 8-bit graffiti polar plotter, <https://s373.net/x/inky/> [Accessed 25 September 2015].

s373.net/x (2009), samian, <https://github.com/s373/samian000> [Accessed 5 October 2017].

Saward, J. (2003), Labyrinths & Mazes -The Definitive Guide to Ancient & Modern Traditions, London: Gaia Books.

Schaeffer, P. (1952), À la recherche d'une musique concrète, Paris: Éditions du Seuil.

Schmidt, S. J. (1998). Cyber como oikos? Ou: jogos sérios, Gianneti, C. (ed), in Ars Telemática – Telecomunicação, Internet e Ciberespaço, Lisboa: Relógio d'Água.

Schrödinger, E. (1926), An Undulatory Theory of the Mechanics of Atoms and Molecules, in Physical Review 28 (6): 1049–1070.

Schrödinger, E. (1967) What is Life? With Mind and Matter and Autobiographical Sketches, London: Cambridge University Press.

Scrivener, S. (2002), The art object does not embody a form of knowledge. Working papers in Art & Design, <https://www.herts.ac.uk/__data/assets/pdf_file/0008/12311/WPIAAD_vol2_scrivener.pdf> [Accessed 12 October 2017]

Serres, M. (1997), As Origens da Geometria, Lisboa: Terramar.

Shannon, C. E. (1951), Presentation of a Maze-Solving Machine, Foerster, H. V. (ed), in Cybernetics, Transactions of the 8th Conference, pp. 173–180, New York: Josiah Macy Jr. Foundation.

Shannon, C. E., Weaver, W. (1998)[1963], The Mathematical Theory of Communication, Champaign: University of Illinois Press.

Sier, A. (2011), Uunniivveerrssee.net. Entry point to infinite stochastic virtual worlds, Consciousness Reframed 12 Presence in the Mindfield: Art, Identity and the Technology of the Transformation, Ascott, R., Girão, L. M. (eds), Universidade de Aveiro ISBN: 978-972-789-356-0.

Sier, A. (2017), Artefactos da porta escondida da ponte. ("Lançados para dentro de um Labirinto")', in Torres, R., Petry, L. C. (eds), Cibertextualidades, 8, pp. 59-70, Porto: Edições Universidade Fernando Pessoa.

Sier, A. (2017), Human dragons playing in cyberspace, in Technoetic Arts: A Journal of Speculative Research, 15:3, pp. 283–96, doi: 10.1386/tear.15.3.283_1.

Sier, A. (2018), Structs for an aspatial quantum-now, in Taboo – Transgression – Transcendence in Art & Science, Honorato, D., Giannakoulopoulos, A., (Eds), Corfu: Ionian University.

Sier, A. (2021), 'Anthemusa: towards a mythological laser based point-lighthouse', in Aura, Luz de Presença, Freire, P. (ed), pp. 94-106, Sintra: Criaatividade Cósmica.

Simondon, G. (1980)[1958], On the Mode of Existence of Technical Objects, London: University of Western Ontario.

Simondon, G., Chateau, J.-Y. (2004), Deux leçons sur l'animal et l'homme, Paris: Éditions Ellipses.

Sims, K. (1991), Artificial Evolution for Computer Graphics, in ACM SIGGRAPH '91 Conference Proceedings, pp. 319-328, <http://www.karlsims.com/papers/siggraph91.html> [Accessed on 7 January 2009].

Sims, K. (1994), Evolving Virtual Creatures, in ACM SIGGRAPH '94 Conference Proceedings, pp. 15-22, <http://www.karlsims.com/papers/siggraph94.pdf> [Accessed on 7 January 2009].

Snow, M. (2002), Des écrits 1958 – 2001, Paris: Centre Georges Pompidou and École Nationale Supérieur des Beaux-Arts.

Sommerer, C., Mignonneau, L. (1999), Art as a Living System: Interactive Computer Artworks, Leonardo, vol. 32, pp. 165-173.

Sommerer, C. & Mignonneau, L. (2003), Da poesia da programação à pesquisa como forma de arte, in Redes Sensoriais, Maciel, K. & Parente, A. (eds), Rio de Janeiro: Contra Capa.

Spence, L. (1994), The Myths of Mexico and Peru, Toronto: General Publishing Company.

Strauss, A. L., Corbin, J. M. (1998), Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory, London: Sage Publications.

Struik, D. J. (1992)[1987], História Concisa das Matemáticas, Lisboa: Gradiva.

Sutherland, I. (1965), The Ultimate Display, in Proceedings of IFIP Congress, pp. 506–508.

Sutherland, I. (1968), A head-mounted three dimensional display, in Proceedings of AFIPS 68, pp. 757–764.

Sutherland, W. R., Mugglin, M. G., Sutherland, I. (1958), An Electro-Mechanical Model of Simple Animals, in Computers and Automation 7:2, pp. 1-6.

Sutton-Smith, B. (1997), The Ambiguity of Play, Massachusetts: Harvard University Press.

Tarkovsky, A. (1998), Sculpting in Time, Austin: The University of Texas Press.

Townsend, C. (2004), The Art of Bill Viola, London: Thames & Hudson.

Trahndorff, K. F. E. (1827), Ästhetik oder Lehre von Weltanschauung und Kunst, Berlin: in der Maurerschen buchhandlung.

Trethewey, K. (2018), Ancient Lighthouses, Torpoint: Jazz-Fusion Books.

Tsing, A., Swanson, H., Gan, E., Bubandt, N. (eds.) (2017), Arts of Living on a Damaged Planet, Minneapolis: University of Minnesota Press.

Uexküll, J. v. (1939), Tier und Umwelt, doi: 10.1111/j.1439-0310.1939.tb01567.x

University of Plymouth (2018), Code of Good Research Practice, Plymouth: University of Plymouth.

University of Plymouth (2018), Research Data Policy, Plymouth: University of Plymouth.

University of Plymouth (2018), Research Ethics Policy, Plymouth: University of Plymouth.

Van den Eynden, V., Corti, L., Woollard, M., Bishop, L., and Horton, L. (2011), Managing and Sharing Research Data. A Guide to Good Practice, <http://repository.essex.ac.uk/2156/1/managingsharing.pdf> [Accessed 12 March 2016]

Varga, B. A. (1996), Conversations with Iannis Xenakis, London: Faber and Faber.

Vesna, V. (2007), Seeing the World in a Grain of Sand: The Database Aesthetics of Everything, Vesna, V. (ed), in Database Aesthetics: Art in the Age of Information Overflow, Minneapolis: University of Minnesota Press.

Viveiros de Castro, E. (2014), Cannibal Metaphysics, Skafish, P. (ed), Minnesota: Univocal Publishing.

Wagner, R. (2003)[1849], A obra de arte do futuro, Lisboa: Antígona.

Ward, D., Cardazzo, G. (1989), Imaginary Landscapes: A film on Brian Eno, New York: A Filmmakers Production.

Weibel, P. (1997), The Unreasonable Effectiveness of the Methodological Convergence of Art and Science, Sommerer, C., Mignonneau, L. (eds), in Art@Science, Wien, New York: Springer.

Weibel, P., Brümmer, L., Kanach, S. (2020), From Xenakis's UPIC to Graphic Notation Today, Berlin: Hatje Cantz.

Wiener, N. (1948), Cybernetics: Or Control and Communication in the Animal and the Machine, Paris: (Hermann & Cie) & Camb. Mass. (MIT Press).

Wiener, N. (1950), The Human Use of Human Beings: Cybernetics and Society, Boston: Houghton, Mufflin Company.

Williams, J. (2011), Gilles Deleuze's Philosophy of Time: A Critical Introduction and Guide, Edinburgh: Edinburgh University Press.

Wilson, E. O., Hölldobler, B. (1990), The Ants, Berlin: Springer-Verlag.

Wolfram, S. (2002), A New Kind of Science, Champaign, IL: Wolfram Media.

Woo, M., Neider, J., Davis, T., Shreiner, D. (1997), OpenGL Programming Guide, New York: Addison Wesley.

World Medical Association (2013), Declaration of Helsinki. Ethical Principles for Medical Research Involving Human Subjects. JAMA. 310 (20): 2191-2194. <http://irb.sinica.edu.tw/doc/regulation/DECLARATION%20OF%20HELSINKI%20(2013).pdf> [Accessed 12 March 2016]

Xenakis, I. (1985), Arts / Sciences: Alloys, Hillsdale New York: Pendragon Press.

Xenakis, I. (1992), Formalized Music: thought and mathematics in composition, Hillsdale New York: Pendragon Press.