Architecture and the Machinic

Experimental Encounters of Man with Architecture, Computation and Robotics

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Experimental Encounters of Man
with Architecture, Computation and Robotics

DIA Master of Architecture

Edited
by
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DIA Series

This book is part of a series of scientific publications, which, at loose intervals, will publish the results of thematic studio projects as a reflection of the work accomplished within the DIA master course. As such, they will reveal a panorama of architectural discourse about the city, society, history as well as the tectonic object as perceived through the eyes of students from all over the world.

Alfred Jacoby, Director DIA

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Preface

Arie Graafland

Man and Machine is a liber amicorum for Alfred Jacoby who was the Director of the Dessau International Architecture Graduate School up till October 2017. The School started as an Institute in October 1999: the Dessau Institute of Architecture (DIA), incorporating research into the curriculum. In these early years DIA had an international Advisory Board. Lars Lerup (Rice University), Robert Oxman (Israel Institute of Technology) and Max Bächer (TU Darmstadt), had their influence in the curriculum. Quite a few of its international students and professors managed to get a stipend or a visiting scholarship from the German Academic Exchange Program (DAAD).

DIA has always been a collection of dedicated teachers from the inside of Anhalt University (Hochschule Anhalt), and from the outside. It has grown from very few to an extensive group of students and teachers; a most remarkable group of international students from all over the planet working and communicating with each other in a truly international school. Jacoby managed to attract very different teachers, either from Anhalt University or from other European, Chinese, or American design schools. No one from the outside in a permanent position, they all came and went. A colorful bunch, different opinions, different studios, different nationalities.

This book is about digital technologies influencing our daily lives, our medical apparatuses, our ways of design, and even our ways of thinking and experiencing. We have collected the ones involved in 'digital design' and the ones reflecting on digital cultures. At first sight the volume contains a somewhat strange selection of writers for a liber amicorum for someone who was never part of digital design. But a closer look shows his work for Fresenius Medical Care, a company that supports the design process of dialysis clinics in many countries across Europe, the Middle East and Africa.

Fresenius Medical Care is a global player in this field with many clinics in different countries. Here machinic technologies are at the forefront. We find his notion of 'care' in the opening contribution of this book. How these digital machine technologies influence our present thinking and doing in design, is the topic of the book. All contributors were present during his directorship at DIA, they all had their own studio's. In the end they were closer to Jacoby's interest than many would expect. There was no concurring ideas between director and digital studio's, but certainly a critical interest. In that sense, this was a good example of what DIA meant to many of us during his years as director.

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Introduction

Dulmini Perera

Machinic.

Man and Machine is an attempt to critically interrogate and present the multiple logics of the machinic explored within the cluster of research and teaching practices (studios, workshops, seminars and theory discussions) that deal with man-machine technologies within the past decade at the Dessau International Architecture Graduate School (DIA). While a more common name for this strand of experimentation and practice within architectural discourse is 'digital architecture' (which these experiments are invariably part of), the diverse natures and evolution of the projects discussed in this volume have contributed to develop a broader position related to the emerging interdisciplinary field of man-machine technologies.

Hence the machinic, as it appears in this collection of essays is not limited to the tropes or themes of digital theory. Neither does it denote a mechanical positivistic framework. Instead, it is closer to Felix Guattari's use of the term to denote process, connectivity, and assembly, that are at the crux of the processes of architectural production, influenced by digital technologies.[1] The machinic in this volume deals with the corporeal and incorporeal processes and the multiple (almost non-unifiable) themes at work, when trying to develop projects (object models) and curricula (knowledge models) related to digital technology. On the one hand, the projects presented in this volume complement themes and broader discussions on man-machine relations, emerging throughout the last decade, mapped out in AD volumes such as Computational Design Thinking (2011) by Achim Menges and Sean Ahlquist, The digital Turn in Architecture from 1992-2012 (2013) by Mario Carpo and Dynamics of Data Driven Design (2014) by Henriette Bier and Terry Knight. At a time, when digital culture in architecture was a core theme of concern.[2] On the other hand, this volume seeks to make connections on the relevance of the man-machine trajectory of experimentation up to a more recent research theme relating to the theoretical and material conditions, known as the Anthropocene.

Computational.

The articles related to digital culture mapped out in the aforementioned anthologies,treat architecture's relation with computation in two ways.

Achim Menges and Sean Ahlquist in the anthology on Computational Design Thinking (2011) describe this distinction, using the terms "computational" vs. "computerization."[3] Alluding to Kostas Terzidas' discussion in Algorithmic Architecture (2006), the authors make a distinction between the dominant mode "Computerization" which refers to entities and processes that are clearly conceptualized in the designers mind and later stored and manipulated via the computer and "Computation;" whereas, in contrast, the computer gets integrated to the architectural design process from the very beginning.[4] While "computerization" consists of experiments in object-based strategies encapsulating information into symbolic representations, the "Computational" approach enables specific data to be realized out of initial abstraction into the form of code, which encapsulates values and actions.[5] In making this distinction, Ahlquist and Menges point to the fact that the challenge for architecture in this respect with regard to computational design is not only about introducing a new series of skills (such as scripting and programming), which were at one point unfamiliar to architecture's educational repertoire, but also instigating a mode of computational design thinking.

The diverse pedagogical approaches and formats introduced at DIA, evinced in this collection, are an attempt to address both of these trajectories. While mastering relevant technical skills is seen as valuable for preparing the students for professional practice, the educational and research projects attempted to inculcate in students an ability to critically approach the "value" and "action" frameworks that formulate these technological methods.

Ecological.

Within the architectural discourse the interest in digital culture is at present overshadowed by other concerns such as the Anthropocene, which is more ecological in character. However, what can be seen is, that these discourses do not necessarily exclude one another. Rather, the history of the machinic as discussed here is, by the same token, a history of rethinking the ecological, where nature is not seen as something out there, but rather as something that is assembled or composed. In other words, they are both histories about the changing notions of the relation between natural system and cultural systems towards one of co-evolution.[6]

More specifically, the contributions seek to explore questions such as:

In what ways do co-evolutionary logic in computational design processes and robotic production, affect the re-theorization of fundamental concepts of the machine, feedback loops, information, machine languages, code?

In what ways are these changes reflected in the tectonic processes brought forth by robotic production?

How is this co-evolutionary logic being utilized within coding and object modeling practices?

How does this help to rethink questions of drawing and representation?

In what ways have these renewed notions of machinic processes and robotic operations influenced the design of architectural spaces that are inevitably linked with machines? (eg.: dialysis centers in medicine, factories in industrial production)

In what ways, have changing notions of mechanization changed user-space relations within these architectural typologies?

What sort of additional sensitivities are required, in order to design such spaces and moreover, how does this impact notions of architectural knowledge?

Adaptation.

With the merging of the distinct and separate categories of designing and execution into one feedback loop within the computational approach, the notion of how the distinct categories of human (animate) and non-human (inanimate) connect together, is of great importance.

Neil Leach's essay on Adaptation constructs a theory around the notion of animate (human) and inanimate components, that come together within these man-machine assemblages. In the computerization paradigm, the term "adaptation" acquires a limited definition, as a way of adapting a range of techniques and skills, or making machines more like human beings etc.

However, within the computational paradigm, it has becomes a way of developing a more multi-directional, interactive approach, between human and machine systems.

In Architecture and Adaptation: From Cybernetics to Tangible Computing (2016), Socrates Yannidous discusses how adaptation allows for a discourse to develop, how humans (animate) and their in-animate counterparts (eg. architecture), can engage in a conversation. A theme taken up extensively in Neil Leach's work.[7]

What is evinced in this discussion, is that the notion of adaptation/interactivity formulates the basis, to move away from the trivialization inherent in coding practices towards the co-construction of languages, with the participation of both humans and machines.

As Yannidous points out accurately in his historical mapping, the very early experiments in cybernetics during the 1960s, such as conversation theory by Gordon Pask, the user programmed architecture of Cedric Price's Fun palace and the participatory logic discussed in Negropontes soft architecture machines, are some of the first steps towards the notion of the intelligent environment of our present day, where intelligence is not merely something that was allocated to the human but rather something that emerged in the interaction between human and machine.

This was the point of focus of experiments during the 1990s and 2000s in labs such as Hyperbody (TU Delft), Media Lab (MIT), and Avatar (Bartlett, UCL).

Neil Leach's and Henriette Bier's work, discussed in this volume, reveal how the experiments at DIA contribute to this trajectory.

For Leach, the notion of adaptation within computational architecture, allows for a rethinking of the very idea of the human condition. Leach approaches the notion of adaptation through the psychological terms of "autoplastic" and "alloplastic" suggested by Sigmund Freud, Sándor Ferenczi, Franz Alexander, and others.

The article is an attempt to upgrade his former theory of adaptation and mimesis (as argued previously in his text on Camouflage).[8] Leach considers the capacity of humans, to make their environment adapt to them, as a necessary extension of the logic of mimesis - the capacity of human beings, to adapt to their environment.

Here, mimesis is understood not in terms of standard "imitation" (a process that infers that the original is always superior to any imitation), but rather as a creative act of "assimilation" (where an individual can incrementally assimilate a given model without ever becoming identical with it).

Leach astutely points to the relatively new discourse on the logic of animated construction, that has opened up recently, as a result of the commercial availability of devices such as sensors, Arduino control boards, servos, and smart materials such as shape-memory alloys.

The idea of the animate (usually restricted to notions of human life), is expanded to incorporate the wider assemblage of human and non-human entities, within these interactive machinic systems. Therefore, according to Leach, the machinic, rather than being a source of alienation, opens up a field of interactions. Hence one of the most significant contributions of interactive architecture, is not to provide a better environmental control system, but is rather understood as a sociological mechanism. Leach's article highlights the post human-all too-human dimension, alive within the discussions on interactive architecture.

Non-representational.

The shift of focus from representational logic (which privileges the linguistic dimension in human communication as opposed to a broader processes of semiosis not restricted to humans), is evinced in the shift from computerization towards computation.

This is explored in Carlos Campo's work by his declaration of a (possible) end to representation. Starting with the parable of Kafka's dead emperor, Campo sees his experiments, with the drawing machine CASUS, as a messenger that attempts to do away with old notions of representation. CASUS, can in some ways be considered a machine reacting against the computerization paradigm, which reproduces modernist values, such as control restricted to Cartesian coordinates of space, negative entropy, stability, budget, and predictability.

CASUS provokes the question, of whether it is possible to imagine an a-representational approach through computation. His teaching experiments with CASU, are a way of exposing students to ways of working with randomness. Two types of approaches are discussed in Campo's work, namely,(a) working "without external information" and (b)"working with external information."

When working with external information, the machine movements are strongly controlled by the author, through a specific pattern. The operator manages the time, the number of writing tips, the initial location of the machine, the number of cycles, the weight of the entire structure, the speed of the stroke, the location of obstacles in the way of the machine, and so on.

All these factors, are based on the abstract analysis of any natural or artificial system, and are fed to the machine via syntax diagrams (alphanumeric codes that encourage the repetition of various behaviors), or in its absence, on a scheduled basis. The similarity between the abstract patterns of natural systems such as the Nolli maps and the syntax diagrams produced via CASUS, is evidence for the broader processes of semiosis, that are present and are common to multiple living systems.

Distributed Agency.

As highlighted by Carpo in his Digital Turn, the digital age demarcates a period in architectural history, that consists of buildings,which could not have been built without digital tools.[9] In order to map the shifting themes within the Digital Turn, Carpo takes the Architectural Design Magazine AD (which was at one point a context for debates on architectural postmodernism), as a site, where the evolution of digital theory and practice is visualised. Using the themes explored in the work of leading theoreticians and practitioners, such as Morphogenesis (Menges) scripting, parametrics (Schumacher), embryo logic (Greg Lynn), hyper surface (Kas Oosterhuis), Carpo maps out the change of interest, from human agency to a distributed form of agency, within the project of computation.

Opposing the set limits of computerization, which restricts the agency to designer and machine as the tools to execute this idea, the computation paradigm, opens up a more nuanced notion of assembled agency.

Software known under the name of BIM (used in most of the studio projects of contributors to this volume, e.g. Kassimir Krastev, Karim Soliman, Henriette Bier, Sina Mostafavi), has been very influential in this regard.

BIM has allowed, to make use of the full potential of participatory authorship and the exchange of information across many agents, for collective decision-making. It constitutes the shift from mass production to mass participation in these strategies.[10] The focus is not on the one sided logic of machinic code, but rather the conversational logic, which emerges within the multiple feedback loops, that go across the components as parts of the extended man-machine system and their relationship within the design -operation and -execution stages.

Carpo discusses, how digital technologies, which at one point in time were used in processes of trivialization, more akin with a modernist agenda, have through time become a way of designing and producing variability and complexity. In other words, digital tools have allowed the materialization of a Deleuzian postmodern cultural framework.[11]

Carpo also highlights how CAD and CAM technologies have enabled the mass production of blobs and boxes (a synthesis between Postmodern unity and Deconstructivist fragmentation).[12] What is more interesting, is the double edge or the paradox, evident within digital technology, as it mass-produces variations and customizes the non-standard. This paradox, is evident in most of the arguments in the following chapters.

Craftsman.

In his polemical text on The Lure of Technology and The Task of the Architect, Jasper Cepl questions the relation between digital technology and the architect as a professional practitioner and educator. In so doing, he touches on some aspects of the aforementioned paradoxes present in digital culture. The notion of the "craftsman" and the notion of "innovation" and their relationship to the architect as a practitioner, are two such concepts, taken up in Cepl's essay. He offers a critique of arguments, stating that the digital allows for a new form of craftsmanship to emerge. Laying out how some of the fundamental aspects on the definition of craftsmanship go against certain concepts such as "innovation" and the "unconventional", which have often been associated with digital culture, he provokes the question of whether one has to use "progressive' technology" to be recognized as a "progressive' architect?"

Hence the rise of the importance placed on the work and projects of digital practitioners, such as Greg Lynn or the recent claims of practitioners such as Patrick Schumacher, that proclaim parametricism as the solid new hegemonic paradigm, for Cepl emerges as problematic and demanding a critical interrogation. Rather than negating the digital turn in its totality, what Cepl critiques, is its first wave of naïve formalism, associated with it. This naive formalism is much in line with what is identified as computerization by Menges and Ahlquist.

Hence, embracing the computational, is also about embracing a critical attitude towards the man-machine systems and its pre-established definitions.

The task of education, then, according to Cepl, is to produce critical practitioners, whose task is not to ask what they can do for technology, but what technology can do for them.

Morphogenesis.

Form finding, (morphogenetic experiments) appears as a key theme in Studio Krastev at DIA since 2011. Krastev's work is focused on using BIM software for exploring the relation between structural forces and material properties (as informed morphogenesis).

The experiments chosen to illustrate his essay, are very diverse, according to their scale, materials that are used, and the way structures are constructed. However, there is one character that is common among them: the morphology is generated by transforming sets of information, rather than by the gradual refinement of a spatial concept.

Information for the experiments, are extracted from non-spatial sets of conditions, such as material properties, structural forces, management models for design and construction. Hence, with the use of algorithms in studio, Krastev's language and coding, shifts away from a deterministic orientation, towards more fluid approaches that define a range of possibilities.[13]

Agency in Krastev's work, appears as assembled and is dispersed around the different elements of the project. Not only is agency distributed amongst the man-machine systems, but also the material systems at work. Materialities and their affordances, become a concern for form-generation and influence the computational process. The experiments with the micro-structural properties of an-isotropic material such as wood, takes advantage of the unusual structural properties of the material (orientation of timber grains etc.), to formulate structures with maximum efficiency. The multiple agencies at work, are also evinced in Krastev's notion of "discrete assemblages", in which the morphology of the whole structure is influenced by the logic of connections between the individual components. As evinced in the design of the "building tool kit"- a model for design and construction management, that involves communities of makers from Berlin and the developers who would provide the basic infrastructure of the workspaces, "discrete assemblages", become a way of executing the participatory logic of the 1960s/1970s open plan. The focus is on the tool kit and developing techniques where the multiple logics of the users can come into play.

Making.

Karim Soliman's contribution, is a personal reflection on a decade of teaching CAD/Logic at DIA, where the initial trend has changed, from simply teaching techniques, to executing design ideas with a more integrative computational approach. Soliman's studio at present uses CNC machines, robotic arms, and 3D printing technologies,in order to create structures with huge spans and double curvature surfaces. BIM/CAM models are used to translate designs into numerical language for machines. They are implemented in the 8annual) design of the Hex 316 pavilion, that is usually constructed on campus.

The emphasis in the educational agenda, is no longer on the teaching of utilizing algorithms, but on rethinking the design of the algorithm itself, to incorporate the complexity of the design questions.

The experiments on designing an algorithm, employed to determine the location of a new UN building, including its main bodies, (such as General Assembly, Security Council, etc.) and another algorithm which periodically changes the location of country-missions inside the building,(to keep up the same neighboring conditions, between the missions of highly developed countries and low developed countries), is an attempt, to use computational tools in order to rethink: global politics of scale, complexity as well as questions working with the multiple logics of different parties.

Soliman's work also reveals the increasing interest in reconsidering the notion of nature and living system, through computational tools.

Bio-mimesis becomes an important technique in the development of the tools. The focus is on the self-organizing properties of living systems.

The experiments try to use natural systems to fine-tune multiple agent-based design models. Using branching systems, such as Voronoi diagrams, space subdivisions, and fractals in 2D and 3D models that help inform different tessellation techniques, his studio creates new and original forms, be it at the level of spaces (Hex Pavilion) or at the level of objects (eg. jewelry units, which simulate the growth of natural systems such as coral reefs).

Feedback loops.

Bier and Mostafavi discuss the change of the notion of agency and authorship through a critical reflection on the Design-to-Robotic-Production and Operation (D2RP&O) which they developed since 2014 by the Robotic Building (RB) team at the Technical University at Delft (TU Delft), and DIA.

Their work opens up a discussion on new trajectories, emerging in architectural robotics.

The machinic giving way to a more assembled human-non-human network, is evinced through multiple feedback loops, that exist between these robotic systems and other agents. A challenge, which they address in their teaching, is to allow the students to understand their limited role within these assemblages.

Feedback loops, which under a "computerization" paradigm, range from designing to robotic production, are enhanced and complemented by unprecedented feedback loops, that connect design-production with real time operation of the spaces, through sensor-actuator mechanisms.

These unprecedented feedback loops,which connect these operations, make allowances for a more computational approach to emerge in the process of using robotics, within architectural design. The strengthening of the user-driven component is evidence for the shift from "mass production" to "mass participation", as highlighted by Mario Carpo.[14] The ambition is to further advance D2RP&O methods, in order to not only increase process efficiency and improve interactive use of physically built space, but to advance human and non-human or cyber-physical interaction in architecture.

Optimization within this paradigm, is not only about efficiency, but also about user satisfaction. Optimization is not only about optimizing the unit for performance but also about optimizing the use of material. That is a more ecological concern. Several experiments, involving additive and subtractive D2RP processes, focused on porosity ranging from architectural (macro-) to componential (meso-) and material (micro-) scales and are discussed in the text. They make apparent the ecological nature of the studio's inquiry.

The two researchers end with a series of interesting questions, all related to the promotion of robotic factories of the future in the realm of building construction, using a range of robots with specialized end-effectors, that are able to implement different tasks.

Plectic.

Krastev, Soliman, Mostafavi, and Bier's application-oriented perspectives, demonstrate the fact, that what is more complex, is the way of teaching and working in a way, in which computation takes in to account the complexity of the assembled networks. The question relates to the limits of the computable within architecture. In the Architecture of theVComputable (1980), Ranulph Glanville questions, what is meant by computable. According to Glanville, for a cybernetician, computable means establishing a productive relation amongst things. In contrast, for a computer scientist, it becomes restricted to a set of tricks a computer can perform.[16]

For such a computer scientist, the computable refers to digital-, serial-, variable-, and quantity-based computing. Glanville states that most often, when one speaks of computing, one speaks of the latter. He identifies the computer scientist's computable with a simple "c" and a cybernetician's Computable with a capital "C". Neil Spiller has revisited this notion of Computable in recent years under the post-digital turn. As Spiller highlights in his Plectic Architecture, the post digital is not an architecture without the digital, but one, that is in synthesis between virtual, actual, biological, cyborgism, augmented reality.[17]

Spiller discusses, how the concept of cyberspace has invigorated architecture's notion of the virtual, as related to experimental, non-prescriptive design, open ended, as well as open for fluctuations and diagramming practices, that radically engage with fluctuating conditions.[18] For Spiller, the "plectic" breaks down the formal notion of digital architecture and denotes the broader framework that describes the way computation is affecting the operations process of architecture.

The post digital approach towards the virtual denotes an opening into the ecological.

Sixth Ecology.

Liss C. Werner's theorization of the notion of a "sixth ecology", through her studio experiments Codes in the Clouds at DIA from 2011-2016, is indicative of Spiller's post-digital turn in architecture. In Werner's text, the machinic refers to an ecological framework, that becomes a catalyst for a wider understanding of architectural formations. As Werner states: "The Sixth Ecology describes...a dynamic relationality; multi-parametric, functionally adaptable, morphologically changing, cybernetic."

She demonstrates the development of the theoretical construct of the sixth ecology through a historical mapping of the emergence of multiple notions of the computational environment. She simultaneously looks at the theorizations of "transformable environments", in the context of digital discussions and environmental discussions since the 1960s. She uses Neil Spillers notion of the "plectic" and Benjamin Bratton's use of the "stack" to describe the converging space between these two histories.

Developed by these intertwining positions, she defines the first five ecologies as natural (meaning nature as understood in the 20th century), infrastructural ecology (meaning streets, water, internet, etc.), socio-cultural (meaning the things humans do), artificial (IoT, robots, humanoids), and conversational (meaning communication between entities, verbal and biological).

What is at stake for her, or what is needed, according to her opinion, is a framework that focuses on the relations, feedback, and the interrelations between the other 5 ecologies that are most often just considered in isolation.

The sixth ecology, according to Werner, is the overall network, that includes unseen parameters, that deal with the relations in the other five ecologies.

For Werner, the "sixth ecology" should be the one, that should be critically approached and discussed within the processes of education, that deal with the machinic. In this sense, Werner's experimental studios, codes in the clouds, is an entry into diagrammatic practice maps (ecologies of interconnected parts), combining site observations with theoretical underpinnings, tools, and core parameters.

The project 'AllaNoo',a space for people to dwell, designed through the phenomenon of noise on site, where 'alla' stands for 'all', 'noo' standing for the mind, is a clear indicator of this trajectory of experimentation. However, Werner points out rightfully, that not only does the development of this sixth ecology remain unexplored, but is still a work under construction and continues to remain a challenge for architectural education.

Virtuality.

In "Technology, Science, Virtuality" (2012), Arie Graafland and Heidi Sohn map the conceptual and theoretical implications of the mutations and hybridizations of spatial concepts within the extended field of computational practices.[19]

Of specific importance to their discussion, is the changing notion of the "virtual." Virtual space has taken up a privileged position in digital practices. As highlighted by Mario Carpo, within the 90's, virtual reality provided a radical alternative to digital architects as a space, that was free from the multiple restrictions and controversies affecting real space.[20]

For Graafland and Sohn, what is at stake within this trajectory, is the notion of embodiment.[21] Embodiment considered in this sense is instantiated, local, specific, and encompasses a broad range of relationships and forces.[22]

In terms of Care,spaces of care and treatment have become significantly digitized in the past decade and provide a critical space, in which embodiment is a critical aspect of the real time operation of these spaces.

Machines, such as dialysis units, have become a part of the complex landscape of these care facilities. However, the human patient, entangled within these machine systems, brings a range of posthuman-all-too-human concerns into the picture.

Here, the research and design projects seem to struggle with one of the most significant questions, that existed since the advent of computerization. True for even the 1960ies, often pushed away into the background, this refers to the question of the mind-body problem. However, for the machinic experiments at DIA, "the body" has remained a core concern.

The contribution of the director, Alfred Jacoby, and the direction he has taken in developing the framework for this research trajectory at DIA (also evinced in his contribution to this volume), is particularly interesting in this regard.

His concerns with the age-old mind-body question, has allowed for a rekindling of interest in the topic, within projects and discourses at the University, allowing a much more complex and nuanced notion of logic, where the body and its "corporeal limits" and "sensory capacities" are not omitted within discussions on the computational.[23]

Care.

The man-machine relationship in these extended care settings, are explored in Alfred Jacoby's text in a more historical manner.

His findings on Health and Design, go back to his cooperation with the Excellence Cluster Research at Humboldt University Berlin and Fresenius Medical Care (as an industrial partner). Showing the body mind problem within Health and Design as a historical departure within a period termed Romantic Science, Jacoby maps the changes in the notion of "care" as it emerges in the broader context of Europe between 1750 to 1850.

This period is important, when considering the history of man-machine systems (at least in the context of medicine). It is the context, in which the idea of a psychological interaction between patient, treatment, and medical practice itself started.

In Mary Shelley's Frankenstein (published in 1831), a self-created monster represents the attempts in medicine, to use man-machinic assemblages as a way of reconstructing nature, or more specifically, human nature. The machinic in this extended man-machine setting provokes two strands of inquiry into ecology: an ecology of knowledge practices (interdisciplinarity) that is not reduced to the sciences or the arts, as well as an extended ecology of the body-and-mind, as producing cognition. A theme that has always been problematic for computational practices.

Jacoby points out, how in the age of Romantic Science in Britain (the focal point of this investigation) and to a lesser extent in Germany, (v. Humboldt, Blumenbach, Schelling, Goethe and Schiller), a unique interdisciplinary cooperation between natural scientists, medical doctors, philosophers, anthropologists, astronomers, and poets emerged. He also points to the opposing camp of positivistic thinkers, as protagonists of a science, that is driven by a philosophy of pure logic, combined with an obsessive drive for numeric verification of accrued knowledge.

Of course, such opponents abandon "romantic" interdisciplinary work as "irrelevant", By so doing, they disqualify single disciplines as ornaments to the core of "true" scientific knowledge, just like Karl Popper, within his well known text Logic of Scientific Discovery (1934).[24]

What this text highlights historically, is that the "notion of care", can never just be a discussion that is purely functional or aesthetic, but rather one which requires an extended form of ecological thinking, where one does not omit the other.

Alfred Jacoby`s vision for DIA, including the broader project of steering the teaching and research trajectory as an interdisciplinary ecology, is much in line with the project of interdisciplinarity and its failings in the age of Romantic Science.

His attempt, to install a chair for Urban Planning and Environmental Design in the University, showed how difficult it is, to inject interdisciplinary cooperation into teaching and research into a Architecture or Urbanism.

In Dessau the field defended itself as a specialized discipline, claiming, in the sense of Karl Popper, to be canonized within its own terms of aesthetics and formalism.

His article on Romantic Science is his attempt to show, that three centuries ago interdisciplinary cooperation successfully served as a very fruitful avenue forward. Not only in Science, but just as well in the Arts.

Embodiment.

Arie Graafland approaches the notion of the machinic by critically approaching the questions concerning the design of a mundane technical object as far as architects are concerned: the dialysis chair. The dialysis chair, a fundamental part of medical or care space in dialysis centers, is often considered a mere technical installation or a machine that becomes a part of a functional brief for architects designing healthcare spaces.

Through his research on the work carried out by the Fresenius Medical Care team which supports the design process of dialysis clinics in many countries across Europe, the Middle East and Africa, Graafland suggests that this functionalist framework is not adequate to address the complexity at work within the man(patient)- machine (dialysis machine with its multiple gauges, digital screens, chords, buttons etc) system at work in the process of dialysis. For him, the chair is a coevolving unit rather than two separate entities that become the consideration of separate stakeholders in design process.

The text invites the readers to explore the dialysis chair as a context where "spheres of life" are entangled in multiple ways, rather than as a functionalist object that is the agenda of designers and technologists.[25] Spheres of shared concerns and risks that are entangled are mutually constitutive but mutually impermeable and require a different field of knowledge not limited to a single discipline. His text stands as an example of the post-digital turn in computation and the notion of machinic it engenders. The text, with its references to Antonio Damasio's "body maps" and Byron Good's redefinition of "context" that is not limited to a physical context but also deals with an emotional context of the patient, is a call for a more embodied logic of operations, a different kind of sensitivity that is not fully encompassed within coding practices. This is a topic he argues as worthy of exploration within contemporary education dealing with man-machine technologies.

Co - Evolution.

The discourse on the Anthropocene and its focus on the multiple crises faced by architecture demonstrate that the challenge for architects at present is to understand and work with a non-binary concept of nature that is not separate from culture. Instead both nature and culture are to be understood as constructs and compositions. As Latour states:

"Nature is no longer what is embraced from a far away point of view, where the observer could ideally jump to see things as a whole", but the assemblage of contradictory entities, which have to be composed together. This work of assembly is especially necessary, if we now are to imagine the "we", ie., that humans are supposed to feel part of, in taking responsibility for the Anthropocene." [26]

In other words, nature (ecology), that is at the crux of the debates of architecture, is only available to architects and designers, through collaborative constructions, by disciplines and disciplinary instruments, through the expansion of discourse networks into broader fields.

The trajectory of research and practices on computation, often discussed under a plethora of titles such as cybernetics, systems research, digital theory, robotics etc. has unwittingly always been a primary component of this ecological discussion. Hence, the multiple logics of the machinic developed through the past decennia, as evinced in these essays, are by the same token steps taken towards a more co-evolutionary understanding of the nature-culture relation.

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Man, Machine, and Care

Alfred Jacoby

Introduction

In his book, The Birth of the Clinic: An Archaeology of Medical Perception (Naissance de la clinique: une archéologie du regard médical, 1963) Michel Foucault describes, how new surgical practices and social revolution helped to finally trespass the outer shell of the body with a scalpel, opening up a new medical perspective, which allowed doctors to act from within the human body. This introvert surgical action allowed for a new medical understanding of the physique of man as much as it changed the physique of the spaces employed to cure the sick.

From the start of the French Revolution right to the end of the Napoleonic period, medical science in France was spurred on by the immediate bloody demands of the battlefield. Until then, religious inhibitions and -interwoven with that- the existing restrictive social class structure had made a body sacrosanct - if only to prevent the proof that the physique of the body itself supported the idea of human equality in its sheer material existence. This produced a medical practice, which left bodies undisclosed and intact and reduced clinical observation to a mere look at the surface. Such practices were finally obfuscated by the horrors of war,as newly designed guns and canons began to rip bodies open. For doctors serving in so called (battlefield) Lazarettes, the surgical necessity to remove organs or amputate limbs became an everyday practice. At the time there was no pain relief – mostly the scalpel had to do its duty on fully or partially conscious patients. Following the logic of war, such Lazarettes were portable tents with no specialised compartmentalisation. On their return from the battlefield, wartime experience helped doctors and (military) administrators to transform temporary structures into new Clinics which contained a multitude of separate cells with specialised operating rooms for the various treatments of patients.

Since then we are in possession of a report that demonstrated the interaction of patient and doctor when the former was not put out of action by anaesthesia.

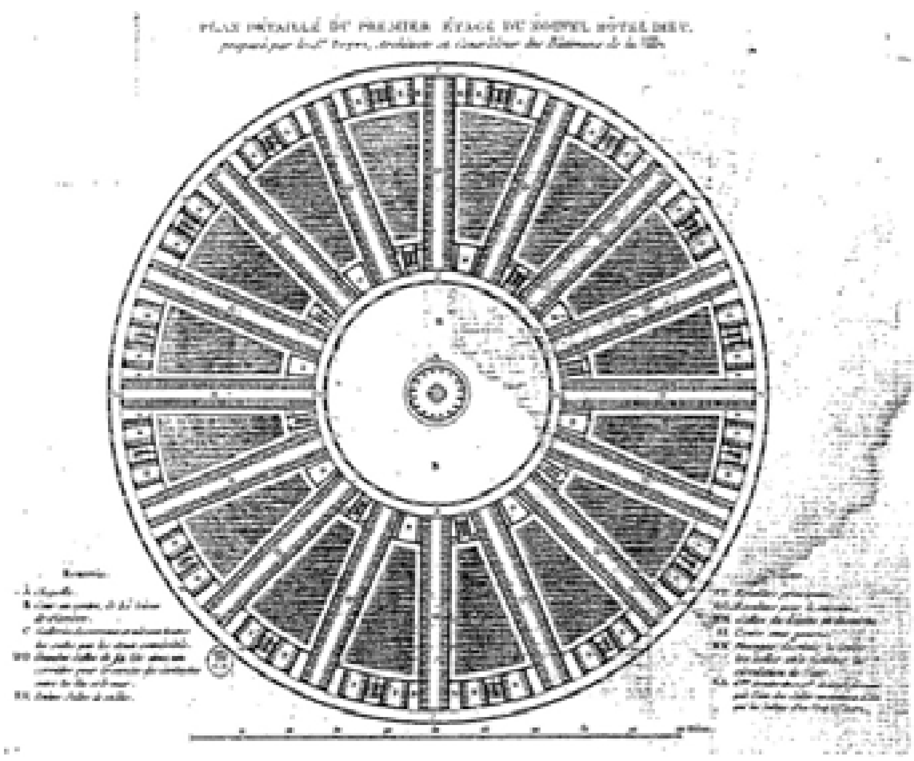

Fig. 1. Plan of Hotel Dieu Paris 1785 Arch. Payot.

In 1811 Madame d'Arblay, née Fanny Burney and a friend of William Herschel the astronomer, underwent a breast cancer operation in Paris. It was carried out by the French military doctor Dominiqie Larrey at the Hotel Dieu Hospital and allowed the patient to live on for another twenty years. The incision was carried out without anaesthetic, Mrs. D'Arblay remaining fully conscious throughout. In a letter to her sister in London, written three months afterwards, she described unremittingly what the state of surgery was at the period.

„When the dreadful steel was plunged into my breast, cutting through veins and arteries, flesh, nerves—I could not restrain my cries. I began a scream that lasted unintermittently during the whole time of the incision... So excruciating was the agony... All descriptions would be baffled ...I felt the knife rackling against the breastbone –scraping it."

Not only was she aware of the makeup of the body (veins ,arteries, flesh, nerves), but one of her afterward reflections was, if the extreme physical pain could not only induce unconsciousness but actually force the soul out of the body.

„I have two total chasms in my memory of this transaction" she writes in her report.

But she also became aware, that she could not face the recollection of the actual event, once she had written it down, as that bore its own pain.

„I dare not revise nor read , the recollection is still so painful." (The notes and letters of Fanny Burney-Madame D'Arblay- Joyce Hemlow 1975).

As a point of departure, this account opens up the field describing soul and feelings as a constructed architecture which connects body and mind. From this viewpoint even today, after the discovery of anaesthetics and the whole array of replacement and digitally controlled surgical apparatuses for our body, her description is highly relevant.

The period from 1750 to 1850 deserves special attention: especially in Britain, as the focal point of this investigation and to a lesser extent in Germany, (v.Humboldt, Blumenbach, Schelling, Goethe and Schiller), the period established a unique interdisciplinary cooperation between natural scientists, medical doctors, philosophers, anthropologists, astronomers and above all poets: It earned it the name of the Age of Romantic Science. Especially medicine which both inspected the vicissitudes of the body as well as the human mind and its feelings, the idea of a psychological interaction between patient, treatment and medical practice itself first started here.

In literature, Mary Shelley's Frankenstein monster is another example of this period. The novel deals exactly with the interaction of the result of rejected feelings producing an insatiable drive for revenge. Her anti-hero, Victor Frankenstein attempts to self-create a human body from dead matter, an attempt which dismally fails. Yet, it describes a starting point for a journey, which today's medicine somehow reflects. Artificial limbs and organs, digitally steered life saving machine, they are all in line with the wish to re-created a deficient human body. Today undertaken with the results of a gigantic leap forward in scientific medical knowledge over the past two and a half centuries.

Yet the work of the British and German romantic poets and philosophers on the soul, or of later Austrian, French or Scandinavian psychologists, philosophers, play writes and poets (Freud, Bergson, Strindberg) working and writing on the mechanisms of the mind, should come under heavy attack as non-scientific in the 20th Century.

Protagonists of a science, that is driven by a philosophy of pure logic, combined with an obsessive drive for numeric verification of accrued knowledge, i.e. of a more rationalist and functionalist practice, most willingly abandoned "romantic" interdisciplinary work as "irrelevant" and disqualified single disciplines as ornaments to the core of "true" scientific knowledge. Karl Popper stands out in this endeavour. His "Logic of Scientific Discovery" (1934) contains a special chapter on the "Elimination of Psychologism", where he writes:

"The question of how it happens,that a new idea occurs to man – whether it is a musical theme, dramatic conflict or a scientific theory - may be of great interest in empirical psychology; but it is irrelevant to the logical analysis of scientific knowledge."

The relevance of re-studying the Romantic Period therefore lies within our own paradigm shift. It has brushed aside Popper's strictly monofunctional correlation between method and scientific discovery. Today, we are drifting away again from Popper's rigorous one dimensional thinking. As for medicine, the single discipline approach caused an array of specialisations but it also just allowed us to see patients as passive objects within the theatre of a "scientific", i.e. verifiable medical practice. It considers treatment far above ideas of care.

Yet, with the deciphering of biological DNA and Genome codes, the body and the mind have more and more become new necessary partners within the realm of scientific advance. The body and its scientifically developed supportive techniques have merged and become necessary partners in a biotechnology where clear boundaries of each become more and more indiscernible. It seems to me, that the more logically particular explanations we offer on a nano-scale, the more the picture of the patient and his feelings during care becomes an imminent subject of scientific concern. As a result, modern medical practice today again departs from purely functionalist single-discipline research and treatment, just as in the 18th Century. We have realised, that just using technologically very advanced tools sometimes falls short of taking care of patients.

The Romantic Revolution - British Medicine, Literature and Science in the 18th Century

Modern science as a result of the First Scientific Revolution (starting around 1620) can be subsumed under the names of Hume, Locke, Descartes and Newton, accompanied by the foundation of the Royal Society in London(1660) and the Academy of Sciences in Paris (1793).

In contrast, in 1945 Bertrand Russell writes about the romantic period starting in 1750:

„From the latter part of the 18th Century until today,art, literature and philosophy and even politics have been influenced positively or negatively by a way of feeling, which was characteristic of the romantic movement. (..)

The romantic movement is characterized as a whole by the substitution of aesthetic for utilitarian standards. (..)

Newton's orderly cosmos, in which the planets unchangingly evolve about the sun in law-abiding orbits became an imaginative symbol of good government. (..)

The romantics did not strive for peace and quiet, but a vigorous and passionate individual life. (..)

The temperament of the romantics can best be studied in fiction. They were attracted by what was strange; ghosts, decayed castles, the last melancholy descendants of once-great families, practitioners of mesmerism and the occult scenes, falling tyrants and levantine pirates. They felt inspired only by what was grand, remote and terrifying." (Bertrand Russell: History of Western Philosophy, 1945)

Even if today Romanticism as a cultural force with its notion of the eternally subjective is generally seen as opposed to the arguments of pure scientific objectivity, it becomes clear that this was not the case within the timespan starting with the French Revolution and lasting throughout the 19th century. Looking at a period of scientific discovery in Britain at the turn of the 18th to the 19th Century, we can see that, what we today consider a path towards „pure science" was then performed by a collaboration of different disciplines.

It involved poets that turn out to be theoreticians of knowledge (Samuel Taylor Coleridge), or the first female novelist who tackled the problem to define feelings and the notion of a human soul (Mary Shelley, Frankenstein and the Prometheus). They all directly and personally interacted with men of pure science" like the chemist Humphrey Davy, the astronomer William Herschel, as well as the anthropologists and biologist Joseph Banks.

The Age of Reason hence not only trusted in mathematics and pure rationality but additionally employed narrative disciplines like literature, history or anthropology, to create what in Britain was coined as „Romantic Science". (J. Golinski: Science as Public Culture ,1992).

The first one to mention such a Second Scientific Revolution was typically not a scientist but a man of letters, the poet Samuel Taylor Coleridge.

In his Philosophical Lectures of 1819 he becomes the chief spokesman for a combination of Romantic Philosophy and scientific method: "Must there not be some power that stands in human nature but in some participation of the eternal and the universal by which man is enabled to question, nay to contradict, the irresistible impressions of his own senses, nay, the necessary deductions of his own understanding – to challenge and disqualify them, as partial and incompetent?"

New Discoveries in the Age of Romantic Science

The Age of Romantic Science spanned two celebrated British voyages of exploration: Captain James Cook's first world expedition on the Endeavour (1768) and Charles Darwin's voyage to the Galapagos Islands aboard the Beagle (which started in1831). Both brought back new astronomical knowledge as well as theories on the origins of man and the complexity of species throughout a formerly unknown part of the world. One of the tasks of James Cook's Endeavour was, to sail to the southern hemisphere , accompanied by the botanists, Joseph Banks and Dr. Daniel Solander, in order to measure the transit of Venus, which was calculated to appear in 1768. For that purpose, Cook's ship carried a special telescope that would directly trace images of the small black spot of Venus onto a sheet of paper making recording easy.

The century between 1750 until 1850 saw some important discoveries that changed the perception of Science. William Herschel's discovery of Uranus (and with it the Milky Way) opened up the perception of the universe even further. Especially in Astronomy, Anthropology and Geography, Cook's voyages and Joseph Banks description of them, changed the way the world could be understood. Parallel to that, at home in Britain. New chemical knowledge was ascertained through experimentation in a lab, when Sir John Davy's invention of a safe coalminers lamp enhanced the exploitation of a new source of energy.

His basic research lead to practical application, defining research technology as the new driving force for an Industrial Age oriented on coal. For each of these discoveries, new technological instruments were key elements of enablement. In both Astronomy and Geography, new telescopes and mapping devices lead to an understanding of an expanding universe, which eliminated several blind spots on the world's map, (reliable mapping having started with Mercator's projection in 1519).

A second less planned yet equally important effect of Cook's expeditions were the observations of unknown "other" peoples as well as geographic explorations of their territories. Both these findings were designed to describe life on a globe still full of unknown voids.

Sir Joseph Banks and his visit to Tahiti

In 1768 Joseph Banks, went to Tahiti with the famous Captain James Cook aboard his Endeavour. What he brought back, next to a Tahitian Prince, was a deeper knowledge of the primitive peoples. The encountered on his trip and whose habits, language and behaviour he learned and mapped. As the later President of The Royal Society, Banks had studied and recorded the behaviours and customs of the peoples of Tahiti on his voyage with Cook, and made recordings of the geography and the people.

Banks was the only one aboard the ship, who had learned their language and he finally brought back to London a princely descendant from the South Seas called Omai. He not only „demonstrated" him in London Society or within his private „Scientific Salon" but had him painted by William Parry alongside himself. It is not clear if this portrait shows Omai as honored guest or valuable human specimen. The paintings of Omai by William Sanderson were later used by the famous physician and early anthropologist Sir William Lawrence in his lecture series on the „Natural History of Man"(1819). With them, Lawrence showed that development of a human species depended on the skeleton adapting to climate and culture rather than evaluating such peoples in a different class as sub-human.

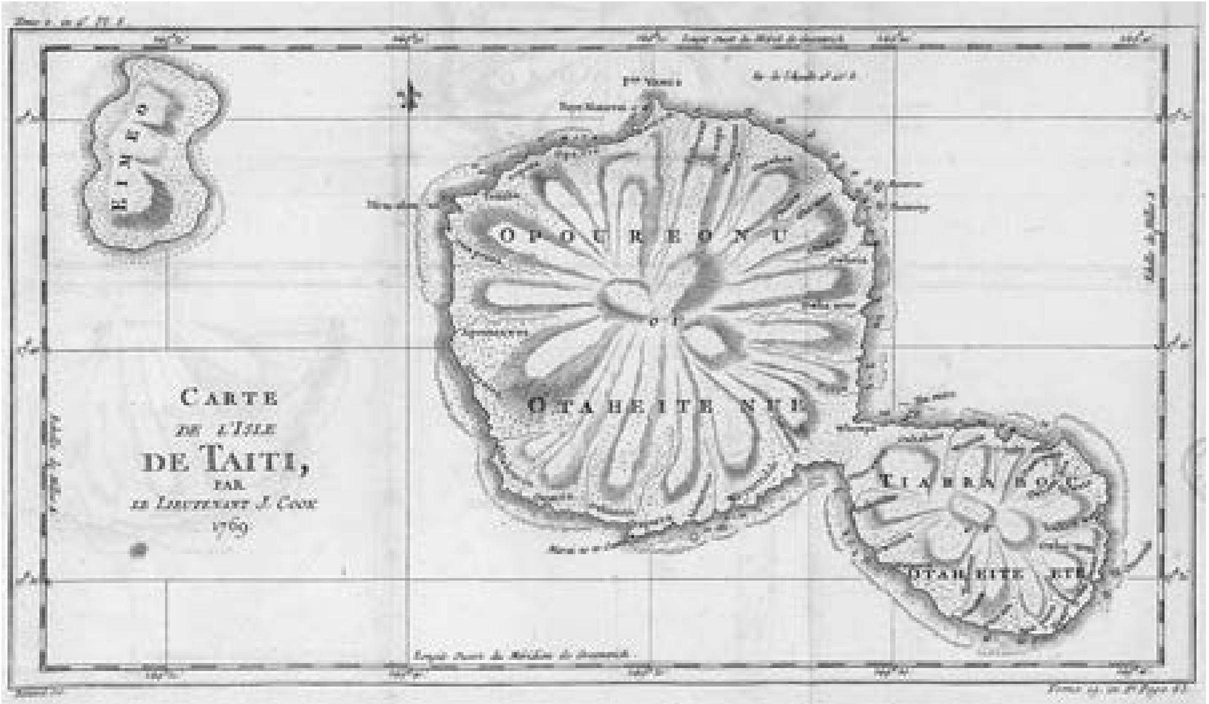

Fig. 2. Map of Tahiti,Captain James Cook, 1776.

Fig. 3. William Parry, Omai, Joseph Banks and William Sanderson.

William Herschel and the Discovery of an Ever Expanding Universe

The new Planet Uranus and later the theories of the expansion of the universe and the idea of looking back in time were directly related to the technical ability of William Herschel, who built a new tool to enable stronger vision in order to literally expand the field of vision. In 1784 William Herschel published his Construction of the Heavens, based on his telescopic discovery of Uranus and the Milky Way.

Important to notice is, that Herschel was his own engineer, who developed the new 40 ft. reflector telescope by himself, which he installed in his home to watch the stars. The 40 ft would be higher than a house, extremely susceptible to wind and weather, especially frost, which could untune the telescopic lenses like a musical instrument.

The whole Observatory consisted of a small room for the assistant, with a desk and a lamp, celestial clocks and observation journals . The astronomer, would climb a set of ladders within a larger scaffolding structure, allowing for the 1/2 ton lens of the telescope to be adjusted to varying points of celestial interest. Presenting the telescope as an enormously expensive funding project to Sir Joseph Banks as the president of the Royal Society of Science, Herschel remarked in 1785:

„The sole end of the work would be to produce an Instrument that should answer the end of inspecting the Heavens , in order to more fully ascertain their construction."

Clearly Herschel here refers to Newtons „ construction" of a universe in balance, held in equilibrium by vice-versa forces that each stellar mass is subjected to.

What is unique in Herschel is that he wanted to make new stellar systems appear by subjecting the eye to this new world. This was possible because in Herschel, the extraordinary engineering genius paired up with a perseverance to observe and record his daily findings by mapping them. If Copernicus inferred the solar centred stellar system of the earth by applied mathematics, Herschel wants to see his system and infers his new knowledge by mapping and recording. The double setup of the scientist as observer and recorder changes the instrument he constructs : It is no longer just a telescopic lens bringing stellar constellations nearer. Herschel's 40ft. Reflector has a double function: It contains both an observatory as well as a recording room and becomes a new tool for observation. With William Herschel unravels a new astronomical paradigm: he describes and maps the Milky Way. The Heavens are no longer a static geometrically defined balanced monocentric system revolving around the sun. With Herschels findings they become a multi centric kinetically ever expanding universe composed of many so called suns. As in the case of many scientific discoveries, finding it was due to new technology, this time a much more powerful telescope that serves not only as a magic tool but is in itself a laboratory.

Parallels to the research of Galileo can be drawn here. He also understood and oversaw the manufacture of the construction of his telescopes 200 years earlier. Yet, embedding the findings into a common scientific paradigm of a science based on laboratory observation using new tools was much more favourable for Herschel than it had been for the famous Italian Renaissance physicist. Along with the expansion of new boundaries on mother earth, Herschels discoveries served the purpose of unravelling not only a planet but a universe.

The Davy Lamp and the Coalmining Industry

Concurrently first chemical experiments concerning coal, the prime material of 18th Century Industry, were conducted by Sir Humphrey Davy. Not only was coal the basic ingredient for cast iron and later on steel production, it became the main topic of the second Industrial Revolution in Britain. As Eric Hobsbawm has shown in his book Industry and Empire, coal and steel production were, up until 1950, the two benchmark parameters to demonstrate and determine the degree of industialisation for the set of industrialised nations for over 100 years. Additionally the bulk exploitation of it was also used as an indicator of the national fiscal production power for instance as a measure for a nation's wealth. Therefore the

Fig. 4. William Herschel by Lemuel Francis Abbott, 1785.

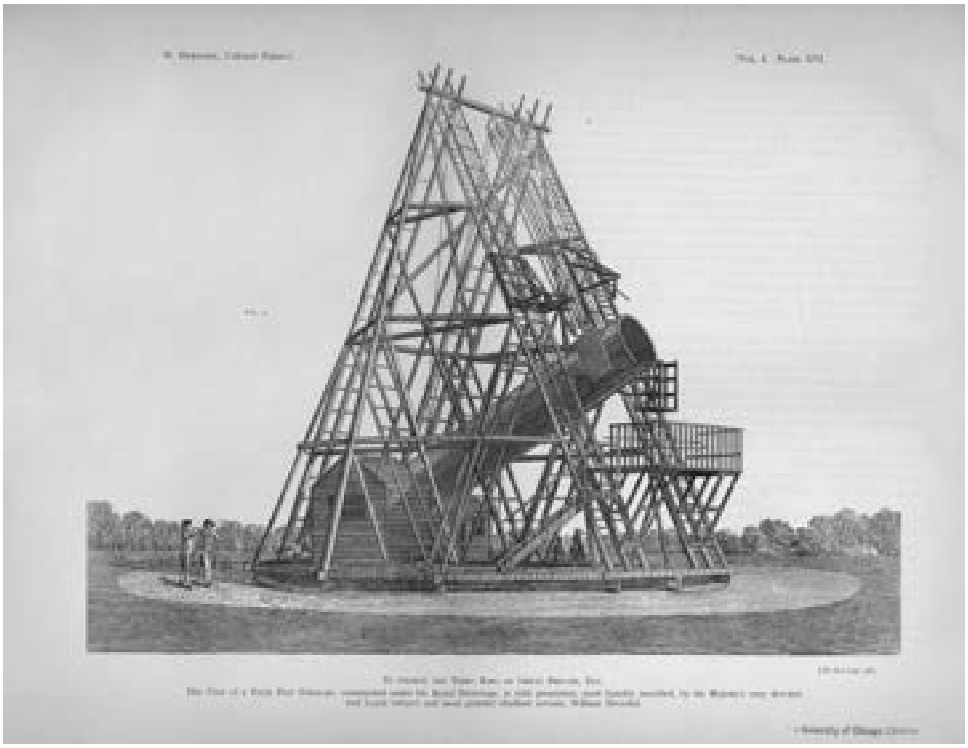

Fig. 5. William Herschel's 40 ft. Telescope.

process of converting this natural resource into national funds, was of prime importance was the safe, which ensured that another scientific exploration was needed. Its discovery was based on the method of induction again within a laboratory setting, as the substance to be observed was gaseous and invisible: carbon monoxide.

In 1815 Humphrey Davies presented a safe coalminers lamp, after an accident in a mine had killed scores of miners. Instead of venturing into far-off foreign lands, its discoverer simply went sous terre, researching a different, known yet hostile environment: the underground coal mine. The invention of the Davy Lamp made the exploitation of this underground industrial environment possible without exposing labourers to the gaseous hazards one could find there. Davy came up with a simple yet ingenious solution: his key innovation was to surround the lamp flame with a cylindrical metal mesh, that absorbed oxygen from the adjacent air and deprived the methane gas of its trigger. Again here we can find a parallel a 100 years later, with the French mathematician Henri Poincare, whose first industrial invention is a direct improvement of Davy's Mining Lamp (see Peter Galison: Poincare's Maps Einstein's Clocks, Empires of Time).

Humphrey Davy and anaesthetics

Just as much as Davy's invention of a mining lamp was an example of exploiting laboratory findings on the reaction of gaseous substances, his dealings with the anaesthetic reactions of laughing gas, did not lead him to an equally revolutionary discovery.

As much as Davy realised the useful application of chemical knowledge about gases in mining, he failed to pursue his knowledge on the effects of nitrous oxide, missing to understand its use for the operating room. Both Davy and Coleridge ventured into the possibility of studying pain and its relief, while Coleridge was one of Davy's test persons on whom he tried the effects of nitrous oxide. The research into the effects of gaseous substances on consciousness and anaesthetic properties had a background in medical research first undertaken by Humphrey Davy in 1816. In that same year Davy entered the Pneumatic Lab of the medical doctor Thomas Beddoes. He was possessed by the notion that inhaling a particular gas, oxygen, or perhaps hydrogen or carbon dioxide, would cure tuberculosis and a wide variety of other ailments.

When he signed on young Davy as his assistant, the affairs of the Pneumatic Institution entered a new phase. For Davy succeeded in synthesising nitrous oxide or "laughing gas" as it came to be known. He testified that inhaling it induced feelings of transcendence. "I seemed to be a sublime being, superior to other mortals." Nitrous oxide also gave him a heightened sense of aliveness. Colours were more dazzling, sounds more acute, and he seemed bonded with nature so that tearing a leaf from a tree caused pain in his own body. Laughing gas provided a passport to a "parallel world", and members of the Beddoes circle who entered it, had difficulty putting their sensations into words. Coleridge described it as "great ecstasy".

Yet, in the midst of these poetic recreations, the medical potential of nitrous oxide was tragically missed. Davy went so far as to note in his diary that, as it eliminated pain, it might be a "great advantage during surgical operations". But it was not until the 1860s that first dentists and then surgeons began to use it as an anaesthetic, so for half a century patients continued to endure unanaesthetised agonies. And even though Madame D'Arbley was an acquaintance of Humprey Davy, she could not profit from his observations on laughing gas.

Mary Shelley: Victor Frankenstein and the Creation of an Artificial Human

For the purposes of this investigation, which deals with questions of healing through medical treatment from the viewpoint of the patient, Mary Shelley and her time is of special interest. Among medics it sparked the discussion on "Vitalism" in England at the time (1815-30), which started a debate on the connection of soul and body. A book that echoed the same tune at the same time was "The Natural History" of Man by William

Lawrence also written in 1819 perhaps at first influencing British Science more than Shelley's Frankenstein.

At the turn of the late 18th century until the middle of the 19th Century in Britain, natural scientists as well as poets, take a prime interest to discover and describe the driving force behind life and the act of creation. Both wanted to search for answers beyond the rigid settings of belief, tradition and dogma, which the Church still firmly upheld. While scientists like Herschel and Davy used a laboratory as the new space for their discoveries, a group of British so called „romantic poets" literally went „soulsearching". This search sparked the so called „Vitalism Debate," that developed especially in Britain (1816-1820), at a time when Mary Shelley would write her horror-novel Frankenstein and the Prometheus. (1814-18).

The Vitalism Debate

Vitalist ideas had been stirring for over a generation. Ever since the French revolution, fundamental questions about the nature of life itself had been raised in medicine, biology and physics. What distinguishes organic from inorganic (dead) matter, or vegetable from animal life? Was there some prime animating force throughout nature (Baruch Spinoza) and if so – was it analogous to or identical with electricity? Since the experiments of Galvani(1792) and Volta, such questions were now increasingly discussed by physicians, science writers and those who studied what Coleridge called „the Science of Mind".

The issue of Vitalism in this time period dealt with an inner substance as a motivator for agent behaviour. At first the Vitalism debate was a dialogue led by the leading London and Paris medics among themselves, which was then finally presented to the general public, mainly through lecture series. In Britain the debate was introduced in 1819 by the President of the Society of Royal Surgeons, Sir John Abernethey, in an annual Lecture

Fig. 6. Mary Shelley.

series on „the Probability and Rationality of Mr. Hunter's Theory of Life". – „Mr. Hunter" (1728-1793) being Sir Abernethy's old Anatomy teacher.

The theory dealt with he existence of a Life Force or Life Principle as an invisible circulatory force beyond blood comparable with the idea of a wave transporting Aether, used by physicists before Einstein's Theory of relativity. Just as scientists of the late 19th Century had invented an aether in order to explain the propulsion of atomic particles in Physics, medical scientists used an artificial medium to explain life phenomena. Abernethy proposed, that human life is based on the concept of universal physiological development. His universal „Vitality" was a subtle, mobile, invisible substance, added onto the visible muscles and bone structure, which blood would connect together. Abernethy's main argument claimed that this force was scientific proof of the existence of a soul.

This theory was directly and controversially challenged by Sir William Lawrence. This newly appointed and brilliant Professor of Anatomy at the Royal College of Surgeons (1812) had worked under Blumenbach in Göttingen and studied the famous local skull collection. Lawrence had translated Blumenbach's work on „Comparative Anatomy" (1807) into English. The book was based on Cardiology, an investigation of the skull, which Alexander v. Humboldt had started, while travelling in South America. It involved the collection, measuring and classification of human and animal skulls.

Hence, in Blumenbach's Göttingen laboratory the classification of racial types began. For this purpose, Blumenbach possessed an extensive collection, which Lawrence jokingly called „B's Golgotha". In his book, Blumenbach raised questions of racial types and the hypothetical link between skull shape, brain size and intelligence.

For his own publication, „The Natural History of Man"(1819), William Lawrence likewise relied on findings within the Hunterian Collection for his own publication. With it, Lawrence came back to his German experience and presented a counterargument to Abernethy's invisible Vitality assumptions, by using the animal and human skeleton collection, which Hunter had bequeathed to the Royal College. From his observations, Lawrence inferred, purely materialistically, that the continuation of physiological development was not due to a vitality force or an inner soul connected to the body by invisible substances, but could be simply inferred by analysing the skeletal development of various species. At the time this raised great stir amongst the Clergy, accusing Lawrence of atheism as his materialist view challenged the Church's belief in the godly ad hoc creation of the human and animal kingdom. Finally in 1820,Lawrence had to withdraw his claims, as he was threatened with court proceedings that could easily lead to a prison term and the consequent ruin of his career. In its pure materialism it can be regarded as a forbearer of Darwin's Origins of the Species published in 1851.

Fig. 7. Blumenbach's Golgatha.

Fig. 8. Sir William Lawrence in 1839.

In Search of the Soul

The explorations in the far East and Africa as well as their experimental measurements of skulls and bones brought Europeans nearer to an understanding of other peoples, their ethnicities and behaviour. This went hand in hand with the removal of white spots of „unknown" territory on a geographical as well as anthropological world map. And the science of the age posed the question of the Substance of Life and the Soul. In Britain it also was a subject inspected and described by the poets of the age, since it directly addressed the ideas of creation.

There are two literary creations, that especially refer to the ideas of creation and soul:

- the medieval story of Rabbi Löw of Prague and the making of a „Golem" (only published as late as 1836 in Austria) as well as
- the romantic composition of a „Frankenstein-Monster",as described in Mary Shelley's famous book, „Frankenstein and the Prometheus" (1819), based on the findings of 18th Century science.

Both texts share an artificial creature ending up as a dangerous, uncontrollable monster unwilling to follow accepted human behaviour. Of course the reasons of unwillingness are different in both creatures. In the biblical example of the Golem, the sole fact that he was created by man was such a blasphemic issue, that of course man could not make anything else than a misfortunate cruel and unintelligent creature. Whereas the „Golem" goes back to a myth, which was first mentioned in the 12th century, „Frankenstein", was inspired by the parallel breakthroughs in anthropology, astronomy,chemistry and in particular medicine and its debates on vitality from 1760 onward. All the discoveries made between 1760-1830 and their ensuing debates had captivated a group of romantic poets and their descriptive imaginations (Byron, Keats as well as Percy and Mary Shelley). As narrative has it, Lord Byron asked all his guests visiting him in Italy to compose a short story based on the effect of horror. Among his visitors were Percy Shelley and his wife Mary.

It is also recorded, that Mary Shelley's husband, Percy Shelley, knew and corresponded with the chief explorer on-board captain Cooks Endeavour, Sir Joseph Banks and was aware of his discoveries. From his travels to Tahiti, Banks had brought back Omai, the Tahitian Prince, to London. He had more or less „exhibited" him in his Scientific Salon, also frequented by Percy Shelley. There, the romantic notions of horror and bewilderment at the unknown species of „Man" could come together. The book primarily depended on the literary invention of a wild monster that was miraculously assembled from non-living matter and with it the fascination of self creation. Alongside these ideas, the novel also played out the drama of scientific expeditions, as much as it firmly installed the idea of a scientific test laboratory, designed to produce results of fiction and horror.

Her „Frankenstein and the Prometheus" (1819) is a moment when the current discoveries of the time were first put together in literary form, dealing with a constructed human, his horrible emotional failings. She demonstrates, that the soul is not pre-determinable, let alone constructible but always a matter of inter-human relations. Bertrand Russell gives a very poignant account of this:

Frankensteins monster is not, as he has become in proverbial parlance, a mere monster:

He is, at first, a gentle being, longing for human affection, but he is driven to hatred and violence by the horror which his ugliness inspires in those that whose love he attempts to gain. Unseen, he observes a virtuous family of poor cottagers, and surreptitiously assists them in their labors. At length he decides to make himself known to them:

„The more I saw of them, the greater became my desire to claim their protection and kindness. My heart yearned to be known and loved by these amiable creatures – I dared not to think that they would turn from me with disdain and horror."

But they did. So he first demanded of his creator the creation of a female like himself and when that was refused devoted himself to murdering, one by one, all whom Frankenstein loved (Bertrand Russell History of Western Philosophy).

Finally the monster speaks of himself:

When I run over the frightful catalogue of my sins, I cannot believe that I am the same creature whose thoughts were once filled with sublime and transcendent visions of the beauty and majesty of goodness. But it is even so; the fallen angel becomes a malignant devil. Yet even that enemy of God and man had friends and associates in his desolation. I am alone."

For the first time, Shelley proposes a strictly materialist anti-religious model of creation, describing the making of a creature in a lab, assuming opinion-leadership as the materialist credo of creation and evolution. At the same time, her psychological insight in the changes of feelings were as important. These character aspects can clearly be found in the description of Mary Shelley's Monster, created by the (amateur-) scientist Victor Frankenstein. The other fascination told by Mary Shelley in Frankenstein is the adventures into foreign lands. This is displayed at the beginning of her book: it begins at the end of the 18th Century in St. Petersburg with an account of a certain R. Walton who writes to his sister in England. This adventurous Polar Explorer introduces the unfortunate hero of the tale, Victor Frankenstein into the story by placing him shipwrecked on Arctic ice.

Walton recounts in the letter to his sister:

„This expedition has been my favourite dream since I was a child. I have read many stories about men who have tried to cross the sea by the North Pole to get to the North Pacific Ocean." He also asks: „Will I meet you again after crossing the sea?"

By the time Mary Shelley wrote her novel (1819) , two other British expeditions had lethally failed: James Cook's voyage to the South Seas and Mungo Park's expeditions to Africa, undertaken between 1768 and 1805.- Neither Cook nor Park returned from their adventures alive, as they were both killed by ferocious human- like „creatures", whose behaviour patterns were unknown to them. An air of the mysterious, the strange and the remotely horrific was ascribed to these „foreign natives". They were regarded as „wild", „uncivilised and dangerous" and at instances therefore demonised as only semi-human.

Along with the description of defects in character, Walton's fictitious North Polar adventure described in Frankenstein, is therefore an obvious second reference to horror and despair. As such horror acts as the anthropological lifeline connecting Walton's intentions to other seafaring expeditions. While for Walton the expedition is the fulfilment of a childhood dream, Victor Frankenstein is shown in deep despair, when searching for the horrid and nameless monster he had created years before in a laboratory, while he worked as a talented young scientist under two German professors in Ingolstadt.

Yet, unknowingly with that, Mary Shelley also reached out into our own time: she put her hero Walton into the same pedigree of suspense and horror as did the expedition of Sir Walter Scott in1905: approximately a century after Mary Shelley's Frankenstein, a parallel endeavour ended in horror and death. In search of the (magnetic) North Pole, Walter Scott and his entire team lost their lives. Their Norwegian contestant in this race, Roald Amundsen not only missed to find the British, but surpassed them, triumphantly leaving behind the Norwegian flag, rammed into the ice at the Pole.

Of course, in 1819 the attempt to create a human being and to install a Human Soul into a formerly „lifeless" body by experimentation in a scientific laboratory, was likewise condemned and described as an error of human reason – if only to satisfy the power of belief, which the Church still had on scientific opinion at the time. Such supremacy of belief in religion over the experimentation conducted by science touched also on the group of romantic poets. Keats, Wordsworth and Charles Lamb were present at a party in London in 1817, later known as the „Immortal Dinner" (B. Haydon, Diary 1817). There, the artist Benjamin Haydon demonstrated his monumental painting „Entry of Christ to Jerusalem" to them.

The painting shows a totally fascinated crowd, welcoming a halo-crowned Jesus, triumphantly riding a donkey, bringing back new religious belief into the ancient capital of

Fig. 9. B. Haydon: Entry of Christ to Jerusalem, 1819.

religious belief: Jerusalem.

What is astonishing is, that in the far right-hand corner, the painting contains portraits of Wordsworth Newton and Voltaire, standing by in amazement as side figures; if only by nature of their position to the scene. They stand for French philosophical scepticism (Voltaire), English piety (Wordsworth) and analytic science(Newton). Their romantic subjugation to the central heroic figure in the painting, is a clear indication of the low position and value, Haydon assigned to science in a still religiously ordered society.

Conclusion:

Through the interaction of various disciplines, „Romantic Science" became a period of scientific transition: it did originate in 18th Century Enlightenment Rationalism, but largely transformed the latter by bringing a new imaginative intensity and excitement to scientific work. This excitement around the „eureka moment" is shown in the masterpiece painting „The Air Pump". (1766) of William Wright of Derby, showing a family „laboratory" where the pater familias demonstrates the workings of a vacuum.

All of them, both socially and academically directly interacted with men of „Pure Science" like the surgeon Sir William Lawrence, (the Natural History of Man,1819) the chemist (and poet) Sir Humphrey Davy, the Astronomer William Herschel and his (mathematician) son John Herschel, as well as the (amateur-) Anthropologists Joseph Banks and Mungo Park. Just as Babbage, the famous Cambridge mathematician remarked after the death of Sir Humphrey Davy the Chemist in 1867: "as a Poet he would have been a great one", implying that scientists of the future should apply both artistic and scientifically rational methods in their research.

As a group the connected scientists and poets of the romantic period formed what Hyppolite Taine later would call a „Creative Milieu" over the entire period in question (Taine originated the concept in his

Fig. 10. William Wright of Derby The Air Pump, 1766.

"Philosophie de l'Art", in 1865). He argued that where creative milieus exist, these tend to be underpinned by "a general state of manners and mind pervading a place", producing in turn a "moral temperature" which allows talent and artistic creativity to develop in particular places at particular times / 1865).

As shown, the second half of the 19th Century, the connection of literature (Shelley) and Neuro-Biology would produce a variety of wild mythologies of the brain (Blumenbach, Lawrence). Their assumptions were all based on roughly anatomically informed explanations of body and soul. They completely lacked the physiological, psychological and neuro-anatomical knowledge we have today.

With the research into cellular neurophysiology and neuro-chemistry, to explain the basis of our nervous system and brain, highly specialised medical doctors and neuro-scientists like Humberto Maturana, Francisco Varela, Antonio Damasio and Oliver Sacks, have since radically changed such insight. Not to forget the extreme influence of new technological discoveries and machines. Part of this paradigm-change were new digital imaging technologies like Tomography and Magnet Encephalography, which were introduced into Medicine. They are now employed to research cognitive and affective functions on healthy as well as ill patients.

In my contribution, which is focussing on the century between 1750 and 1850, I set out to connect the ideas of interdisciplinarity with the resulting and then available scientific discoveries, something that was unique in the period I described. My first concern was matters of medicine.

Today, such thinking is recurring, as an attempt to demonstrate the relevance of both, scientific rules (in our case of medical treatment) and their effect, on what Mary Shelly would have called the „Human Soul".

Of course, medical treatment has by now been institutionalised and compartmentalised. Scientifically, it has advanced, since then, beyond what we would just call a leap forward. In this way my contribution seeks to open up a discussion in medical treatment, on what I would call, the task of „Mapping the Patient", using all available mapping devices available to us now.

Above all, such „mapping" points towards the importance of „feelings" of our patients. With institutionalisation and specialisation of medical treatments, there is a widening gap between „feeling" your body or just „having it serviced". Apparently, our industrial medical process cannot yet bridge this gap. It should be brought to do so. As we have learnt from the Romantic Period in Science, such endeavours are worth it, as they have severely added to our well being.

Man Machine Technology

Arie Graafland

"Dialysis Centres, An architectural guide" (2012) is a publication by an architect, Maria Merello de Miguel, an engineer Carlo Boccato, and a manager Guido Giordano, all are part of the Fresenius Medical Care team which supports the design process of dialysis clinics in many countries across Europe, the Middle East and Africa. Fresenius Medical Care is a global player in this field with clinics all over the planet. The aim of the book is to guide the design process for architects and technicians in designing dialysis centers. A dialysis clinic or centre is an ambulatory healthcare facility for treatment of outpatients with chronic renal disease. It means the loss of kidney function, the process is irreversible, there is no cure. Accumulation of toxins will damage other organs leading to heart rhythm disturbances, infections, disorders in the digestive tract or abnormal changes in the nervous system. Dialysis rooms are places where you get a treatment that will take four to five hours each session. During that time you must remain immobile; lying or sitting on a dialysis chair or bed, patients are allowed to read, watch TV, talk to others or take a nap, if they can.[1] In other words, for a substantial part of the day, and this often three times a week, you are bound and immobilized by a complex machine which purifies tap water into dialysis water amounting to four hundred liters per treatment.

There are two main types of dialysis; haemodialysis (HD) and peritoneal dialysis (PD). Heamodialysis is an extracorporeal treatment employing a synthetic membrane as a filter. Peritoneal dialysis is an intra-corporeal treatment employing a natural membrane: the peritoneum which lines the walls of the abdomen and covers the internal organs. Peritoneal dialysis patients learn to a self-treatment and perform treatment at home. Rich Snyder advises home-based or nocturnal dialysis where possible.[2] A cleansing liquid is introduced through a catheter placed in the abdominal wall, ending in the pelvis behind the bladder. The cleansing liquid is removed from the body through the catheter together with the toxins and excess water. The main purpose of the book is the building of new dialysis clinics, and in some cases the refurbishment of

Fig. 1. Dialysis machine.

existing buildings. A lot depends on the amount of 'stations' and the needed floor space. A station is a dialysis chair with the machinery involved. More stations require more floor space. Floor space per square metre is related to building costs. The set up of the book is a good example of a functional analysis in architecture. It however equals out function with architecture. Activities in the building are grouped in functional areas, a quite normal way of working in architectural practices. In a dialysis centre you will need dialysis chairs (stations), medical rooms, patient and staff rooms, support services, the water treatment facilities, circulation spaces and the technical facilities like heating, ventilation and cooling. An important issue is surveillance of patients, there has to be a direct line of sight between the dialysis chair and the observation desk.

The site of the building is important too, where to locate a new building, or can we still use the old building and refurbish it. Questions that are on the conference table in every architectural practice, day in day out. The well being of patients and staff is dealt with too, the interior of the building should be friendly, harmonious and uniform, the authors write. The colors of furniture, wall covering and flooring are important. Colors should be clear, light and friendly. Pictures and paintings should not be complicated and should avoid illness. Natural light should be applied where possible, direct sunlight should be controlled as patients can be very sensitive to light. The way patients and staff members arrive and use the building is dealt with in flow diagrams, 'patient flow' and 'staff flow'. Also the goods arriving at the building are of the same order, 'goods flow'. The 'well designed dialysis room' is in all aspects a medical facility that we know of many modern hospitals. Vinyl, steel, digital screens beeping away, an air-conditioning you cannot control, a desk which controls you. Surveillance, floor spaces, flow charts, amount of stations per square metre, ventilation, cooling. But where is the patient? What is she experiencing in this facility where her blood streams through machineries? What kind of 'semiotic-material technologies' in Haraway's sense are put in place here? What kind of 'affordances' in J.J. Gibson's

Fig. 2. Dialysis chair.

sense do we have here? Do the bright colors really help her with her leg cramps? Is she looking at the pictures on the wall at all? What are you going to do in these hours, watch TV? Read a book? Can you see the gauges on the dialysis machine, see venous pressure, arterial pressure, trans-membrane pressure, the remaining time, yes, important since soon it will be over, your pulse rate, the blood from your body and back. How do all these 'spheres' of life support hang together? How does it all work? Don't we need a 'spherology' as in Peter Sloterdijk 's work.[3] What kind of 'well being' do the architects actually provide. Are they not interested in the 'machinery', the 'envelopes'. I do not think so, after all they are fully 'modern'. They are treating objects unfairly, Latour would say. By treating human life supports as matters of concern, "we pile concerns over concerns, we fold, we envelop, we embed humans into more elements that have been carefully explicitated, protected, conserved and maintained (immunology being, according to Sloterdijk, the great philosophy of biology).[4]

On my desk are three other more modest books; A View from the Chair by Thomas V. Carr, a book by Kathleen Russell, Dialysis Advice, A Patient's point of view and a book by Angelene Hall, Duck Summer, A Memoir. Carr is the founder and president of Patients4patients.org, a non-profit organization to help new patients adapt to life on dialysis. He is for sure on the side of the patient. Carr's booklet includes a 'Patient Bill of Rights', quality care is at the forefront. Russell wrote a booklet like Carr. Both are modest books, not well known publishers, affordable books. Russell became a well informed patient like Angelene Hall. Russell recommends to get familiar with the lab results and learn from your doctor or dietitian what you might be able to do to improve them. She writes, learn the terminology and compare each month's results with previous results. She mentions that she always gets cold during the treatment, resulting from the overhead air circulation ducts that blow towards her chair. She sometimes uses a screen to block the cold draft. Some dialysis centers have heated chairs and overhead heat, but blankets can help her too. Almost all patients have a problem with spending time in the chair, what to do? She invited many others in her view from the chair. Kathleen Russell's advice is, stay positive, happiness for her is a choice. Carr's advice is no different, remember to always smile, the better you feel about yourself, the better the day that lies before you, he writes. Hall has learned to navigate through "the demands of telephones and pagers, physicians (who) were short on reassuring conversations. Social workers, clutching notes on the patient's medications, don't know what to say to bring comfort, and technicians are trained to do their job, not to talk. As hospital personnel shuffle the patient from medical offices to registration stations to labs, none of them provide details about the scheduled services or show much concern about the patient's well-being. Nobody seemed to know anything and if they did, they weren't talking".[5] In the chair you can read, sleep, or watch TV, Russell brought her own DVD player and watching movies was her way to pass the time. She recommends signing up with a service like Netflix, film helps you to forget the time. It is like longer (inter) national flights, you have to find ways to sit through it. But in the end the flight is much easier. If the clinic is open twenty-four hours, you could consider nocturnal treatments. These longer treatments remove more toxins and fluids, and eliminate them more gently over a long period of time. In Snyder's unit where he does the rounds he has seen patients who were healthier and more energetic, needing less medication he writes. Treatments can last six to eight hours, during the day there is less time, treatments are shorter. But one has to spend three nights a week in a clinic, away from loved ones or family.

Returning to the view from the dialysis chair, we see this is also part of Haraway 's trope of technoscience, technoscience should not be narrated or engaged only from the point of view of those called scientists and engineers. Technoscience is heterogeneous, she writes.[6] We need to fore-ground the practices as the medical anthropologists Mol, Good and Prentice have shown us. The dialysis chair is not in the middle of different perspectives, the body, the patient, the disease, the doctor, the technicians, the technology: all of these are more than one. Also the chair or 'dialysis station' where you sit for hours. We need to know more about the comfort this set up of chair and environment, this little 'ecology', gives to the body and how it relates to Damasio's 'body maps' and Gibson's affordances. It is like an object as Byron Good understands the 'context', both physical, social and emotional of the patient. The optimism in both books by dialysis patients is understandable, dialysis might ruin your life, suicide is considerably more likely among dialysis patients, anger is also common.

There is a lot of waiting time. Many haemodialysis patients experience sexual problems and as many as 70% of men on dialysis may be impotent.[7] You will have to live with what your doctor calls your 'access', your fistula, graft or line to place needles into your body. A fistula is a direct connection between an artery and a vein, placed in your forearm. A graft is an indirect connection via an artificial tube placed between artery and vein. They are surgically created. Blood leaves via the fistula on the arterial line where pressure is monitored and alarm limits set for safety purposes. Your blood is fed to the dialyzer filter, across one side of the membrane. The dialysate (diffusion medium) prepared by the fluid unit is fed to the other side of the dialyzer membrane. Impurities from the dialyzer diffuse across the membrane and are transported down the waste/drain. Purified blood is then returned to the patient on the venous line.

With every entry into the facility your blood pressure, pulse rate, temperature and weight will be checked and rechecked when you leave. And even entering a building can be a problem. Let me quote again the third booklet, the educated patient, Angelene Hall. She informed herself before treatment. "When I arrived at the hospital around 5:15, several people lingered outside the hemodialysis unit waiting to go in, but the automatic doors weren't working. Those in wheel chairs generally showed no expression, as if this were just a typical morning. A few slept on gurneys with their hands folded across their stomachs, or along their sides, while fluid dripped into the IV. Others leaned against the smudged green wall, apparently not caring if the doors opened or not. As for me, I wanted to twitch my nose like the character on the old television series, "Bewitched", and make the whole scene vanish".[9]

References

1 Dialysis Centres, An architectural guide, p 10.

2 Rich Snyder, What you must know about dialysis, p 157.

3 Peter Sloterdijk, Spären I, Blasen and Sphären II, Globen.

4 Bruno Latour, A Cautious Prometheus? A Few Steps Toward a Philosophy of Design (with special attention to Peter Sloterdijk), keynote lecture for the Networks of Design meeting, Falmouth, Cornwall, 3rd September 2008.

5 Angelene J. Hall, Duck Summer. A Memoir. My odyssey as a dialysis patient, p 72.

6 Donna Haraway, op. cit. p 50.

7 Andy Stein and Janet Wild, Kidney Dialysis and Transplants, p 123.

8 Frank Sikapa, Clinical Technologist Companion, p 2.

9 Angelene J. Hall, Duck Summer. A memoir. My odyssey as a dialysis patient, p 66.

The Lure of Technology and The Task of the Architect[1]

Jasper Cepl

John F. Kennedy, in his Inaugural Address delivered in January 1961, urged his "fellow Americans" to get their priorities right, when he proclaimed, "ask not what your country can do for you — ask what you can do for your country."[2] Likewise, but with a twist, I'd like to encourage my fellow architects: Ask not what you can do for technology — ask what technology can do for you.

Too often it's the other way around: It seems those immersed in the Digital have surrendered to its rule, but no longer seem to ask what the Digital can do for them — or rather: for architecture. Because it does do a lot for them: It propels them to fame, and that seems to be what it is ultimately all about. For instance, if we are to believe the CV published in Rivka and Robert Oxman's Theories of the Digital in Architecture, Greg Lynn is one of the ten most influential architects worldwide (according to Forbes).[3] Assuming this CV was provided or at least sanctioned by Lynn, we may ask: Isn't that a bit preposterous? Well, certainly not as preposterous as Patrik Schmumacher's claim that there was "a solid new hegemonic paradigm" — parametricism.[4] But no further comment is needed here, suffice to say: In this power game, getting your name in the history books — as the first or at least the most radical — seems to be real objective of this self-proclaimed avant-garde.

But the forms they propose aren't even new. Or at least they don't excite me. They remind me of Hermann Finsterlin's visions (fig. 1), which were rightly condemned by Le Corbusier, who described them as "viscous ejaculations recalling underwater horrors"[5]. Are we better off, now that the "hell of Finsterlin"[6] can be built? I doubt it. I'll subscribe to Le Corbusier, still, anytime; and add that there is more than poetry in the right angle. Euclid is in all of us, his geometry cannot be overcome. At least, I, personally, prefer to have myself, that is: my body, mind and soul, taken into account in architecture. As a human, I am still walking on the face of this earth with my back straight, setting one foot before the other, looking at the world in front of me. I don't want to feel like an amoeba swimming in the body fluids of some strange animal. In short: The forms that are now feasible do not seem desirable to me. I find them awful. Why would I want to wade through a city made of the remnants of disembowelled animals, through a nightmarish quagmire of intestines, through buildings seemingly made for spineless worms, through forms that I find nauseating rather than exciting?

But there is hope: We may have moved beyond a first wave of naïve formalism, especially with digital manufacturing on the horizon. There is a lot of talk about mass customization, digital printing, robotics, and whatever else; much less on formal "innovation" (a word I put in brackets because I think it makes no sense). Though new temptations may arise, as advances in production technology expand what can be built, with attention shifting to actually building, the worst may be over. Chances are, we now enter a new phase in which the architect also turns into a "maker" and focuses on that.

On the horizon may be what some consider a new area of craftsmanship. Or rather a renaissance thereof: Architects had been craftsmen before. Take medieval masons, for instance. It seems there is reason to believe that such a time will come again, thanks to digital fabrication. At least that seems to be the hope of those engaged in the area. So, the architect may again be able to merge designing and building, like a medieval mason. But does this set him on par with a craftsman of old?

In an attempt to clarify this, I'd like to ask: What is, or was, a craftsman? One answer may be: He is someone with expertise both in conceiving and producing things, and he knows from experience what to produce and by which means. Being the master of a craft means: Getting the thing perfectly right, and right away, without having to research the proper way to do it. There is little experiment or Weltanschauung involved — as is highlighted in Karl Arnold's caricature (fig. 2) on the quarrel between Muthesius and van de Velde over type vs. art, which had stirred up the Werkbund conference of 1914. To the right, it shows the craftsman, the "master carpenter Heese" who had produced "the chair to sit on", whereas van de Velde had created the "individual chair" and Muthesius the "type-chair" – both had created a problem that had not existed for the

Fig. 1. A page from the 1924 issue of Wendingen dedicated to the work of Hermann Finsterlin, which led Le Corbusier to condemn Finsterlin's designs as "viscous ejaculations recalling underwater horrors". From: Wendingen, series 6, 1924, no. 3, p.12.

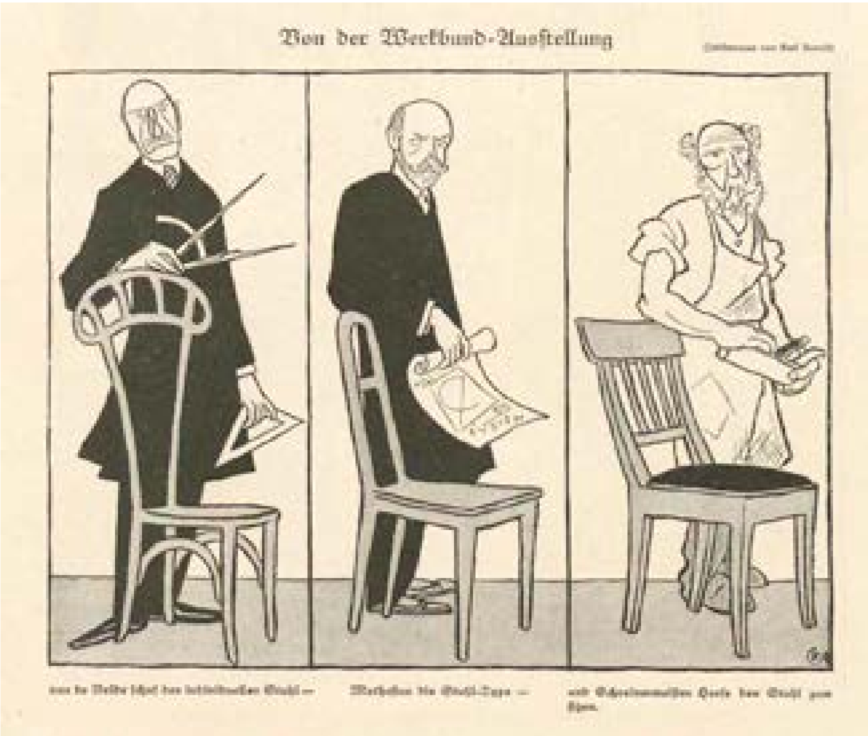

Fig. 2. A chair turning into a problem of Weltanschauung. Karl Arnold's caricature on the quarrel between Muthesius and van de Velde over type vs. art; showing the "master carpenter Heese" who had produced "the chair to sit on" — in contrast to van de Velde and Muthesius, who had created the "individual chair" and the "type-chair", respectively. Both had created a problem that had not existed for the craftsman. From: Simplicissimus, vol. 19, no 18, p. 285.
www.simplicissimus.info/uploads/tx_lombkswjournaldb/1/19/19_18_285.jpg

craftsman.

While the craftsman, too, will certainly reconsider his approach before producing something more complicated or uncommon, he generally relies on a kind of tacit knowledge that goes without much intellectual fuss, and without much uncertainty. Craftsmanship is about traditions and conventions. The craftsman's knowledge is accumulated over generations and passed on from a master to an apprentice, who stays with the master to learn what he knows — he won't be asked to challenge conventions (as students are told to do in architecture school).

The same problem is addressed in Adolf Loos's "Es war einmal ein Sattlermeister" (Once there was a master saddle maker), published in the second issue of Das Andere, in 1903. In this little satire, meant to show the stupidity of the 'Secession', the saddle maker approaches a "professor", obviously Josef Hoffmann, to ask him if his saddles were modern. After being told that his saddles were not, the saddle-maker is devastated. The professor tells him that he lacked "imagination". To help him, the professor offers to have his entire class work on the problem, and he himself also provides a number of designs. After just one day, the saddle maker is presented with forty-nine designs for modern saddles. The saddle maker carefully examines them. In the end he is much relieved and he exclaims: "Professor, if I understood as little about riding, about horses, about leather and about workmanship as you do, then I would also have your imagination." He realises that he is in fact looking at the Emperor's new clothes. And, so the story goes, he walks away, and "lives happily and content." Loos closes: "And he makes saddles. Modern ones? He does not know. Saddles."[7]

Well, making saddles, though still a craft in existence, may not concern us anymore. The saddle-maker, depicted here as a kind of noble savant, is hard to relate to. But since it will generally be difficult to find a 'craft' that hasn't lost its importance, we may have to settle for a somewhat faulty comparison to continue this line of inquiry: To look at a 'craft' still widely in use, let's take a musician and consider him a craftsman. Even if he does not produce anything, a musician may help to get the point across.

Playing an instrument is a highly-advanced craft. There is no doubt about how to play, say, the piano, or how to learn it. There may be nuances in technique, but no one would argue that there could or should be an entirely new way of playing the piano, or that the way the piano is played today (or the instrument itself) is no longer up to date. In music, we still have an understanding of craftsmanship that architecture has long lost. You cannot reinvent piano playing, and you wouldn't want to. (Exceptions prove the rule.)

Admittedly our problems are more complex and as they are also shifting all the time, it's hard for any kind of traditional approach to persist. And some may argue that you can't really compare a musician and an architect anyway, because the former merely reproduces while the latter comes up with plans for others to reproduce. So maybe a composer makes for a better comparison. And, of course, there is less unity in composing than in performing. There are lot of different kinds of composers and compositions. So maybe comparing the musician and the architect was not such a good idea after all. But the comparison, while faulty, may still prove helpful. If it shows that the architect is not a craftsman in the end.

Another look at music may further clarify this. An aspiring musician must practice for years to master an instrument. There is a study claiming that top musicians have an average of 10,000 hours of practice behind them;[8] many of them more, as this is an average, and not the golden rule (which got popularized by Malcolm Gladwell, who made use of the argument in his popular Outliers).[9] If we, for the moment, accept the idea of 10,000 hours of practice — knowing that the comparison is superficial — it means that you must practice for 1½ hours every day, 365 days a year, for almost 20 years. Now, of course, if you were to sit beside your robot for 8 hours per day, 365 days a year, you would have spent the same amount of time in less than 4 years.

But apart from the fact that you cannot compress 20 years of practice that way

— playing an instrument 8 hours a day for 4 years won't let you mature in the same way — the 'maker' faces another problem unknown to a musician, who, while knowing it will take him years to master an instrument, does know where he will get in the end. This cannot be said of the 'maker-architect' in question. He cannot know where he will get in 20 years, or in 4 years for that matter — simply because there is no such thing as a craft to grow into. And I doubt there will be one in the future. Digital manufacturing will, without doubt, become more commonplace, but I don't quite see a new kind of craftsmanship on the horizon. And, given the fact that craftsmanship is overtly conventional, architects may not even want that after all. At least it would be against the grain, as there seems to be but one convention in architectural discourse, and that is: to be unconventional. Reiser + Umemoto make this perfectly clear in their Atlas of Novel Tectonics (fig. 3): To be "interesting" you better be "unconventional".

In architectural discourse, the idea of convention is widely avoided. Which is stupid, or at least insincere, because you inevitably call for conventions as soon as you try to establish criteria such as these. Though this is seldom acknowledged from within, there is as much convention in the 'avant-garde' as anywhere else. It can't be any other way. Any peer group, including the digital avant-garde, will need conventions to establish some common ground. But unintentionally upholding a convention of unconventionality can never be a good idea. With convention as a blind spot, you're bound to discard all common sense and to chase shadows instead.

But this is off topic. Back to the 'maker': Using a 3D printer, or any other such tool, does not turn him into a craftsman, nor does it allow for the kind of mastery a musician may gain through practice. Instead, for quite some time to come, he will be struggling with his new tools, and as they are ever-developing, he will always be a bit behind in coming to grips with them.

Yet, with the Digital seemingly taking hold of everything, ever greater expectations arise. Jeremy Rifkin has even declared the advent of the "Zero Marginal Cost Society", dreaming of "prosumers" who will change the way our economy works.[10] Whether this vision will ever become reality does not matter much (I doubt it). Even if things may soon be produced much cheaper, what does get more expensive is the cost for the machines themselves. Not only for producing and maintaining them, but also for developing them. Hence, we may enjoy new freedoms in realizing forms, which could not have been produced before, but at the same time, like never before, we depend on those providing us with tools.

While the architect may happily enjoy his new independence, he shouldn't forget that there are now more and more engineers behind him. They may no longer be needed in the conception and production of the buildings themselves, but they are now the ones providing the architect with tools he cannot himself conceive or produce. Architecture and engineering may no longer be two disciplines destined to cooperate in the actual process of building. Instead we get an opposition of tool-users and tool-makers. We may thus get to a new division of labour between architect and engineer. But that will not make us architects more autonomous. On the contrary: We will rely on an industry providing us with the tools we need.

In the process, we may get rid of some middlemen. That may allow us to produce an architecture we'd never get if we still had to rely on the skill of construction workers, which are no longer the artisans they once were. Yet some say: What if the architect is the middleman who becomes superfluous? What if he is made expendable by automations in design and construction? That shouldn't worry us. It simply overestimates what can be done with AI, which will essentially remain imitative. What should concern us is how we get carried away by the prospects offered by the Digital. Staring at the Digital, all else escapes attention or is distorted. The future seems all shiny and bright. But is not the Architect there to make our lives worth living today, as we are living them? We lose sight of the present, in which we have to build with the means at our disposal now.

I do acknowledge that, in the realm of academic research, you have the opportunity,

Fig. 3. Conventional unconventionality, according to Reiser + Umemoto: "conventional / less interesting — unconventional / interesting".
From: Reiser + Umemoto, Atlas of Novel Tectonics, New York: Princeton Architectural Press, 2006, p. 118.

or even the responsibility to try things that could not be done in the real world, because they are too expensive, untested, time consuming, and so on. But I'd maintain that practice is something altogether different. Those who want to get something real built cannot and should not go about their business as if it was research. We have to put up buildings here and now, in the hope to improve our lives, and not to experiment with tools for some unforeseeable future.

That — apart from the fact that most of the forms now on vogue are simply misconceived — is why I posit that we should be wary of willingly giving ourselves over to the whim of those luring us with all sorts of exciting prospects. We cannot wait for the 3D-printed or robot-assembled house, or whatever else is on the horizon. But if we spend our time struggling with some algorithms or some complicated machinery instead of considering the task of building in all its complexity of societal, environmental, technological, and aesthetic concerns, we are, in the end, but procrastinating.

So I wonder: Is the 'Digital' all that counts? Does it render all architecture, which does not try to make use of the newest of the new, irrelevant? Do you have to use 'progressive' technology to be recognized as a 'progressive' architect? I'd say: Design whatever you want — and not what technology suggests. Finding out what to want should be the architect's concern: His task is to find a balanced approach worthy of the responsibility given to him. Pushing the limits of technology does not rank among the pressing issues he should be concerned about. Technology, in itself, does not force you to use it — if does not help you, don't use it. If you don't use it: don't worry. You can still be a good architect. Know your tools (and ask what they can do for you). Do not ask what you can do for them.

References

1 This essay is based on my contribution the conference "Computation, Craftsmanship, Crisis", organised by Lara Schrijver, held at Dessau in July 2014, and on notes prepared for the "Digital Dialogue" that took place in Dessau in December 2015.

2 Transcript available at: www.jfklibrary.org

3 See Theories of the Digital in Architecture, [edited by] Rivka Oxman and Robert Oxman, London and New York: Routledge, 2014, p. xii

4 Patrik Schumacher, "Parametricism: A New Global Style for Architecture and Urban Design", Architectural Design, July/August 2009 (issue on "Digital Cities", guest edited by Neil Leach), pp. 14–23, here p. 15

5 Le Corbusier, writing under his pen name Paul Boulard, in: L'Esprit Nouveau, no. 25, 1924. Quoted in: Charles Jencks, Le Corbusier and the Continual Revolution in Architecture, New York: The Monacelli Press, 2000, p. 126

6 Ibid., p. 127. Jencks's translation may be a bit too strong. Le Corbusier's "les enfers" may more appropriately be translated as "the underworld".

7 Adolf Loos, "Es war einmal ein Sattlermeister", in: Das Andere: Ein Blatt zur Einführung abendländischer Kultur in Österreich, no. 2, 1903, pp. 1–2. Translated by Eduard Sekler in his "Research and Criticism in Architecture", Journal of Architectural Education 12, No. 2 (Summer 1957), pp. 31–32, here p. 31

8 K. Anders Ericsson, Ralf Th. Krampe, and Clemens Tesch-Romer, "The Role of Deliberate Practice in the Acquisition of Expert Performance", Psychological Review 100, 1993, pp. 363–406

9 Malcolm Gladwell, Outliers: The Story of Success, New York: Little, Brown and Company, 2008, chapter 2: "The 10,000-Hour Rule"

10 Jeremy Rifkin, The Zero Marginal Cost Society, New York: Palgrave MacMillan, 2014

Adaptation

Neil Leach

Adaptation can be seen to be intrinsic to the survival of any organism. Indeed, arguably adaptation can be read as the primary logic that underpins life itself. The natural world has evolved and survived as a result of adaptation. We can see adaptation at work in microorganisms, as flu viruses adapt to vaccines. We can see adaptation at work in creatures—most notably creatures such as the chameleon or the mimic octopus—as they physically adapt to their environment. We can see adaptation at work in nature on a large scale, in the complex adaptive systems of aggregations of individual agents such as the swarm behaviors of flocks of birds or schools of fish. And we can see adaptation at work in human beings. Indeed—according to some theoretical perspectives—human beings are constantly evolving psychic entities that are continually absorbing external impulses. Human beings should therefore be understood as mutant creatures, continually adapting and mutating as part of the natural struggle for survival.

This raises an interesting question about architecture. If human beings are constantly evolving, mutant creatures, what role does adaptation play in architecture? Clearly we can detect two related forms of adaptation between human beings and their buildings, whereby buildings have evolved in response to impulses of human beings, and human beings themselves have been conditioned by their environment. As Winston Churchill once said, "We shape our buildings, and afterwards our buildings shape us."[1]

Indeed the history of architecture can be read as a history of the relationship of human beings to their buildings. Attempts to relate the proportions of buildings to the those of the human figure—from Vitruvius and before, through to Le Corbusier and other more recent architects—are part and parcel of this history. And beyond straightforward proportions, there have been other attempts to relate the form of buildings to the physiognomy of the human form, as in the inscription of traces of human features into architectural designs of Michelangelo and others.[2] From antiquity onwards, the incessant urge to embody the human into architectural design—either through a deep relationality based on shared proportional logics or through the incorporation of aspects of the human figure in building forms—points towards this need to identify with buildings.

But what exactly underpins this urge for human beings to relate to their buildings? Why would architects seek to produce buildings that relate to the human body? Any attempt to relate the form of a building to the form of a human must emanate from some deeper psychological desire to establish a perceived connection between human beings and their environment. This article explores this psychological desire in relation to the adaptation between human beings and their physical environment in terms of two kinds of adaptation— "autoplastic adaptation" and "alloplastic adaptation." It outlines the urge for human beings to adapt to the physical environment around them, and then asks whether the growing potential for buildings to adapt to their users might point towards an important psychological role for interactive architecture.

Autoplastic Adaptation

"Autoplastic adaptation" is a psychological term developed by Sigmund Freud, Sándor Ferenczi, Franz Alexander and others. "Autoplastic adaptation" refers to attempts on the part of the subject to adapt to the external environment, when faced with a difficult situation.

An obvious example of autoplastic adaptation happens in a prison, where inmates adapt psychologically to their environment—and even derive comfort from that environment, no matter how inhospitable it might be—much as victims of kidnapping can develop "Stockholm Syndrome" and form a bond with their captors. In the Alcatraz Penitentiary, for example, one inmate, Leon "Whitey" Thompson, began to bond with his cell so closely, that he felt that he became part of it, as much as the cell became part of him: "I knew every mark, every thing in that cell. And pretty soon that cell became like part of me or I became a part of the cell. I couldn't visualize living anywhere else in the prison than in my cell. It was like coming back and greeting an old friend really, because it was part of me."[3] Equally there is the famous story of Nelson Mandela who—after his

Fig. 1. Francesca Woodman [courtesy of the Francesca Woodman Estate],
illustration taken from Leach, Neil. Camouflage. 2006. Camb., MA: MIT Press. Woodman.

release from Paarl Open Prison in South Africa—commissioned an architect to design him a replica of the bungalow in which he had been kept under arrest, on the basis—presumably—that he had grown to feel at home in that environment.[4] Such incidents seem to manifest extreme examples of the human desire to either find a familiar space for a home or to familiarize oneself with the unfamiliar.

Of course we can cite frequent examples of "memes" within culture where physical resemblance can spread by a logic of copying—whether it be through fashion, catchy tunes or simple verbal expressions.[5] But it is interesting to see what lies behind this urge to blend in and conform to the behaviors of others from a psychological perspective.

The book Camouflage traced out a line of enquiry that looked beyond the physical resemblance of human beings to their buildings, and charted an alternative approach that interrogated the psychological urge to assimilate and adapt to one's environment.[6] The central theory in this research was that of mimesis. Here mimesis is understood not in terms of standard "imitation," as used by thinkers such as Plato—a process that inferred an allegiance to an originary model that infers that the original is always superior to any imitation of it. Rather, mimesis should be perceived as a creative act of assimilation, where an individual can approximate him or herself to a given model, and incrementally assimilate to it without ever becoming identical with it.[7]

Mimesis is a psychological term, emanating from observations of Freud about the process by which we can identify with other people.[8] Walter Benjamin and Theodor Adorno then develop it as an aesthetic concept that can be used to explain how human beings identify with the world around them. Benjamin, for example, uses it to explain how children can identify with their surroundings during a game of "hide-and-seek" to such an extent that they need to utter a shriek of self-deliverance in order to escape from being trapped forever in their hiding place:

"Standing behind the doorway curtain, the child becomes himself something floating and white, a ghost. The dining table under which he is crouching turns him into the wooden idol in a temple whose four pillars are the carved legs. And behind a door he is himself a door, wears it as his heavy mask and as a shaman will bewitch all those who unsuspectingly enter. At no cost must he be found. When he pulls faces, he is told, the clock need only strike and he will remain so. The element of truth in this he finds out in his hiding place. Anyone who discovers him can petrify him as an idol under the table, weave him forever as a ghost into the curtain, banish him for life into the heavy door. And so, at the seeker's touch he drives out with a loud cry the demon who has transformed him—indeed, without waiting for the moment of discovery, he grabs the hunter with a shout of self-deliverance."[9]

Benjamin sees mimesis as operating ideationally through the medium of words, but these words open up the possibility of an identification with physical objects such as furniture and even buildings:

"In time I learned to disguise myself in words, which were actually clouds. For the gift of seeing likeness is nothing but a weak vestige of the old compulsion to become and act like something else. But words exercised this coercion on me. Not those that made me resemble models of good behavior, but those that made me like dwellings, furniture, clothing."[10]

The term is then picked up by Adorno who goes on to explore its potential of relating to the physical environment through a more visceral form of identification:

"According to Freud, symbolic intention quickly allies itself to technical forms, like the airplane, and according to contemporary American research in mass psychology, even to the car. Thus, purposeful forms are the language of their own purposes. By means of the mimetic impulse, the living being equates himself with objects in his surroundings."[11]

Importantly, for Adorno mimesis operates as a form of "sensuous correspondence" between the individual and the environment, and we must therefore distinguish between forms that have the capacity to induce that correspondence and those that do not As such, it is clear that mimesis infers a degree of aesthetic relationality that depends on the sensuousness of the design itself. The message is simple: there is an underlying desire in human beings to relate to their environment, and if we are to produce an environment that is able to foster such a relationship it needs to be sensuously designed.

The term mimesis therefore opens up a way of understanding how human beings begin to equate themselves with their environment, but also how they come to absorb external forms into the designs of buildings, so that others can relate to them:

"It is through the mimetic impulse that human beings absorb external forms, incorporate them symbolically into their self-expression, and then rearticulate them in the objects they produce. . . Architecture, along with the other visual arts, can therefore be viewed as a potential reservoir for the operation of mimesis. In the very design of buildings, the architect may articulate the relational correspondence with the world that is embodied in the concept of mimesis. These forms may be interpreted in a similar fashion by those who experience those buildings, in that the mechanism by which we begin to feel at home in the built environment can also be seen as a mimetic one."[12]

Alloplastic Adaptation

Alongside "autoplastic adaptation," Freud, Ferenczi and Alexander also developed the notion of "alloplastic adaptation." Whereas autoplastic adaptation refers to the urge on the part of the subject to adapt the self to the environment, alloplastic architecture refers to the urge on the part of the subject to make the environment adapt to the self—again when faced with a difficult situation.

We might therefore also consider the capacity of humans to make their environment adapt to them, as a necessary extension and corollary of the logic of mimesis—the capacity of human beings to adapt to their environment. These two logics can be seen within a dialectical framework as the opposite of each other. Yet both logics depend upon adaptation—the adaptation of the self to the environment, and the adaption of the environment to the self—and both effect a form of identification. For any form of identification to take place there must be some form of equivalence—between one animate object and another, or one inanimate object and another:

"One of the assumptions in the identificatory moment of assimilation is that, as animate creatures, we can somehow equate ourselves with our inanimate architectural surroundings. This introduces a distinction between life and death, animate and inanimate. Either we "play dead," and become inanimate like our surroundings, or we animate those surroundings, and make them like ourselves. These processes may be interpreted through the discourse of psychoanalysis, for which the life and death instincts remain fundamental impulses. It is the distinction between Medusa, who turned everything that met her gaze to stone, and Daedalus, who reputedly had the capacity to bring statues to life."[13]

We might therefore posits two dialectically related logics:

1. The urge for animate humans to become inanimate like the inanimate world of buildings around us.
2. The urge for animate humans to "animate" the inanimate world of buildings.

Indeed this reciprocal process of adaptation is already hinted at by Michael Taussig, who describes mimesis as "the art of becoming, of becoming other."[14] The theory of mimesis therefore invites comparison with the concept of "becoming" as championed by Gilles Deleuze and Felix Guattari. The most notable example of "becoming" offered by Deleuze and Guattari, is perhaps that between a wasp and an orchid. Here the orchid entices the wasp through its nectar, and the wasp is thereby coopted into helping to cross-pollinate the orchid.[15] This is an example of co-adaptation, whereby the wasp has adapted to the orchid, no less than the orchid has adapted to the wasp. Wasp and orchid serve each other's mutual interests.

What the theory of "becoming" begins to suggest is that alongside the potential—outlined in the theory of mimesis—for humans to assimilate to their environment, there is also the potential for the environment to assimilate to the self. But how are we to understand the potential identificatory mechanisms in animating the

Fig. 2. Behnaz Farahi, "Alloplastic Architecture," installation, tutored by Alvin Huang, Neil Leach, Michael Fox; a performance artist dances with the
any actual physical contact. A Kinect motion sensor device tracks the movement of the dancer, and thereby reconfigures the entire structure throug
Shape Memory Alloy [SMA] springs; MVI_1494.MOV.Still001.bmp

structure that reacts to her presence without
h the use of an Arduino control board and

Fig. 3. "Alloplastic Architecture"; MVI_1494.MOV.Still008.bmp

inanimate? Indeed, how is it even possible to animate the inanimate?

In Camouflage the argument is made that such animation may operate solely in the mind. It follows the logic of the work of Jacques Lacan, in arguing that there is a basic form of "animate knowledge" that structures the way the human mind operates. For Lacan sees knowledge as grounded in a form of "primordial anthropomorphism," and questions "whether all knowledge is not originally knowledge of a person before being knowledge of an object, and even whether the knowledge of an object is not, for humanity, a secondary acquisition."[16] We can therefore recognize an animating tendency behind this anthropomorphizing urge to see things as humans before we see them as things. This could be compared to the animating desire of the paranoiac to animate the inanimate, such that walls have ears and eyes. We might therefore detect in Lacan's work a desire for what we might call "paranoid knowledge," that could itself be compared to the creative potential of Dalí's famous "paranoid critical method":

"'Paranoid knowledge' emerges out of an anthropomorphizing urge that is the foundation of all knowledge. At its most extreme, it can manifest itself in the literal anthropomorphization of building forms, as in the "paranoid critical vision" of Dalí, who sees the skyscrapers of New York come alive at sunset, "ready to perform the sexual act." In its more subtle forms, however, it simply means that we can forge attachments to buildings as though they are human beings."[17]

If the term "paranoid knowledge" seems too extreme, the alternative term "animate knowledge" could be adopted, a term that is stripped of the negative associations of paranoia, and yet retains the animating potential of that condition. As such, "animate knowledge" might explain the all too common urge to anthropomorphize the external world and thereby animate the inanimate environment. It might therefore be understood as an alternative mechanism of identification between the self and the environment:

"The act of making the world like the self is equivalent to the act of making the self like the world. Both involve a play between the animate and the inanimate, and both ultimately serve the same ends. Once the inanimate world of architecture has itself been animated, identification can take place. We can therefore understand animate knowledge as the corollary to assimilation. It marks the capacity not to make the self like the other, but to make the other like the self."[18]

But how are we to adapt this theory in the light of recent explorations into interactive environments? For sure, it would seem that a whole new logic of animated construction has opened up recently, largely as a result of the commercial availability of devices such as sensors, Arduino control boards, servos, smart materials such as shape-memory alloys, and readily available popular devices such as Kinect that can be re-appropriated and used to monitor the behavior of humans in interactive installations.

What these devices offer is the possibility not only of the environment being "imagined" as animate—as in the logic of paranoid knowledge—but of it actually becoming animate. Moreover, if we consider projects such as Behnaz Farahi's "Alloplastic Architecture" interactive installation, we can see that the use of a dynamic tensegrity structure can "mimic" human behavior, in that the human body itself can be seen to be a form of tensegrity structure, with bones acting as compressive members, skin and other tissues as passive tensile members, and muscles as active tensile members.

Here I want to suggest that a new chapter is opening up within the field of architecture that has two fundamental impacts on previously assumed givens within the world of design.

1. The introduction of activation devices that change the shape of an architectural environment—or "animate" it, to keep to our earlier language—according to the movement of the users, employing a secondary series of devices that track the movement of those users, offer the potential of "animating the inanimate" beyond the psychological tendency to perceive the inanimate world in animate terms.

2. These technological developments

Fig. 4. "Ferrofluid", Arusyak Manvelyan, Kate Shelegon, Alexander Amirov, DIA, tutored by Neil Leach, Alexander Kalachev, Karim Soliman; a Kinect device tracks human motion and through the use of robotic vehicles controls the patterning of ferro-fluids on a screen; pattern formation.

challenge the still popular assumptions that technology is alienating by establishing that—far from inducing alienation—technology has the potential to overcome it.

But most importantly of all, perhaps, this begins to suggest that there is a significant psychological role that interactive architecture might play to undermine the potential alienation of human beings from their environment. For if we assume that the urge behind "autoplastic adaptation" is to adapt the self to the environment—a process that will happen, as we have seen, even in extreme environments such as prisons—it is the role of design, surely, to facilitate that process. Design, in other words, can help us to feel at home in, and become part of, our environment. Design in this sense should be seen in static terms as the design of architectural forms. By extension, the urge behind "alloplastic adaptation" is to make the environment adapt to the self. While some kind of fantasy of adaptation—one that operates in the mind—can be promoted through the development of techniques such as the "paranoid critical method" championed by Dalí, true adaptation must surely depend on actual physical adaptation. Here, then, we are addressing not form but formation—the adaptation of form—and the development of a material behavior that might reflect and resemble the behaviors of the human body. If then we can devise environmental behaviors that make the subject feel more at home within a space, does it not suggest that one of the most significant contributions of interactive architecture might be not within the physical realm but the psychological one? As such, might not the most significant potential contribution of interactive architecture be not as some form of environmental control system—as some have supposed—but rather as a sociological mechanism that promises to create a more hospitable environment, more in keeping with the human condition?

Fig. 5. "Ferrofluid", kinect detector.

References

1 http://www.winstonchurchill.org/learn/speeches/quotations, accessed 4/09/2013

2 Here we might also cite the famous image of the architects' fancy dress party in the "Fête Moderne" ball that Rem Koolhaas includes in Delirious New York, where William van Allen, dressed up as his design for the Chrysler Building, clearly wins the contest (Pencil Points, February 1931, p. 145, quoted in Koolhaas, Rem. 1994. Delirious New York. New York: 010 Publishers. 129). This scene has been reevoked recently in Vanity Fair, with images of Michael Graves and Peter Eisenman impersonating their buildings (Mary McLeod, Mary. 1996. "Everyday and 'Other' Spaces," in Architecture and Feminism, edited by Debra Coleman, Elizabeth Danze, and Carol Henderson. Princeton: Princeton Architectural Press. 26). See also Louis Hellman's Archi-têtes, where architects are portrayed in sketches composed of elements of their own projects, to illustrate this desire (Hellman, Louis. 2000. Archi-têtes. London: Academy, 2000).

3 Leon "Whitey" Thompson, Alcatraz Cellhouse, audio tour produced by the Golden Gate National Park Association.

4 See Neil Leach, Camouflage, Camb., MA: MIT Press, 2006, p. 5.

5 See Richard Dawkins, The Selfish Gene (Oxford: Oxford University Press, 1989), p. 192.

6 Neil Leach, Camouflage, Camb., MA: MIT Press, 2006

7 Such an approach, of course, is in direct opposition to the work of certain ontological or phenomenological thinkers, such as Martin Heidegger, for whom the world is largely already formed, and for whom the creative work of art is simply a "revealing" of that already existing truth. Not only does the theory of mimesis challenge such an approach that valorizes the existing—by allowing for the creative potential for mimesis to actually improve upon the original model—but it also challenges the "given" nature of the world as assumed by Heidegger. The concept of mimesis, then, can be understood as an overcoming of the limitations of Heideggerian thought. It argues that the world is continually in flux, and any framework that assumes a static outlook on existence is necessarily at fault in that it fails to account for the capacity for all kinds of life forms to adapt as a necessary precondition of survival.

8 In his Book of Jokes, Freud describes the process of empathizing with the subject of a joke—for example, with someone slipping over a banana skin: "When, now, I perceive a movement like this of greater or lesser size in someone else, the securest way to an understanding (an apperception) of it will be for me to carry it out by imitation. . . . But actually I do not carry the imitation through, any more than I still spell words out if I learnt to read by spelling. Instead of imitating the movement with my muscles, I have an idea of it through the medium of my memory-traces of expenditures of similar movements." (Freud, Sigmund. 1905. Jokes and Their Relation to the Unconscious, translated by James Strachey. London: Routledge, 1960, 191-192). Crucially then it is through our memories of the slipperiness of banana skins and the process of slipping that we can put ourselves in the position of that person, and empathize with their predicament, while always maintaining a critical distance that allows us to laugh at that individual. Freud observes that the principle might be useful in understanding aesthetics: "I believe that if ideational mimetics are followed up, they may be as useful in other branches of aesthetics . . . " Freud, Jokes, 193.

9 Walter Benjamin, One-Way Street, trans. Edmund Jephcott and Kingsley Shorter (London: Verso, 1979), p. 74.

10 Benjamin, Walter. "A Berlin Childhood," in Reflections, 417, as quoted in Weber Nicholsen, Shierry. 1997. Exact Imagination, Late Work: On Adorno's Aesthetic. Cambridge, MA: MIT Press, 143.

11 Adorno, Theodor W. "Functionalism Today," in Leach, Neil, ed. 1997. Rethinking Architecture. London: Rout ledge, 10.

12 Leach, Camouflage, 45.

13 Leach, Camouflage, 168.

14 Taussig, Michael. 1993. Mimesis and Alterity. London: Routledge, 36.

15 In Camouflage the assumption is made, however, that the wasp being referred to is the Digger Wasp (Gorytes mystaceus and Gorytes campestris) and the orchid is the fly orchid (Ophrys insectifera), and that there is mutual interaction in a form of pseudo-copulation, whereby the wasp is attracted not by nectar but by the simulation of sexual activity. See Leach, Camouflage, 84.

16 Lacan, Jacques. 1975. De la psychose paranoïague dans ses rapports avec la personnalité, followed by Premiers écrits sur la paranoia. Paris: Éditions du Seuil, 326, as quoted in Borch-Jacobsen, Mikkel. 1991. Lacan: The Absolute Master, translated by Douglas Brick. Stanford, CA: Stanford University Press, 57.

17 Leach, Camouflage, 160.

18 Op.cit.

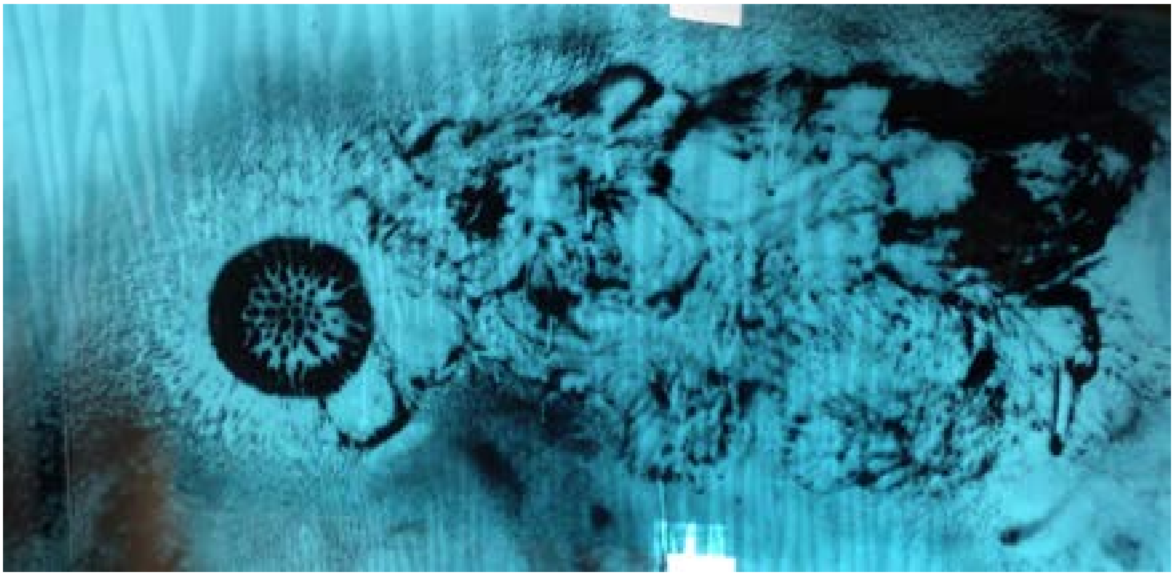

Fig. 6. "Ferrofluid", final result.

Cybernetification II: Toward a sixth ecology

Liss C. Werner

Digital infrastructure and learning algorithms, digital industry and automated services, digital society, humanities, and health converge with the Anthropocene. This mix has given birth to extraordinary challenges; for architecture as discipline, in its role as cultural heritage and as materialized co-evolution of man and machine. Despite of re-modelling and re-designing work-flows to integrate data necessary to arrive at a structurally and energetically 'good' piece of architecture, or rethinking an IoT (Internet of Things) supply chain management from planning via production to construction of a building or city and its performance monitoring, the digital has impacted our 20th century our long-standing relationship to architecture, technology and nature. This chapter suggests first ideas of a sixth ecology – influenced by Felix Guattari's "The Three Ecologies"[1, 2] Reyner Banham's "Theory and Design in the First Machine Age"[3] and Benjamin Bratton's "The Stack"[4]. The Sixth Ecology describes one of and for a dynamic relationality across systems; multi-parametric, functionally adaptable, morphologically changing, cybernetic. One, where man, machine, technology and 'nature' merge – or speaking for architecture: designer and computer, builder and robot, planner and construction factory, construction site and biologically grown habitats. In 1958 Gilbert Simondon states that "culture has become a system of defence designed to safeguard man from technics. This is the result of the assumption that technical objects contain no human reality."[5, 6, 7] Vaucason's 18th century automaton the defecating duck[8, 9] describes a cornerstone for the beginnings of humanification of mechanical technical objects. The rise of digital technical objects since the 1980s and the disappearance of their atomic materiality in a wireless world describes a step further. Humanification of technology crosses the border of co-evolution and co-existence towards coalescence. My research on the 'sixth ecology' and concepts such as 'netgraft' and 'neurotecture' has been influences by the work conceived computational architecture studio Codes in the Clouds which I ran between 2009 and 2016 at DIA, Dessau International Graduate School of Architecture.

A glimpse into a temperamental Environment 1964-2010: an architectural ecology on the move

Subjects related to the digital and computational in architecture have been developed since the early 1960s – possibly earlier - through projects such as the IBM Pavilion at the 1964 at the New York World's Fair designed by Charles and Ray Eames or Ivan Sutherland's Sketchpad (1963) developed at MIT; the latter entails a sketching software, an 'automated' drafting tool, a graphics tool, a communication system between human and the machine in order to create shapes and drawings. The software functioned on a set of algorithms, a cathode ray pen, a human and a screen, describing the interface between the two 'alien' species, the Human-Computer-Interface (HCI). The Colloquy of Mobiles, an interactive (possibly even user centred) structure developed by the British cybernetician Gordon Pask followed suit in 1968.[10] It was exhibited at Cybernetic Serendipity at the Institute of Contemporary Arts (ICA) in London. The exhibition was curated by Jasia Reichardt and featured the use of computers in art, music - and the phenomenon of feedback. The same era brought out Nicholas Negroponte's Architecture Machine Group (1967–1985, MIT) developing 'Architecture Machines' that would see, learn, forget and assist the architect. Negroponte based the research of the Architecture Machine Group on the concept that "If a machine can be a self-improving evolutionary specie, it sports better chance of making its computational and informal abilities relevant."[11] He states that "Most computer-aided design studies are irrelevant inasmuch as they only present more cooperation with the machines that have been thought to be inhuman devices – devices that can intelligently respond to the tiny, individual, constantly changing bits of information that reflect the identity of each urbanite as well as the coherence of the city. If this is true, then the first issue is: Can a machine deduce responses from a host of environmental data?"[12] Negroponte actively combined architecture, urban design, computer sciences and biological principles culminating in the emergence of projects presenting self-organization and generative/iterative evolution rather than designing projects of finite geometry or function. In architectural theory and practice the search for new typologies and interdisciplinary approaches was tested on a number of levels, ranging from 'utopian' mega-cities and urban-scapes including projects by Archizoom via the Japanese Metabolism with projects, buit and unbuilt, by e.g., Kenzo Tange, Kisho Kurakawa and Yona Friedman with 'Spatial Cities'. The idea of endless growing architecture (Il Monumento Cintiunuo by Superstudio, 1969) modular buildings (Interaction Centre by Cedric Price, 1972), self-organizing public spaces (Fun Palace by Cedric Price and Gordon Pask), cities conceived through industrial automated production and rule-based compositions (houses I to X by Peter Eisenman, 1967- 1975) have triggered a change of mind-set from object-focused design strategies to relation-focused ecological environments – slow but steady. Christopher Alexander's books "Notes on the Synthesis of Form"[13, 14] and "Pattern Language"[15] have supported this development until today. Architects started defragmenting their building designs, to reconstruct them differently, sometimes with underlying rules sometimes based on individual preference of composition. In either case the long-established typologies of building components got distorted and questioned; new spatial qualities emerged. Architectural theory and societal critic kept driving experimental projects in form and expression also in the 1980s (Dame Zaha Hadid The World (89 Degrees), 1983, or Bernard Tschumi's Parc de la Villette, 1982-1998).[16] An evolution that, between the mid 1960s and late 1980s, underpinned an understanding of a building or a city as system, as organism.

Each element would be connected one or more others; some relations stronger, some loser, some evolving independently and some influenced in their morphology by environmental changes and impact.

Deconstructivism – to complete the short overview - played a crucial role in the transformation of architecture. It brought to being architecture that lived of incoherence, defragmentation and contradiction; disharmonious and without underlying logic in order to arrive at a visually pleasing architectural composition. In this context, I may want to suggest deconstructivism as an era that bridges between postmodernism (approx. 1960s-1990s) and the digital. Between 1990s and approx. 2005 deconstrucivism ran in parallel with the first digital turn, accompanying projects such as Frank Gehry's Guggenheim Museum in Bilbao (1992-1997). Late Deconstructivism was the birth child of more than two decades overwhelming architectural theory. Gottfried Wilhelm Leibniz (and the baroque) was rediscovered, Gilles Deleuze and Félix Guattari, Kenneth Frampton, Peter Eisenman, Anthony Vidler, Rem Koolhaas, Kurt W. Foster, Guiseppe Terragni, Diana Agrest and a number of highly influential architects and theoreticians created the Oppositions readers (1973-1984); even Hans Reichenbach's idea of the manifold became part of the debate. Architecture became truly com-plex and com-pli-cated through new mind-sets that discussed architecture beyond buildings, technology and construction but as politics, as capitalism, as economics, utopia and society – and they discussed the role of the architect as an organiser of cities, and designer of statements. A progressive group of architects that accepted, embraced and celebrated non-linearity, networks, causality and multiplicity in opposite to the linearity and clarity that was assumed to be 'the true characteristic' of architecture, initiated and carried through a radical change. Architecture transformed and steered towards a becoming a new kind of animal; one that would soon underlie rule-based principles and play with becoming digital, with being governed by the topological logic of NURBs[17], tessellation and what we used to call 'pulling vertices';[18]"Hybrid Spaces"[19] happening in cyberspace[20, 21] slowly turning, unfolding and finally releasing the first digital turn[22] – a new age (1992-2010)[23]."Architecture in the Digital Age – Design and Manufacturing", a compilation conceived through a conference held at University of Pennsylvania in 2002 and edited by Branko Kolarevic mirrors the new Zeitgeist towards the fluid and relational that started entering its adolescence. In the introduction Kolarevic refers to Greg Lynn and states "In his essay on "Architectural Curvilinearity"[24] published in 1993, Greg Lynn offers examples of new approaches to design that move away from the deconstructivism's "logic of conflict and contradiction" to develop a "more fluid logic of connectivity." This new fluidity of connectivity is manifested through "folding," a design strategy that departs from Euclidean geometry of discrete volumes represented in Cartesian space, and employs topological conception of form and the "rubber-sheet" geometry of continuous curves and surfaces as its ultimate expression."[25] The new species of digital architecture developed in the 1970s supported by CAAD (Computer Aided Architectural Design) in the 1990s has created the path towards an architecture produced by computer and architect in mutual relationship.[26] The evolution of architecture since the 1970s - as in parts outlined above - had finally led to the beginning of the first digital turn between in the 1990s, and subsequently to the emergence of new typologies of buildings, architects and design tools - atom-based, bit-based, and cyber-physical - a combination of both.[27, 28]

Ecology - ... and the Anthropocene

Etymologically 'ecology' stands for the study (-logy) of habitation (eco), eco stems from the greek οἶκος (oikos), for house; to be extended to a quarter, or a section in the city. The notion of ecology seems to be one of the constants of interest in architecture. 'Ecology' as a science was established in the late 19th century as branch of biology through Alexander von Humboldt (1769-1859) and later Hermann von Helmholtz (1821-1894), Ernst Haeckel (1834-1919) – who coined the term 'ecology'[29] and Jakob von Uexküll (1864-1944)[30] but to mention a few.[31] The understanding of ecology for architecture and urban design was limited to the 'natural' in our habitat; the ecological balance of greenery, water, biodiversity, air pollution and sealed surfaces had been the focus. The online dictionary Merriam Webster defines ecology as a) "a branch of science concerned with the interrelationship of organisms and their environments", b) "the totality or pattern of relations between organisms and their environment".[32] The etymological dictionary etymonline understands ecology slightly differently by referring to "relationship of living things to their environments" rather than 'interrelationships' and 'organisms'.[33] Here the debate could arise if all living things are organisms or if all organisms are living things. Culture for instance, can be seen as a living thing, but perhaps not like an organism. One could look the situation from a different perspective and argue that all organisms are living things, but not all living things are organisms, since an organism is goal driven. Organizations may or may not be. Once an organization becomes an ecology it provides the system, the environment, for the organisms to inhabit the system and to thrive – an ecology emerges. The discussion about what an ecology does require a clear definition and understanding of the terms organization, system, living thing and organism.

In this chapter I would like to include all interrelationships and all organisms/living things (natural and artificial)[34] in their environments, including the micro-organism of economy, politics or the multitude of dynamic domains and subdomains residing in the Internet and outside of it. As hinted at in an earlier part of the chapter the topic to discuss is our (human) relationship to technology and technical objects. In fact, I would like to go a step further and suggest that the human condition is the relationship to technology and technical object. A shift in the balance of the whole made of parts towards a whole made of relationships is taking place. The difference from one to another can be seen in a comparison between models and means of information exchange, including top down regulation, back-and-forth-conversation and feedback mechanisms, as well as their implications for evolution; and even more relevant in the 21st century – mutation and fundamental structural change.

In his critic to capitalism "The Three Ecologies"[35, 36] Félix Guattari presents the combination of a social ecology, a mental ecology and an environmental ecology. Among other observations he describes a shift in society, politics and the human condition through a) the increasing power of the individual,[37, 38] b) the irreversibility of the man-nature-convergence - more precisely, he states that "return to the past to reconstruct former ways of living. After the data-processing and robotics revolutions, the rapid development of genetic engineering and the globalization of markets, neither human labour nor the natural habitat will ever be what they once were, even just a few decades ago."[39], and c) the impossibility of separating man from nature.[40] According to Guattari, social ecology aims at reconstructing the social, due to deterritorialized capitalist power; mental ecology relates to what Gregory Bateson calls the 'ecology of ideas', the study of how ideas interact;[41] environmental ecology is based on the principle "that anything is possible". Guattari also refers to the environmental ecology as 'machinic' ecology, that deals with the increasing influence of humans on the environment.[42] He states that "in order to comprehend the interaction between ecosystems, the mechanosphere and the social and individual Universes of reference, we must learn to think 'transversally'".[43] Guattari further refers to the challenges we are facing due to increasing world populations and climate change. At this stage I would like to argue a direct link to the Anthropocene, the 'epoch of human impact'. Our interest considering this chapter lies in what Guattari calls machinic ecology.

The architectural theoretician Reyner Banham, in the 1960s/70s observes the subject of architectural ecology from a 'technical' and domestic / social point of view. His emphasis is on the building as techné relevant to construct the relationship between human and building and between human and technology on one hand, and the impact of 'modern' technology "in form of small machines – shavers, clippers and hair-dryers" p.9 on the domestic revolution on the other. The building and its design act as interfaces for both, since it may require further electrical circuits for the operation of electrical machines or air condition for a good climate once for instance large panes of glass are installed instead of thick brick walls. "Theory and Design in the First Machine Age"[44] and "The Architecture of the Well-tempered Environment"[45] present two books relevant for the architect to engage with the actual building as system made of relationships, ducts that would feed the building with air, pipes that would feed the building with water, cables that would give comfort to the inhabitant of the first electrical age and a heating system that would grant the necessary warmth needed in the coder seasons. Banham presents detailed examination of a large variety of buildings, one of which is the Frederic C. Robie House, Woodlawn Avenue in Chicago, built in 1910.[46] He describes the house as integrated system of technology and architectural aesthetics. Light-sources are designed into the custom-made furniture and "hot pipes at the backs of the built-in cupboards in the bay windows at the ends of the room, which slots in the skirting and the cupboard tops to permit the warmed air to circulate."[47] Banham refers to environment, environmental ingenuity and pioneering environmentalists for example in relation Sir Joseph Paxton, the architect of the Crystal Palace (1851) or Gustave Eiffel, civil engineer and architect of the Tour Eiffel (1887-89). The term 'environment' overrides that of 'building', and the building departs from its existence as discrete object and becomes accepted as an environment. "The list covers:

Las Vegas; environment defined in light without visible structure of any consequence.

Drive-in movie House; rally of mobile environmental structures in a space defined by light and sound.

AEC mobile theatre; space enclosed by membrane supported on a cushion of air.

Space capsule; rigid structure containing entirely and continuously manufactured life-support environment.

St. Georges School; massive structure conserving environmental output of the contained activities now has taken on a life on their own."[48]

Our current times, in which the Anthropocene and digitization describe prominent parameters, Architects, theorists and practitioners from many disciplines respond to the demand for re-thinking what Reyner Banhan called The Well-tempered Environment. The Anthropocene marks a geological state of the global impact on the Earth's ecosystem through human activity, "in which humans become a global geological force".[49] The term Anthropocene was coined by the ecologist Eugene F. Stormer in the 1980s. The Dutch nobel prize winner Paul Crutzen has extensively researched and written about the beginnings, development and arrival of the Anthropocene.

Crutzen dates the first stage of the Anthropocene back to "around 1800 with the onset of industrialization, the central feature of which was the enormous expansion in the use of fossil fuels."[50] Since then the Anthropocene went through a number of stages. Now, in the late 2010s the Anthropocene coincides with social and technical phenomena. Man has finally influenced all 'natural' spots on earth, humans have almost departed from their 'natural', 'god-given' goal of reproduction, nature and culture merge and artificial and human intelligence interact on a regular basis regulated through invisible economic and political forces.

The definition of 'ecology' concerning the relational of, in and for all 'things' seems applicable. Erich Hörl's recent publication "General Ecology: The New Ecological Paradigm"[51, 52] investigates ecology as a state, in which everything is connected to everything. Hörl in the introduction to the book refers to Barry Commoner's 'The closing Circle: Nature, Man and Technology."[53, 54] The idea of an era of ecology or an ecological age is not a novel one. However, since the networks between human, non-human and humanoid agents become denser and increasingly differentiated, ecology deserves to be seen in a broader scale. The individual disappears in the background structure appears in the foreground. Figure 1 shows a selection of 2-dimensional network studies to investigate hierarchical growth through DLA (diffused limited aggregation) (left), centralized static structures (centre) and evolutionary re-clustering through movement from one place to another (top-right). The work started a debate on network versus cluster and the possibility of multiple layered relationships – and ecologies existing at simultaneously.

The Anthropocene in the 21st century allows us to redefine the natural as a state, rather than a representation of something organically grown without human influence. The natural is something that we, as humans, take for natural, such as a chair, or a wall, a knife, or a cell-phone. Objects, formerly technologically state of the art, rare and alien to our 'human' world. The systems approach of ecology paired with the Anthropocene helps us to depart from pre-determined ideas about architecture and its production. It offers us to embrace technology and AI to assist us in designing – maybe.

Toward a Sixth Ecology – post-anthropocene

The production of architecture is directly influences by this development of the ecological age. A pool of parameters - some clearly defined (climate, budget, material behaviour), others acting in the background (politics, culture, economics, software development) - author the design of digital tools, prototypes, processes and finally buildings and cities.[55] The concept of ecology adopts cybernetic principles of feedback, conversation and learning. It also feeds principles developed by the Austrian biologist Ludwig von Bertalanffy's "General Systems Theory"[56], originally published in 1949. Those include but are not limited to systems dynamics and the focus on a system's structure rather than a system's function.

The mission for how to continue the new architectural paradigm seems clear: digital infrastructure, methods and algorithms, industry, services and digital production, the growth of a digital society, a changing understanding of the humanities and digital health are desiring to be filled with life. They also demand an architectural response, in which the extreme digital and the extreme analogue and natural can co-exist and create a fruitful ecology. An increasing variety of sub-ecologies or micro-ecologies (biological, artificial, human, non-human) triggers an increase of ideas and concepts. It also increases the variety of possible habitats, possible cultures and ways of communication. Each entity, agent and cluster brings its own understanding (its own culture) into the equation of the sixth ecology. They inhabit their semiotic niches[57] - a term coined by Yuri Lotman. Semiotic niches are part of the interaction of all connected entities in the network as well as part of the environment in which they exist and act. The semiotician Yuri Lotman specifically refers to linguistics and signs, which for the sixth ecology is abstracted to code, syntax and taxonomy of environments (Umwelten)[58] (fig. 2).

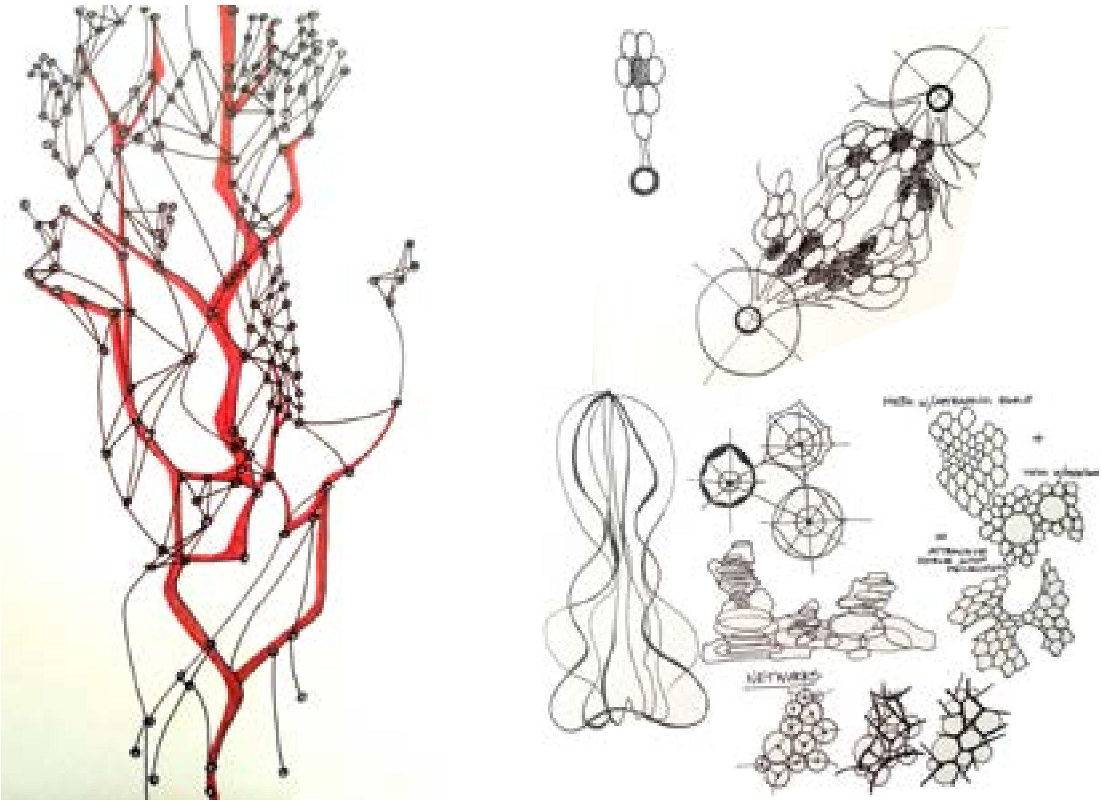

Fig. 1. Cerebellum Network Studies, Natalie Belous and Kamel Lokman, 2014

Machines of loving Grace:
I like to think (and the sooner the better!)
of a cybernetic meadow
where mammals and computers
live together in mutually programming
harmony
like pure water touching clear sky.

I like to think (right now, please!)
of a cybernetic forest
filled with pines and electronics
where deer stroll peacefully
past computers
as if they were flowers
with spinning blossoms.

I like to think (it has to be!)
of a cybernetic ecology
where we are free of our labors
and joined back to nature,
returned to our mammal
brothers and sisters,
and all watched over by
machines of loving grace.[60]

In "The Stack: On Software and Sovereignity"[61] Benjamin H. Bratton describes the terrestrial and extra-terrestrial infrastructure by proposing "that these different genres of computation—smart grids, cloud platforms, mobile apps, smart cities, the Internet of Things, automation—can be seen not as so many species evolving on their own, but as forming a coherent whole: an accidental megastructure called The Stack that is both a computational apparatus and a new governing architecture. We are inside The Stack and it is inside of us."[62] The image of sitting in a computer recalls the photograph of the computer ENIAC, taken by the US Army in 1946, showing an operator within the machine, being an active part of the machine.[63] We may understand ourselves as agents within this infrastructure, this net of everything. The Stack is made of six layers: earth, cloud, city, address, interface and user, that are undeniable interconnected and interrelated. The architectural designer, like any other designer, operates within the stack and involuntarily gets influenced by each layer and relationship; involuntarily since he or she cannot control which information to integrate into a design process. The conversation with the worlds has become overwhelming. Bratton's 528-page critical view suggests a cybernetic relationship of everything that resolutes in a coherent whole. It spins further the wheel of cybernetics - a theory, a science, a world view and a technique for constructing conversation between things – and for construction things – material and immaterial – critical and not always positively.

Subjects, which have been globally discussed since the mid-nineties have culminated in the rise of the digital natives, and cyborgian humanoids on a socio-technical level, the rise of the bitcoin and blockchain on an economical level and the rise of emergent properties through developments in the fields of design-to-production, material intelligence, the democratization of design on an industry and services level – through real-time customer response and direct digital design of mass-customized products - and digital craftsmanship[64]. The latter relates to a rethinking of a craft of drafting on conversation, or still contradiction to the craft of coding in architecture and production of architecture. The questions are, can we master the at of coding in order to fulfil architecture's responsibility and love up to its standards? Do we actually know what the responsibilities and state of the art standards are? What is it that architecture has to deliver to respond to contemporary dramatic changes? Isn't the ease of using a computer for designing and producing architecture, for drawing and rendering the way out of the tedious process of revising designs over and over again? It is so easy to feed the machine with necessary data to spit out a 'good' piece of architecture. Surely issues in architecture are more complex, and the process of design an individual one between the designer, the tool and the to be designed[65, 66, 67] Richard Sennett refers to CAD and states "The seduction of CAD lies in its speed, the fact it never tires, and indeed in the reality that its capacities to compute are superior to those of anyone working out a drawing by hand. Yet people can pay a personal price for mechanization; misuse of CAD programming diminished the mental understanding of its users. This seems a sad story, but perhaps it can be told in a different way. Might we, in our very comparative imperfection, learn something positive about being human?"[68] p.81

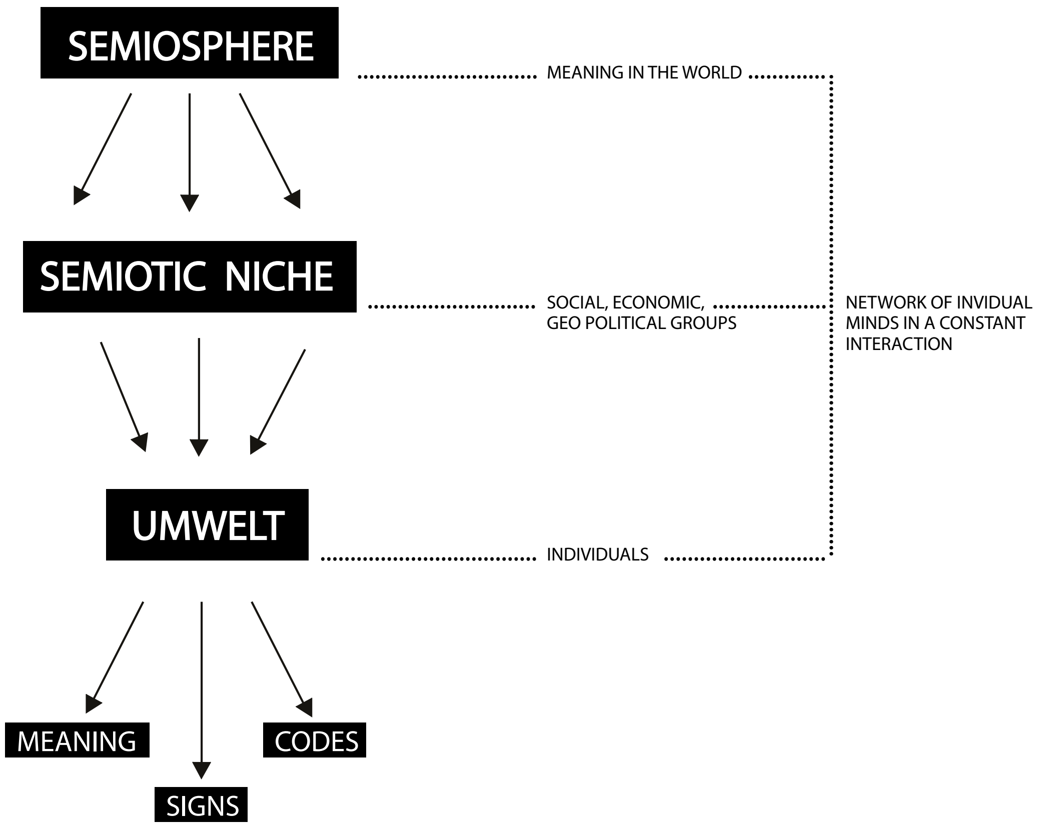

Fig. 2. Cerebellum Semiosphere[59], Natalie Belous and Kamel Lokman, Codes in The Clouds VII 'Topology Frequencies', 2014.

Ecology, in regards to the design process in architecture and the building as manifested micro-organism within a larger system of dynamically interweaving subsystems, and overlapping layers, has changed according to the global development. The entrance into the Anthropocene – not only as a geological phenomenon but as sign, as a phenomenon for radical change – complexifies the task for the architect even further. The ,architect' is, of course not the only one affected during the design and construction process. The role of the architect changes dramatically, and so does the role of the architectural teacher, architectural education, architecture schools developing curricula for the digital age and the students of architecture. Opinions of how to engage range widely, due to a number of reasons not always comprehensible. If we regard ecologies as the study of habitation, derived from multiple relations, one of the aspects of designing is how we design the actual design process. Students in the master studio 'Codes in the Clouds' have regularly developed series of project maps (ecologies of interconnected parts) of their projects, combining site observations with theoretical underpinnings, tools and core parameters. Figure 3 shows a project map of the project 'AllaNoo', a space for people to dwell, designed through the phenomenon noise on site. 'alla' stands for 'all', 'noo' stands for the mind. The design was conceived through the combining factors of kinetic architecture and the interfering sounds of anthrophony (noise through humans), biophony (noise through nature) and technophony (noise through technical objects) (fig. 4).

My research on the sixth ecology has developed since 2015 with the first publication on "Architectural Ecologies: Code, Culture and Technology at the Convergence", which "opened up the possibility for the conception and study of a post-digital architecture[69] (Spiller, 2009), where the computational matter becomes the catalyst of a wider understanding of architectural formations as embedded in a wider field of ecological interactions with natural, cultural and technological systemic ecologies."[70] If we understand ecology as relational and as form of habitat ecologies cannot be reduced to known paradigms, economy or the mind. I am suggesting ecologies themselves as dynamic environments that, once parts of the ecologies are connected, interact and develop. The first five ecologies I suggest are

1. natural ecology – meaning nature as understood in the 20th century
2. infrastructural ecology – meaning streets, water, internet, etc.
3. socio-cultural ecology – meaning the things humans do
4. artificial ecology – IoT, robots, humanoids
5. conversational ecology – meaning communication between entities, verbal and biological

The sixth ecology describes the overwhelming network and includes unseen parameters, that do strongly affect architecture. It focuses on relations and feedback, and behaves according to principles of second order cybernetics, meaning the sixth ecology combines paradigms that have been alien to each other before the embodiment of the digital. The sixth ecology takes into consideration existing knowledge and the development (breeding) of such through interaction. At this stage I would like to call the sixth ecology, a concept in development, 'entailment' or 'entailing ecology'.[71, 72]

The term 'entailment' refers back to the cybernetician later consultant to Cedric Price's Fun Palace and teacher at the Architectural Association Gordon Pask, who developed the so-called 'entailment meshes' as part of his 'Conversation Theory'.[73, 74] In 1969, he states that "a building cannot be viewed simply in isolation. It is only meaningful as a human environment. It perpetually interacts with its inhabitants, on the one hand serving them and on the other hand controlling their behavior. In other words, structures make sense as parts of larger systems that include human components – and the architect is primarily concerned with these larger systems; the (not just the bricks and mortar parts) are what architects design. I shall dub this notion architectural 'mutualism'."[75]

In this respect, I would like to close the chapter with a question. 'What is our post-millennial human environment how will we, as architects, respond?'

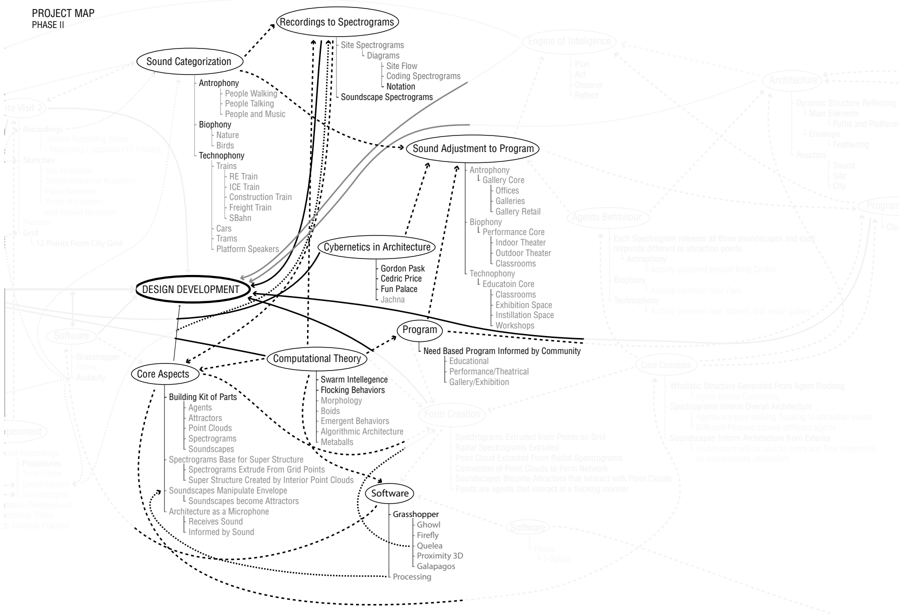

Fig. 3. AllaNoo 'Project Map 02`, Anastasija Palagina and Zachary Wilson, Codes in The Clouds X 'White Noise', 2016.

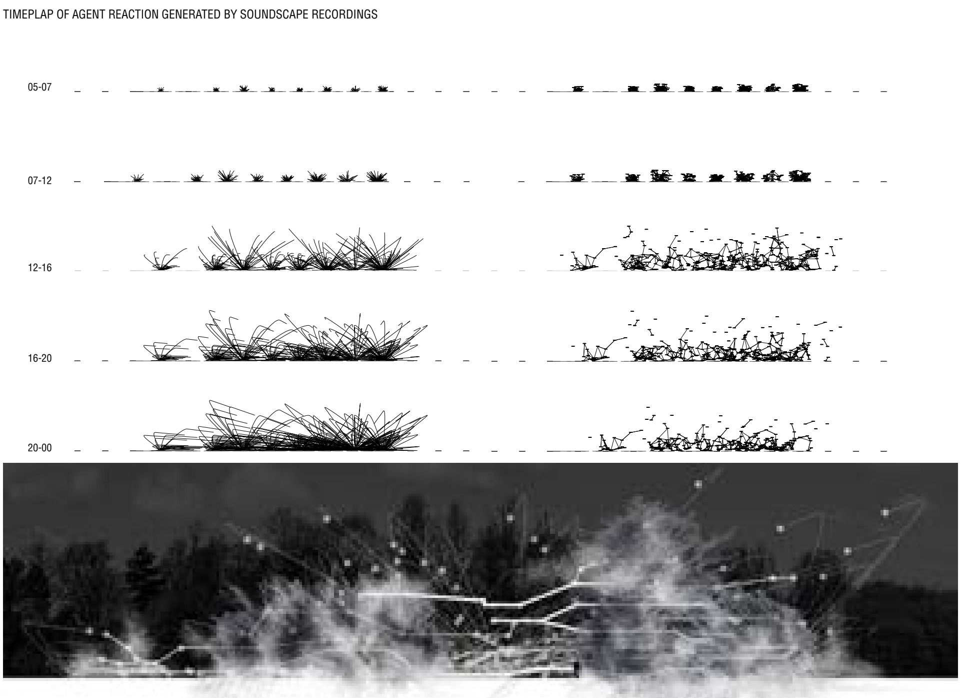

Fig. 4. AllaNoo 'Agent Reaction`, Anastasija Palagina and Zachary Wilson, Codes in The Clouds X 'White Noise', 2016.

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Notes

1 Félix Guattari, The Three Ecologies, trans. I. Pindar, Sutton, P. (London: The Athlone Press, 2000).

2 Félix Guattari's theory of The Three Ecologies finds its foundations in Gregory Bateson's Steps to an Ecology of Mind (1972) "Ecology in the widest sense turns out to be the study of the interaction and survival of ideas and programs (i.e. differences, complexes of differences) in circuits." Gregory Bateson, ed. Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology (Chicago: University Of Chicago Press, 1972). p.491

3 Reyner Banham, Theory and Design in the First Machine Age, 2nd ed. (New York: Praeger Publishers, 1970).

4 Benjamin Bratton, The Stack (Cambridge: The MIT Press, 2016).

5 Gilbert Simondon, On the Mode of Existence of Technical Objects, trans. Ninian Mellamphy (Paris: Aubier, Edition Montaigne, 1980).

6 Translated from the French to the English language by Nimian Mellamphy, University of Western Ontario, June 1980

7 The term 'reality' may be defined as a phenomenon entailing human characteristics such as emotions or the driving will to live – not the prove of physical existence of mankind. 'Technics' and 'technical objects' may be defined as a purely utilitarian, and not as result of evolution.

8 Jessica Riskin, "The Defacating Duck, or, the Ambiguous Origins of Artificial Life," Critical Inquiry 29, no. 4 (2003).

9 The French engineer Jacques Vaucanson created the Defecating Duck and other kinetic automata that mimicked nature around the year 1730. The duck seemed to be able to digest food in a chemical stomach. The reality however was, the stomach was pre-filled with digested kernels to be released on demand. See. Wood, Gaby, Edison's Eve: A Magical History of the Quest for Mechanical Life, 2003.

10 Gordon Pask, "A Comment, a Case History and a Plan," Cybernetics, Art, and Ideas (1971).

11 Nicholas Negroponte, "Toward a Theory of Architecure Machines," Journal of Architectural Education 23, no. 2 (1969).

12 Ibid.

13 Christopher Alexander, Notes on the Synthesis of Form (Cambridge. Massachusetts: Harvard University Press, 1971).

14 originally published 1964

15 Christopher et al. Alexander, A Pattern Language: Towns, Buildings and Construction (New York: Oxford University Press, 1977).

16 These are two selected projects of a large range of experimental work and have been chosen due to author's preference.

17 non-uniform rational basis spline

18 We are writing the years around 2000

19 Peter Zellner, Hybrid Spaces (London: Thames & Hudson, 1999).

20 Michael Benedikt, "Cyberspace: Some Proposals," in Cyberspace: First Steps, ed. Michael Benedikt (Massachusetts: MIT Press, 1991).

21 The term 'Cyberspace' stems from the Science Fiction writer William Gibson (1984), see Benedikt, Michael 'Cyberspace: First Steps', MIT Press, 1991

22 Mario Carpo, ed. The Digital Turn in Architecture 1992 - 2012 (London: Wiley, 2012).

23 See Carpo, Mario, The Digital Turn in Architecture 1992-2012, AD Reader, 2012.

24 Greg Lynn, "Architectural Curvilinearity: The Fold, the Pliant and the Supple," in Ad Profile: Folding in Architecture, ed. Greg Lynn (London: Academy Editions, 1993).

25 Branko Kolarevic, ed. Architecture in the Digital Age: Design and Manufacturing (London: Taylor & Francis, 2003).:3

26 I may want to add that the complexity of architecture as understood here is not reduced to the design tool and the designer, but ought to take into consideration all environmental factors, as well as material qualities and behavior of materials used in a project.

27 At this stage I could have chosen the terms ‚material' or ‚real' and ‚virtual'; I refrained from doing so, since, and I would like to quote John Frazer: "virtual worlds should not be seen as an alternative to the real world or a substitute, but as an extra dimension which allows us a new freedom of movement in the natural world.". John Frazer, "The Architectural Relevance of Cybernspace in Architectural Design (1995)," in The Digital Turn in Architecture 1992-2012, ed. Mario Carpo (London: Wiley, 2013). pp.48-56

28 cyber-physical systems here refer to 'objects' such as drones, robots, street lights, etc., that are integrated parts of the 'Internet of Things'; and not to humanoid robots, which may become integrated and active parts of society.

29 etymonline, "Ecology," https://www.etymonline.com/word/ecology.

30 The selection of scientists stands as exemplary and certainly only shows a fragment of the scientists and also sociologists in the 20th century who actively developed the notion of ecology.

31 Ecology as such existed long before without being a

science or specific field

32 Merriam Webster, "Definition of Ecology," https://www.merriam-webster.com/dictionary/ecology.

33 Etymonline, "Ecology," https://www.etymonline.com/word/ecology. Accessed 2017/11/08

34 including culture as man-made and nature as made by a higher force, e.g., evolution or 'God'

35 Guattari.

36 Guattari's book follows / is related to "Steps to an Ecology of Mind" by the English anthropologist and cybernetician Gregory Bateson Bateson.

37 Guattari. :41

38 "the question of subjective enunciation will pose itself ever more forcefully as machines producing signs, images, syntax and artificial intelligence continue to develop." Felix Guattari, The Three Ecologies, trans. Ian Pindar and Paul Sutton (London and New Brunswick, NJ: The Athlone Press, 2000).p.41

39 Guattari. :42

40 Ibid.

41 Bateson.

42 "Natural equilibriums will be increasingly reliant upon human intervention, and a time will come when vast programmes will need to be set up in order to regulate the relationship between oxygen, ozone and carbon dioxide in the Earth's atmosphere." Guattari. p.66

43 Guattari. :43

44 Banham., originally published 1960

45 The Architecture of the Well-Tempered Environment (London: The Architectural Press, 1969).

46 The Architecture of the Well-Tempered Environment (London: The Architectural Press, 1969). :115-19

47 The Architecture of the Well-Tempered Environment (London: The Architectural Press, 1969). :117

48 Ibid. :285

49 W. Steffen, Crutzen, P. J., McNeill, J. R. , "The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?," Ambio 36, no. 8 (2007).

50 Ibid. :614

51 Erich Hörl, "Introduction," in General Ecology, ed. Erich Hörl (London: Bloomsbury, 2017).

52 Erich Hörl's 'General Ecology: The New Ecological Paradigm' is an anthology combining essays from the field of cultural history, theory and sciences, sociology, literature, media culture, communication sciences.

53 Barry Commoner, The Closing Circle: Nature, Man, Technology (New York: Knopf, 1971).

54 Hörl. 1-45

55 At this stage we could suggest that architecture enters an age of post-architecture, in a way that humans have (according to Katherine Hayles) become post-human; N. Katherine Hayles, How We Became Post-Human (Chicago: University of Chicago Press, 1999). I would refrain from such an alien extreme, and propose that 'post-architecture' and 'post-human' are states of the natural development of our society and culture.

56 Ludwig v. Bertalanffy, General System Theory: Foundations, Development, Applications (New York: George Braziller, 1968).

57 The term semiotic niche was developed by the Estonian semiotician Yuri Lotman in his concept of the semiosphere in 1982

58 for contextual understanding see Jakob von Uexküll, Umwelt Und Innenwelt Der Tiere (Berlin: J. Springer, 1909).

59 Juri Lotman, "On the Semiosphere," Sign Systems Studies 33, no. 1 (1984).

60 Richard Brautigam, All Watched over by Machines of Loving Grace (Communication Company, 1967).

61 Bratton.

62 The MIT Press, "The Stack - Overview," https://mitpress.mit.edu/books/stack.

63 see ENIAC (Electronic Numerical Integrator and Computer), one of the earliest general-purpose computers, University of Pennsylvania, February 1946. A photograph, originally by the US Army, published in the article "Lightning Strikes Mathematics", published in Popular Sciences in April 1946 Allen Rose, "Lightning Strikes Mathematics," New York, https://books.google.de/books?id=niEDAAAAMBAJ&pg=PA83&redir_esc=y&hl=en#v=onepage&q&f=false. shows Irwin Goldstein setting switches on one of ENIAC's function tables in ENIAC - the so-called 'Giant Brain' - at the Moore School of Electrical Engineering. The operator is in the computer and the computer in him.

64 Digital Craftsmanship sits in relationship with the book 'The Craftsman' by Richard Sennett, originally published in 2008. Richard Sennett, The Craftsman (London: Penguin Books, 2010). Sennett discusses craftsmanship as a human property, which had been 'threatened' by the invention of labouring machines in the 18th century, examples are the careful carving of the Stradivari violin or the weaving of a piece of fabric (Vaucanson's loom invention following a technique he applied when designing the magic flute player – p.87).

65 see Ranulph Glanville, "Re-Searching Design and Designing Research," Design Issues 15, no. 2 (1999).

66 see Donald A. Schön, The Reflective Practitioner : How Professionals Think in Action (New York: Basic Books, 1983).

67 see Leonard J. Waks, "Donald Schon's Philosophy of Design and Design Education," International Journal of Technology and Design Education 11 (2001).

68 Sennett. :81

69 Neil Spiller, "Plectic Architecture: Towards a Theory of the Post-Digital in Architecture," Technoetic Arts: A Journal of Speculative Research 7, no. 2 (2009).

70 L. Werner, Rossi A., PanahiKazemi, L., "Architectural

Ecologies: Code, Culture and Technology at the Convergence" (paper presented at the EMCSR 2014, Vienna, 2014).

71 see Gordon Pask ‚entailment meshes' in Gordon Pask, Conversaton Theory - Applications in Education and Epistomolgy (Amsterdam: Elsevier Scientific Publishing Company, 1976).

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73 Pask.

74 see Liss C. Werner, "The Origins of Design Cybernetics," in Design Cybernetics: Navigating the New, ed. C. M. Herr T. Fischer (Springer, forthcoming).

75 Gordon Pask, "The Architectural Relevance of Cybernetics," Architectural Design (1969). :494

Computational Morphogenesis in Studio Krastev, 2011-2017

Krassimir Krastev

During the middle ages, the master builders of gothic cathedrals used hanging chains to determine the ideal geometry of structural arches, called later "catenary" arches precisely because of this method. Antoni Gaudi elaborated this model further to investigate possible geometries for his structures, and later in the 20th century, the work of Frei Otto was thoroughly informed by the interactions between structural forces and material properties. Their experiments relied on the information that is inherently contained within material formations subjected to physical loads and forces. The aim of these experiments was to extract this information in a format that is useful to generate structural morphologies. This is how experiments with soap film actually informed the tensile membranes designed by Frei Otto, a process which he coined as "finding form".

A more contemporary look at 'finding form' should involve computational technology particularly when we talk about extracting information to be used to generate architectonic structures. The following essay is a short exploration of morphogenetic experiments in different scales and media done by Master students in Studio Krastev in DIA since 2011.

Morphogenesis by material properties

The first example zooms into the micro-structural properties of anisotropic materials, such as wood, and explores methods to take advantage of the unusual structural properties of the material to formulate structures with maximum efficiency. Computational algorithms, paired with structural analysis, determine not only the structural morphology and its components, but also the orientation of timber grains on each panel of the shell. The structure eventually becomes an aesthetic representation of the physical stresses within its material, while maximizing the strength of the thin shell because the orientation of each panel allows its timber grains to maximize their resistance to the forces within the panel (Fig. 01).

The next iteration of this experiment looked into timber manufacturing processes in an attempt to define a structure that benefits from every product of the industry. Again the logic is similar – let the forces determine the place of each component based on its material microstructure (orientation of grains in timber). This time not only the structural efficiency is maximized, but also waste from the material fabrication process is minimized resulting in minimum embedded energy. The structure is made of all the products from the timber fabrication process, including the elements with irregular shapes as the place and orientation of each structural member is chosen according to its shape and grain orientation (Fig. 02).

Finally, the methods of the previous two experiments were used to elaborate a combined strategy to integrate linear and planar components with variable grain orientation into a structure that was informed by the structural analysis model of its geometry (Fig. 03).

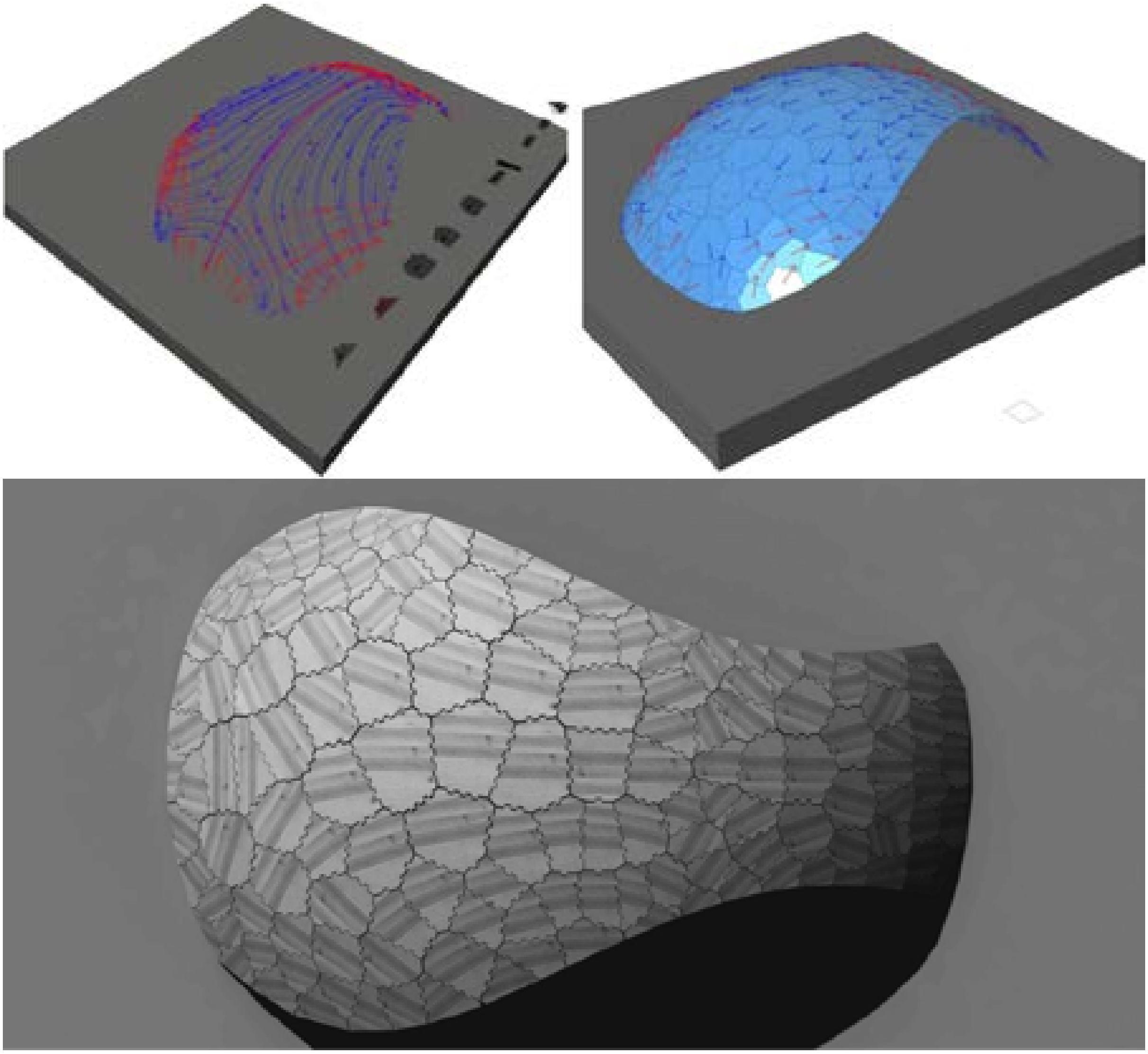

Fig. 1 Imperfect Matter, Dimitar Baldjiev, Studio Krastev, DIA, 2015.

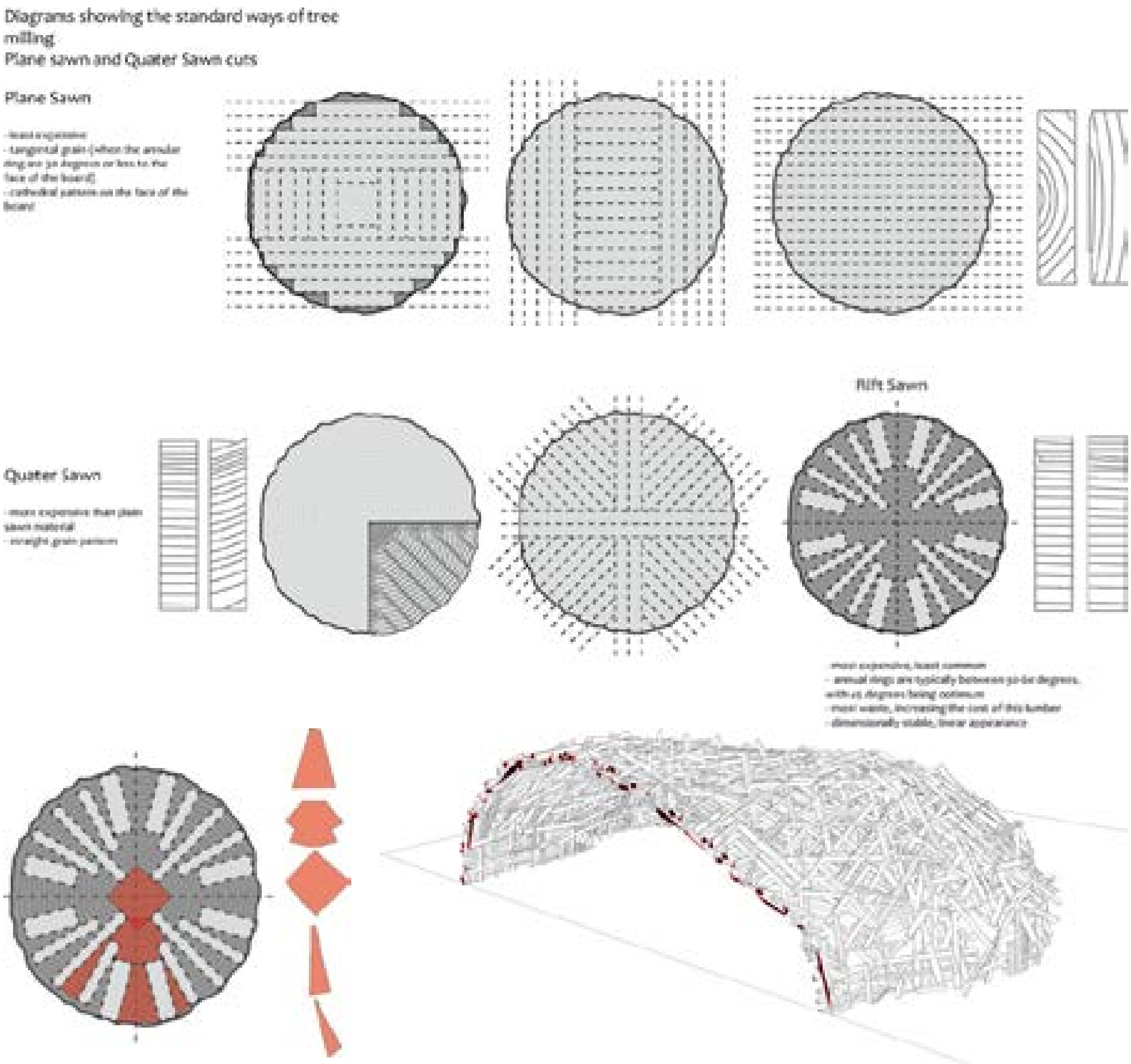

Fig. 2 Imperfect Matter, Dimitar Baldjiev, Studio Krastev, DIA, 2015.

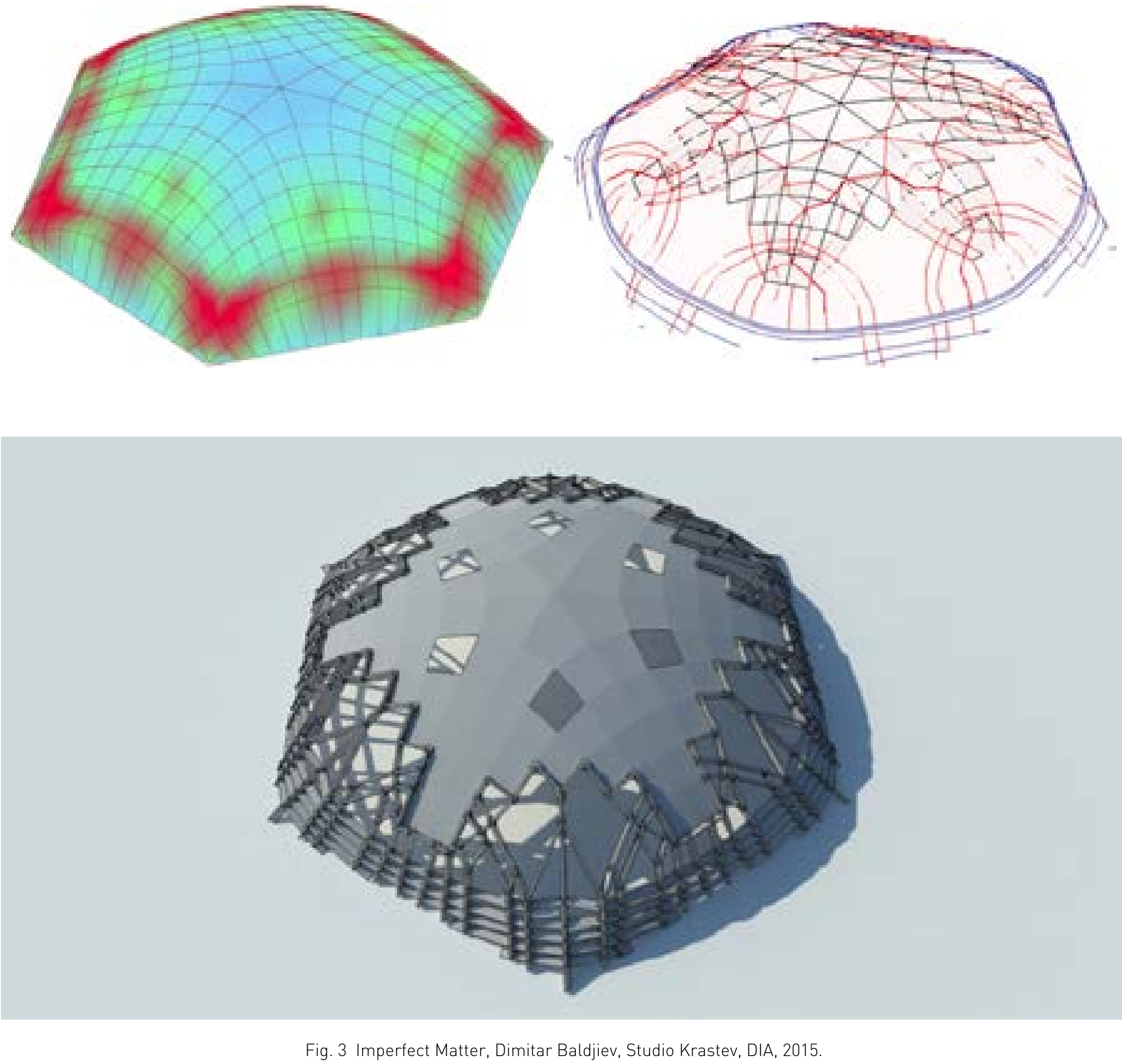

Fig. 3 Imperfect Matter, Dimitar Baldjiev, Studio Krastev, DIA, 2015.

Discrete assemblages

Another approach to morphogenesis of structures requires the understanding that any structure can be estimated as an assemblage of discrete individual components. In Buckminster Fuller's work, the structure as a whole is actually morphed by the logic of the connections between its individual components. And although Frei Otto's form finding techniques relied on material properties, such as the surface tension of soap film, more recent computational methods would use simulations of lattice assemblages of discrete elastic components to achieve similar results. Such methods use a computational process called dynamic relaxation[1] which relies on discretization of structures to find the positions of the individual components where all forces are at equilibrium. A good example that used dynamic relaxation as a form generating method is the definition of the geometry of the roof over the Great Court of the British Museum, completed in 2000 by Foster + Partners. The main constraint that the geometry definition aimed to satisfy was to minimize the lateral loads and to concentrate them at the corners of the existing masonry walls of the rectangular court where they could be absorbed as tension in the edge beam[2]. The dynamic relaxation process found the right position of each structural node by repeating many cycles of small gradual changes to the geometry. The result is exciting and pleasing aesthetically, an extremely elegant addition to the historic Greek Revival masonry structures of the museum.

Another complex morphogenetic method is called topology optimization (TO)[3]. It relies on the Finite Element Method (FEM)[4], the common tool used for structural analysis of statically indeterminate structures. Pairing a form generating algorithm with structural analysis can result in an effective tool to form structures that achieve maximum strength with minimum amount of material for a given set of loads. A common TO system computationally increases or decreases the density of material at different locations in the design space until the structure is optimized. The resulting form is complex and organic, and this morphogenetic process is often used to generate elements that would be 3D printed (Fig. 04).

One experiment with TO in DIA assumed that a structure should be constructed by universal space filling blocks, in the particular case truncated octahedrons. These elements are as big as standard masonry blocks, and they should easily attach, as well as detach from each other, in an attempt to create a system that would allow the geometry to grow and change over time. To define the initial design or any subsequent change, the users would have to input the volume of the interior space in a specially prepared software interface. Then the TO algorithm would compute the optimal structure (or changes to the current structure) that would occupy the design space without interfering with the user defined interiors (Fig. 05).

The resulting structure is dynamic and organic, but such modular system is obviously more suitable for temporary installations rather than buildings for continuous habitation. The proposal raises some obvious questions: how would it accommodate services, lifts and other constructions, such as doors and windows, etc. and how would the rooms be used, cleaned and maintained without installing additional elements to produce smooth surfaces? The proposal provides for superior flexibility of space, as rooms with theoretically endless variety of shapes can be designed or later added to the structure, but it does not demonstrate a clear vision about the building systems other than the structural system. To achieve the full functionality for habitation, the modular system would need to be complemented with additional components. Constraints, other than the purely geometrical ones, should be introduced in the morphogenetic process.

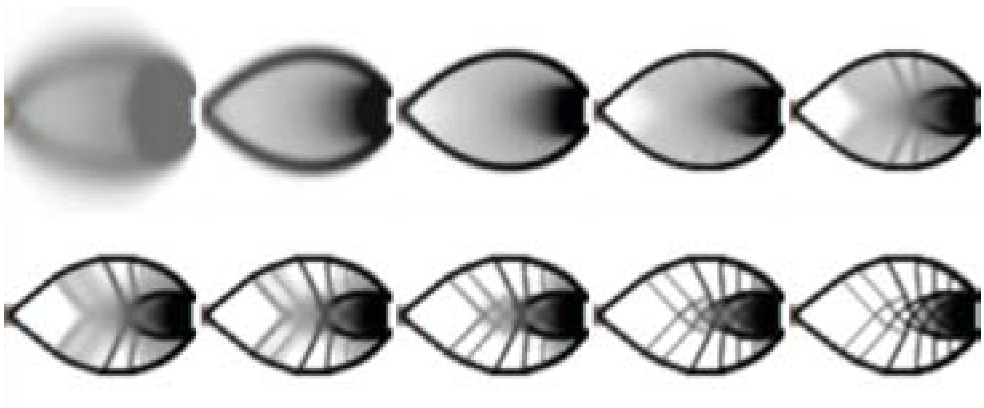

Fig. 4 A sequence that demonstrates the gradual change of density of material in a rectangular design space, producing a Michel truss with Topology Oprimization. Load Reactive Morphogenesis, Sebastian Bialkowski, Studio Krastev, DIA, 2013

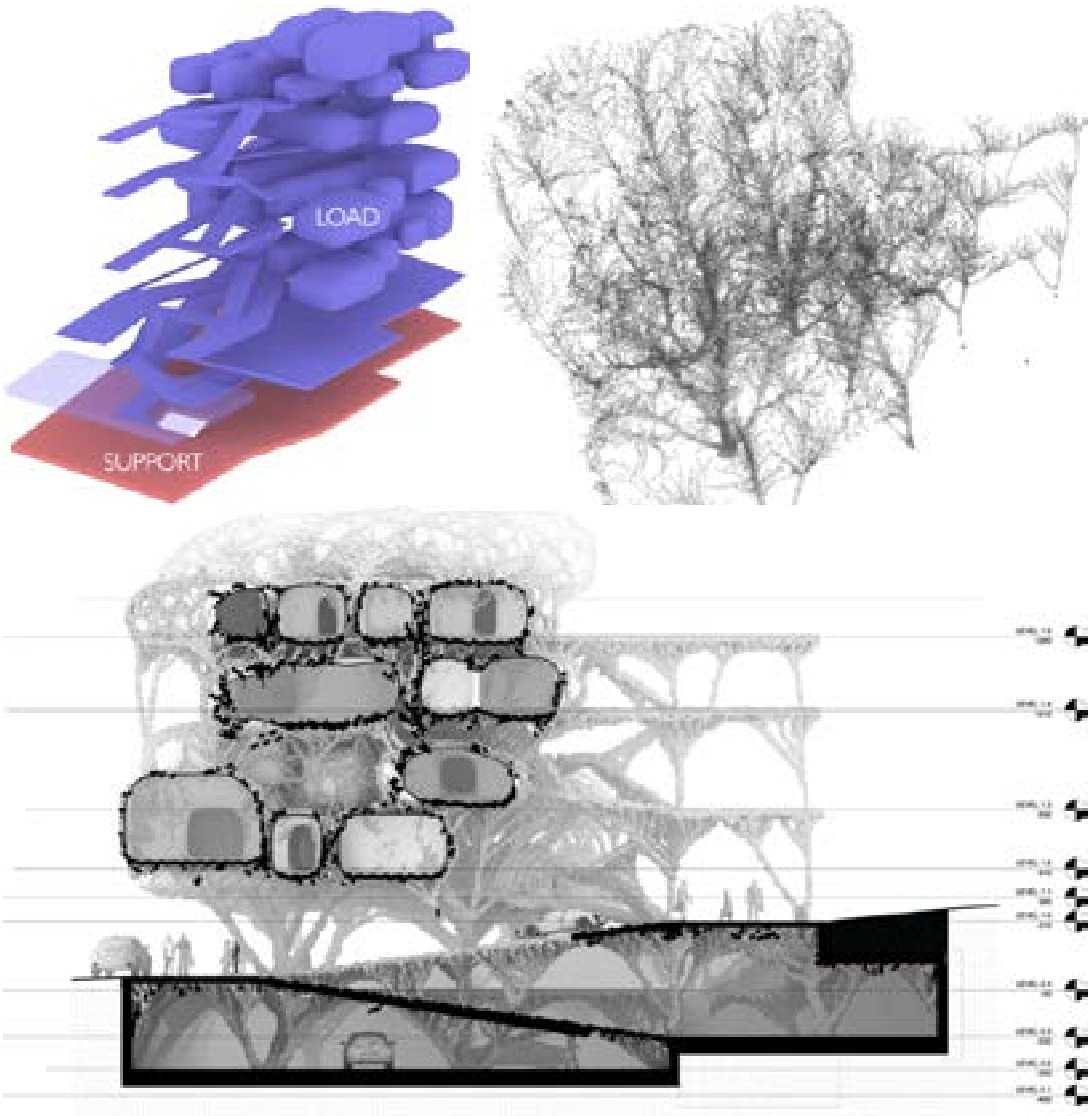

Fig. 5 The morphogenetic process starts with the definition of the volume of the interior space. Then the TO tool defines the structure and populates it with block units. Sebastian Bialkowski, Load Reactive Morphogenesis, Studio Krastev, DIA, 2013.

Models of collaborative design and construction

When talking about architectural constraints, an important factor that also informs the design of buildings is the management of the construction process. There are a few contemporary examples of adopting a construction management model that is different from the conventional 20th century models. Those construction management models involve different agents to participate in the construction process, as well as different materials and logistics. This leads to distinctive structural and spatial morphologies, as well as innovative design processes. Especially interesting outcomes are observed when the actual users of the building participate in its design and construction. For example, in the management model of the "Open Building" movement from the 60's of the 20th century (until today), the building is only partially completed by a developer on a conventional construction site. Initially, only the loadbearing structure and the building services are completed. Then the future occupants are allowed to design and build the interior partitions and sometimes even the cladding, completely customizing the space for their needs. Examples of projects that followed this model include NEXT21 from 1993 in Osaka, Japan, for which, after the erection of the loadbearing structure and installation of the services, 13 different architects were given the task to design the separate housing 'units'[5]. Following a similar model, the Pritzker prize winner Frei Otto with Josef Paul Kleihues designed the Ökohäuser in Berlin in 1987, where the future residents planned their own spaces with help by consultation with experts. In a more recent example, another Pritzker prize winner, Alejandro Aravena, designed series of community housing developments in which the possibility for future extension to each residence is allowed by the structure of the building, but left to the users to design and accomplish on their own means. In all of these examples the architecture emerges from the process defined by the construction management model, and design is the outcome of the collaboration between different agents involved in this model, rather than the aesthetic vision and spatial concept of one architect.

The following experiment from Studio Krastev in DIA explores the possibility to adopt similar model for design and construction management, involving communities of 'makers'[6] from Berlin. The study suggests the development of a range of tools, strategies and software applications that should be sufficient means for the makers' community to design and build their own workspaces in Berlin. This "toolkit" could be used for a design process that is thoroughly developed for the different stages and scales of the project development (Fig. 06).

A study was carried out on typical urban formations in Berlin and a taxonomy of typical sizes and proportions of buildings and building components was recorded. This taxonomy informed quick sketchy volumetric feasibility studies of possible building forms to be occupied by the community. After a volume is chosen, the next stage of the project begins, where the loadbearing structure and the services are constructed by a developer. The distribution of both structure and services is efficiently minimized by a process of topology optimization (TO) to ensure maximum flexibility for the possible configurations of spaces and interior partitions, which are not yet known on this stage of the process. Once the basic structure is erected and services installed, the building is ready to be occupied by the makers. The toolkit ensures flexibility, allowing for continuous changes of the building's occupancy throughout the entire lifetime of the structure. The cladding and partition wall systems are composed of modular elements that form a reciprocal frame[7] structure. The components can be manufactured by the makers themselves with the tools available in their workshop. The design of the façade and partitions is left to the makers, but guided by the initially constructed loadbearing structure and by the sizes and proportions of the modular reciprocal frame components. And although the morphology of the building may appear random and chaotic, it still fits well with the surrounding building forms, their sizes and proportions (Fig. 07).

Both of the previous examples, Load Reactive Morphogenesis and Workspaces of the 21st century: Makerspaces, propose models to

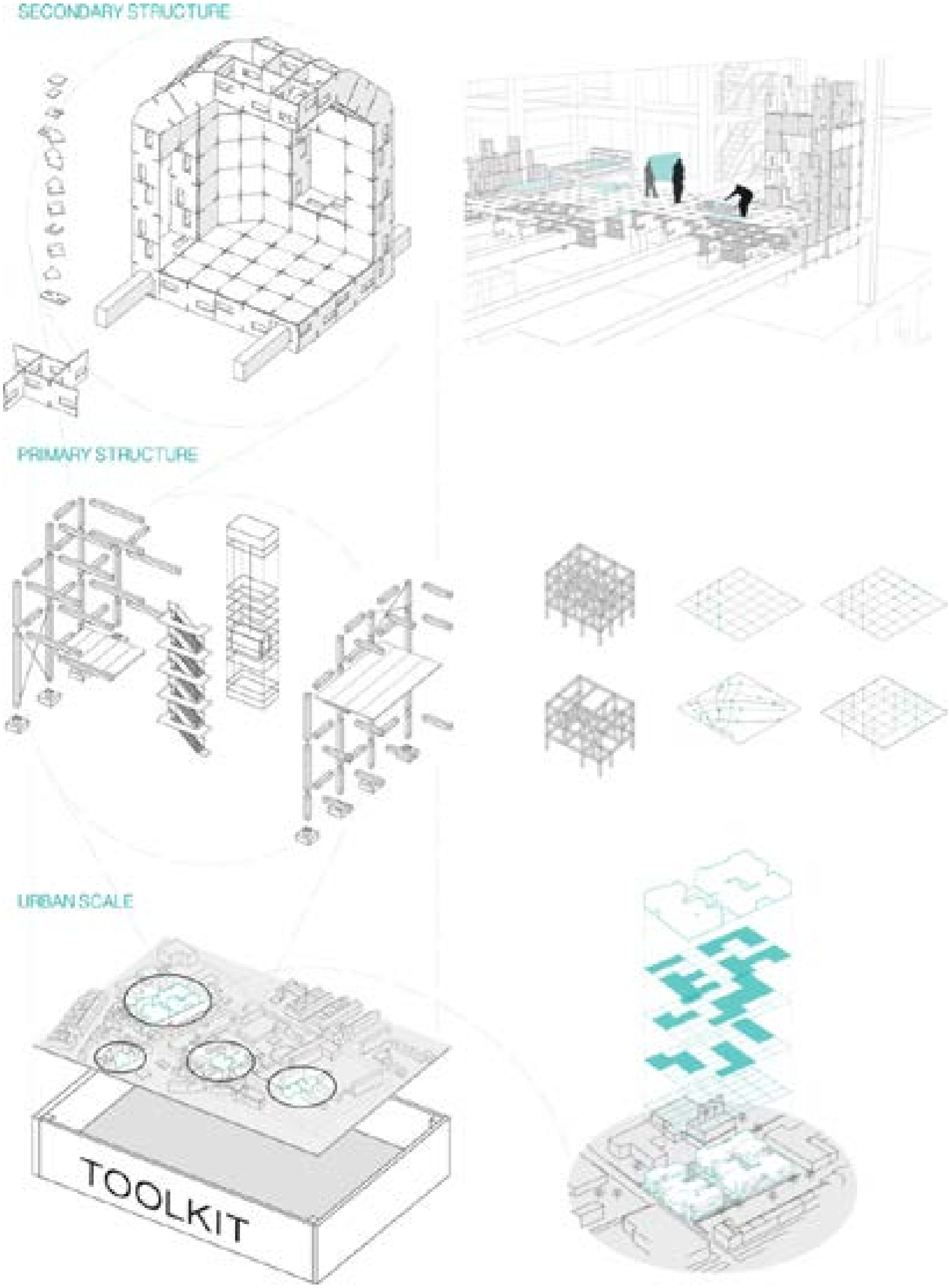

Fig. 6 A range of strategies for design and construction dealing with different scales and phases of project development are combined into a toolkit to aid the makers' community to design and build their own workspaces. Jekaterina Porohina, Workspaces of the 21st century: Makerspaces, Studio Krastev, DIA, 2016.

achieve an 'open ended' design with significant degree of customization, but the structures are still constrained by the modularity of their components. Would a structure that does not rely on the repetition of standardized components demonstrate a better performance of the spaces within (Fig. 08)? And how would such a structure get built?

One fashionable answer to these questions is to construct by 3d printing, because it achieves a large degree of customization of the geometry. However, this additive manufacturing method has limitations when applied to the construction industry. One limitation is that the size of the object that is being printed cannot exceed the size of the machine. Unless the machine is able to 3d print an extension to itself during the process[8] larger structures can only be constructed if they are composed of smaller 3D printed components, so modules still need to be assembled on site. Another serious limitation is the size of the nozzle through which the material is extruded: the smaller it gets, the finer the details, but also the slower the process. If we want to scale any 3 dimensional shape by a factor of 2, the result is twice as long, twice as wide and twice as tall, or its volume increases by a factor $2^3 = 8$ times. Any scaling of an object by a factor of X results in volume increase by a factor of X^3. And since the size of the nozzle is constant, the time necessary for the fabrication of the X times larger shape would increase by a factor of X^3. This is a serious limitation which makes 3D printing very non competitive with traditional fabrication and assembly methods.

While 3D printing for the construction industry is still subject to further development, many designers embrace all other kinds of computer numerical control (CNC)[9] machines and tools. This drive for mass computerization of technology since the beginning of the 21st century, together with the development of ever better CAD and CAM systems, brings up possibilities for unprecedented integration between design and manufacturing through computation. Many designers seize this opportunity to delegate processes of traditional fabrication and construction techniques to automation with the use of robotics and other CNC machines.

The following study proposed to adapt two traditional technologies to be done with CNC machines - casting and masonry block laying - in order to achieve a higher degree of customization of geometry while overcoming the limitations of 3d printing. The project explored CNC fabrication combined with assembly by robots as a construction strategy to completely eliminate human labour (other than management and supervision) from the construction site (Fig. 09).

The experiment also claimed to invent a new fabrication method for concrete units, called "positive casting", as it explored the possibility to construct a structure that is completely customized and each of its components is uniquely shaped. The method proposed that a 3 dimensional fiber lattice is initially shaped by cutting with a hot wire using a 6 axis robotic arm or a 4 axis CNC hot wire cutter. This practically allows for any shape to be formed, as long as its surfaces are ruled surfaces. Then the shapes are soaked into concrete and when pulled out, the concrete is retained within the pores of the lattice.[10] When dried they become custom shaped concrete blocks (Fig. 10) with the fibrous lattice acting as reinforcement in a way similar to fiber-reinforced concrete (FRC)[11].

Eventually, these concrete units are stacked into a structural assembly by robotic arms. The bonds between the blocks can be like masonry bonds: weak in tension, but strong in compression. The components can be oriented in a way that they always follow the compressive forces within the wall. The result is a kind of a stone lattice, which acts much like a traditional masonry structure, but composed of unique custom shaped elements. The structure is completely customized, allowing to optimize its form in a way that the strength of the structure is maximized while the volume of the material is minimized. The method allows a very high degree of customization achieving minimal discrepancies between the digital model and the built structure (Fig. 10), and it overcomes the limitations of other traditional and contemporary methods alike.

Fig. 7 Workspaces of the 21st century: Makerspaces, Jekaterina Porohina, Studio Krastev, DIA, 2016.

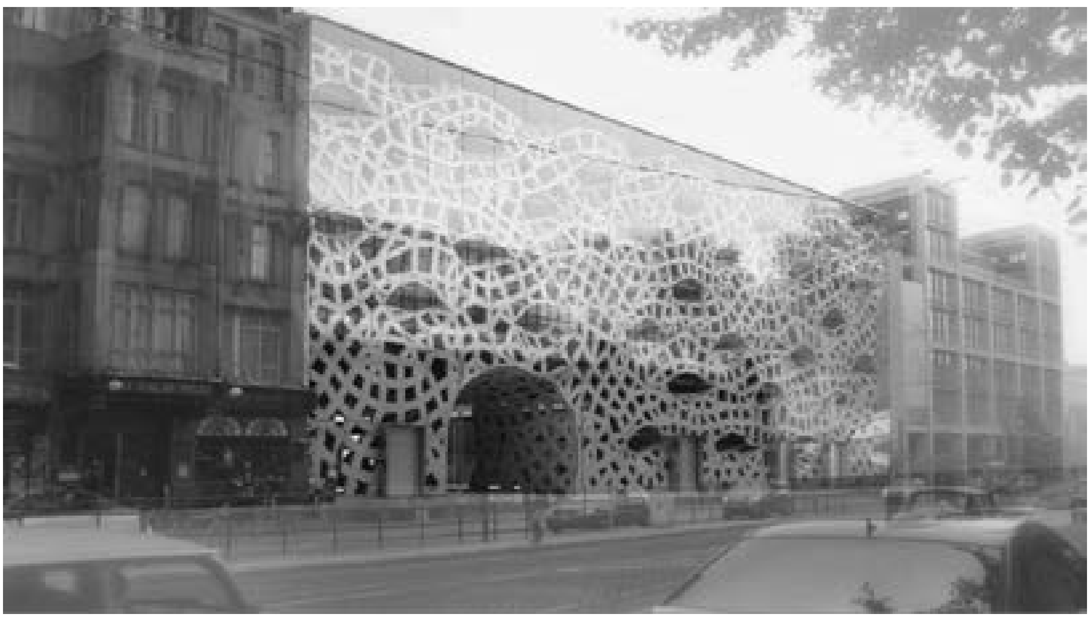

Fig. 8 Smart Masonry, Dmytro Zhuikov & Arina Agieeva, Studio Krastev, DIA, 2015.

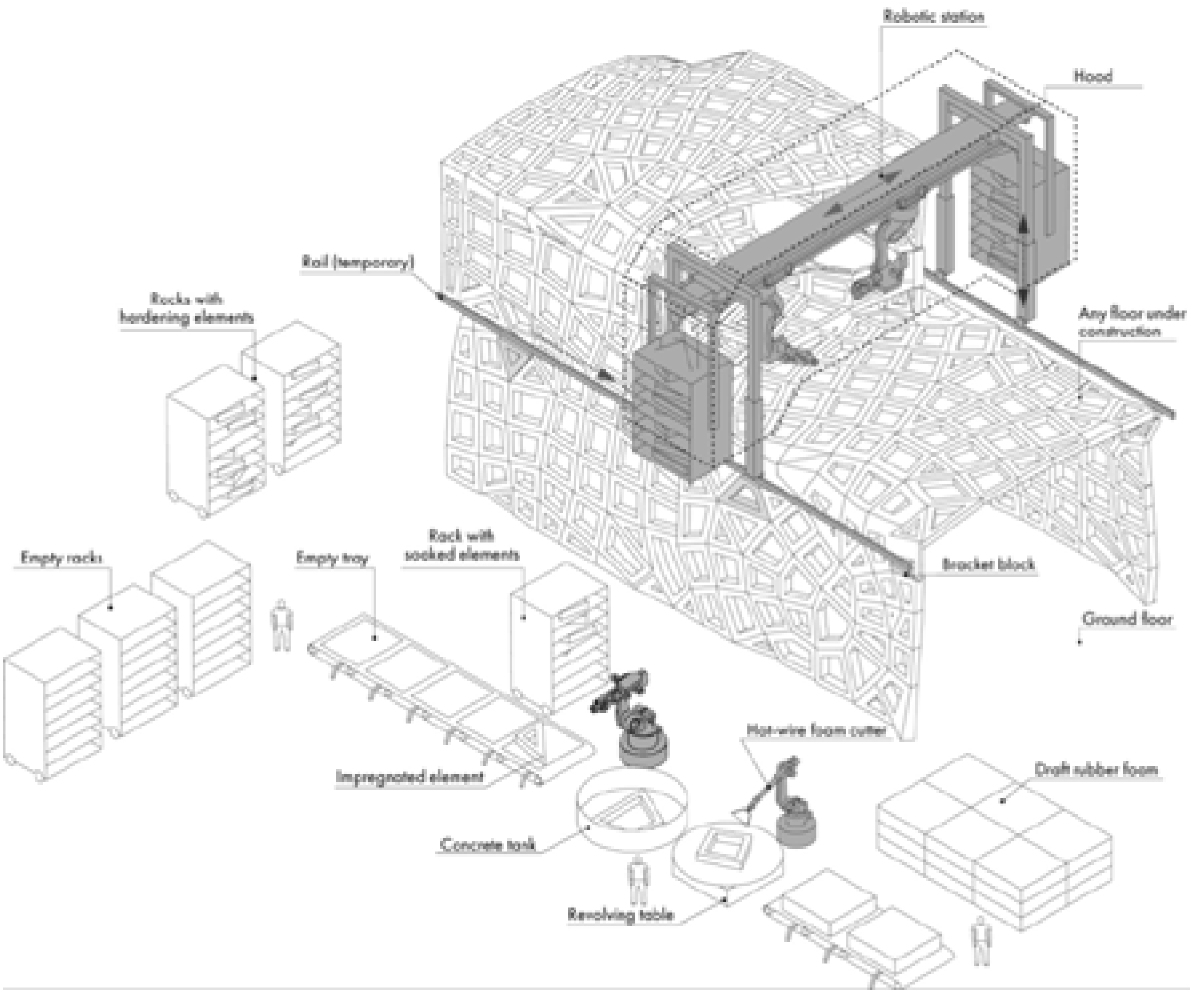

Fig. 9 Fabrication and assembly sequence – a conceptual diagram,
Smart Masonry, Dmytro Zhuikov & Arina Agieeva, Studio Krastev, DIA, 2015

Fig. 09: Custom shaped blocks, formed with the 'positive casting' method,
Smart Masonry, Dmytro Zhuikov & Arina Agieeva, Studio Krastev, DIA, 2015.

Informed morphogenesis

The experiments chosen to illustrate this essay are very diverse according to their scale, the materials that are used, and the way structures are designed and constructed. However, there is one peculiarity that is common among them: the morphology of each experiment is generated by transforming sets of information rather than by the gradual refinement of a spatial concept. This information is extracted from non spatial sets of conditions, such as material properties, structural forces, management models for design and construction, and yet, it is perfectly capable to generate structures that are architectonic. The morphogenetic process is literally 'informed' by data that traditionally has not been associated with spatial design. This shift towards sound reliance on data is not particular only to the cases outlined in this essay. Globally, the theory and practice of design have become increasingly dependent on the availability of information and tools to manipulate it. This is partially due to the increasing abundance of data and tools to mine it or manipulate it in comparison with previous times in history. For good or bad, this also leads to a peculiar shift in the role of the designer: from being the creator to give form to a project towards being a moderator to manage the flow and manipulation of data that generates architectonic morphologies.

References

1 "Dynamic relaxation is a numerical method, which, among other things, can be used for "form-finding" for cable and fabric structures. The aim is to find a geometry where all forces are in equilibrium. In the past this was done by direct modelling, using hanging chains and weights (see Gaudi), or by using soap films, which have the property of adjusting to find a 'minimal surface'." Wikipedia, Dynamic relaxation, https://en.wikipedia.org/wiki/Dynamic_relaxation

2 Williams, C.J.K. (2001), The analytic and numerical definition of the geometry of the British Museum Great Court Roof, 434-440, Mathematics & design 2001, Burry, M., Datta, S., Dawson, A., and Rollo, A.J. eds. Deakin University, Geelong, Victoria 3217, Australia.

3 "Topology optimization (TO) is a mathematical method that optimizes material layout within a given design space, for a given set of loads, boundary conditions and constraints with the goal of maximizing the performance of the system."
Wikipedia, Topology optimization, https://en.wikipedia.org/wiki/Topology_optimization

4 "The finite element method (FEM) is a numerical method for solving problems of engineering and mathematical physics. It is also referred to as finite element analysis (FEA). Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations. The finite element method formulation of the problem results in a system of algebraic equations. The method yields approximate values of the unknowns at discrete number of points over the domain.[1] To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. FEM then uses variational methods from the calculus of variations to approximate a solution by minimizing an associated error function".
Wikipedia, Finite element method, https://en.wikipedia.org/wiki/Finite_element_method

5 Kendall, Stephen, PhD et al, NEXT21, Osaka, Japan, 1994, http://www.open-building.org/ob/next21.html

6 "The maker culture is a contemporary culture or subculture representing a technology-based extension of DIY culture[citation needed] that intersects with hacker culture (which is less concerned with physical objects as it focuses on software) and revels in the creation of new devices as well as tinkering with existing ones. The maker culture in general supports open-source hardware. Typical interests enjoyed by the maker culture include engineering-oriented pursuits such as electronics, robotics, 3-D printing, and the use of Computer Numeric Control tools, as well as more traditional activities such as metalworking, woodworking, and, mainly, its predecessor, the traditional arts and crafts."
Wikipedia, Maker culture, https://en.wikipedia.org/wiki/Maker_culture

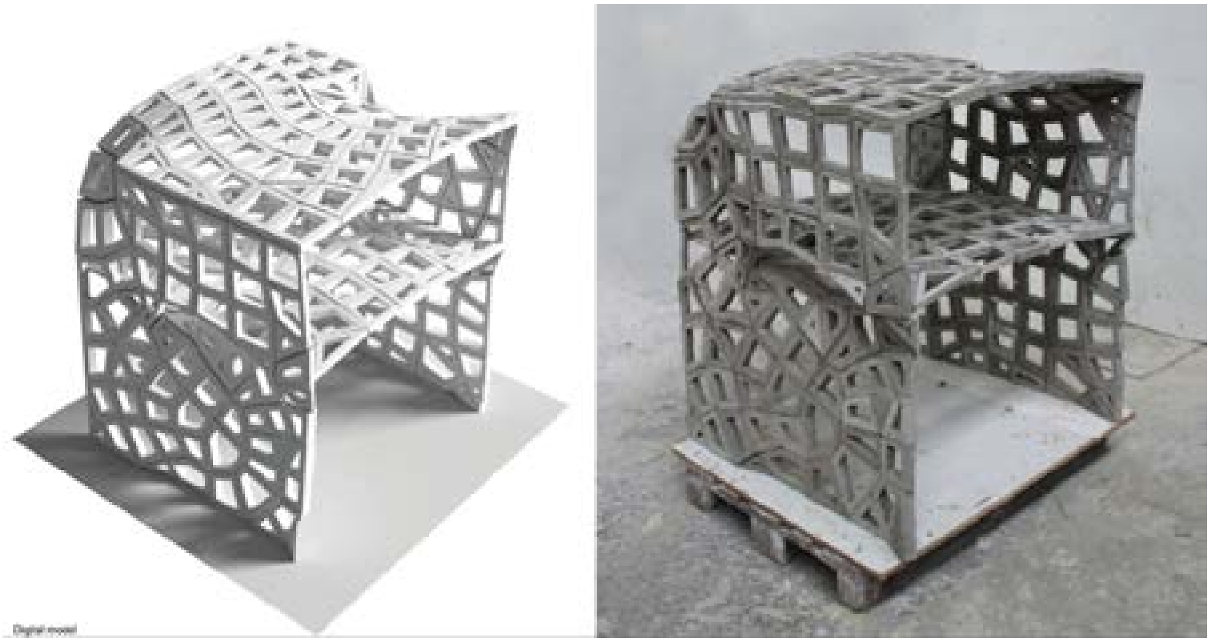

Fig. 10: The digital model and the physical mock up, side by side, Smart Masonry, Dmytro Zhuikov & Arina Agieeva, Studio Krastev, DIA, 2015.

7 "The reciprocal frame is a three-dimensional grillage structure mainly used as a roof structure, consisting of mutually supporting sloping beams placed in a closed circuit." Larsen, Olga P., Reciprocal Frame Architecture, 2008, Elsevier Ltd.

8 For example, in the MX3D Bridge project, a bridge is 3D printed by a robotic arm that is fixed at various positions onto the structure that is being printed – this is how the size of the element that is being printed can exceed the extents of reach of the 3d printing machine.
MX3D Bridge, http://mx3d.com/projects/bridge-2/

9 "Computer numerical control (CNC) is the automation of machine tools by means of computers executing pre-programmed sequences of machine control commands. [1] This is in contrast to machines that are manually controlled by hand wheels or levers, or mechanically automated by cams alone. In modern CNC systems, the design of a mechanical part and its manufacturing program is highly automated. The part's mechanical dimensions are defined using computer-aided design (CAD) software, and then translated into manufacturing directives by computer-aided manufacturing (CAM) software. The resulting directives are transformed (by "post processor" software) into the specific commands necessary for a particular machine to produce the component, and then loaded into the CNC machine."
Wikipedia, Numerical control, https://en.wikipedia.org/wiki/Numerical_control

10 For the purpose of completing the experiment on time, the 'lattice' was mimicked by a simple polyurethane sponge (similar to a sponge used in the kitchen). In reality, a stronger fibrous structure, that is still possible to be cut with a hot wire, should be developed.

11 "Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers – each of which lend varying properties to the concrete. In addition, the character of fiber-reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation, and densities."
Wikipedia, Fiber-reinforced concrete, https://en.wikipedia.org/wiki/Fiber-reinforced_concrete

Design-to-Robotic-Production & Operation

Henriette Bier and Sina Mostafavi

Computational design and robotic production and operation have today a considerable impact on architecture. Machinic and robotic processes influence not only the design and production of architectural spaces but they significantly change user-space interaction. Virtual modelling and simulation interface the physical production and real-time operation of built environments thus establishing an unprecedented Design-to-Robotic-Production and Operation feedback loop, which is focus of this paper. This feedback loop is requiring interaction and/or collaboration between human and non-human or cyber-physical agents fundamentally changing the role of the architect.

Introduction

By increasingly employing computational and robotic processes, architecture does not rely anymore on human agency only but gradually incorporates aspects of non-human agency. This paper explores the potential of computational and robotic approaches for building processes and buildings by reflecting on research in Design-to-Robotic-Production and Operation (D2RP&O) developed since 2014 by the Robotic Building (RB) team at the Technical University (TU) Delft.[1] The emphasis is on explorations in virtual modelling and simulation that are interfacing the robotic production and real-time operation of physically built space thus establishing an unprecedented feedback loop. This feedback loop is linking design and production with smart operation of the built environment by advancing applications in performance optimization, robotic manufacturing, and user-driven building operation. It re- lies on interaction and/or collaboration between human and non-human agents, thus fundamentally changing the role of the architect. Authorship becomes hybrid and diffuse since it involves human and non-human agency, which is not located in one or another but in the heterogeneous associations between them.[2]

Design-to-Robotic-Production & Operation

Design-to-Robotic-Production and Operation (D2RP&O) builds up on interaction between human and non-human or cyber-physical agents not only at design and production level but also at building operation level, wherein users and environmental conditions contribute to the emergence of multiple architectural configurations. These utilise sensor-actuator mechanisms (fig.1) that enable building components and buildings to interact with their users and surroundings in real-time. Their conceptualisation and materialisation process requires D2RP&O chains (fig. 2) that link design to production and operation of buildings. In this context, design becomes process-oriented and use of space is time-based, which implies that architects design increasingly processes from which sensorially or physically reconfigurable buildings emerge.[3]

In this context, spatial reconfiguration serves a variety of purposes. It facilitates adaptation for ensuring physical comfort and/or efficient use of space by instantiating multiple, changing uses of physically built space within reduced timeframes. Furthermore, interactive energy and climate control systems embedded in building components make buildings smart and energy-efficient. For instance, the Swarmscape project (fig. 1) showcases a floating structure on the river Maas in Rotterdam. The flat soft-robotic structure offers passers by a surface to sit or lie down on and when the wind is blowing it curls up to offer shelter.

While the building components of Swarmscape are all dynamic and mostly soft, in most cases physically built structures are hybrid incorporating static and dynamic, soft and hard components. They require advanced virtual modelling and simulation that interface the production and real-time operation of physically built space[4] i.e. D2RP&O.

D2RP and D2RO are different but complementary processes. D2RP links computational design with robotic production (fig. 2) with the aim to optimize not only materialization processes at architectural scale but also material architectures. Several experiments involving additive and subtractive D2RP processes were focusing on porosity ranging from architectural (macro) to componential (meso) and material (micro) scales. If porosity on the macro scale

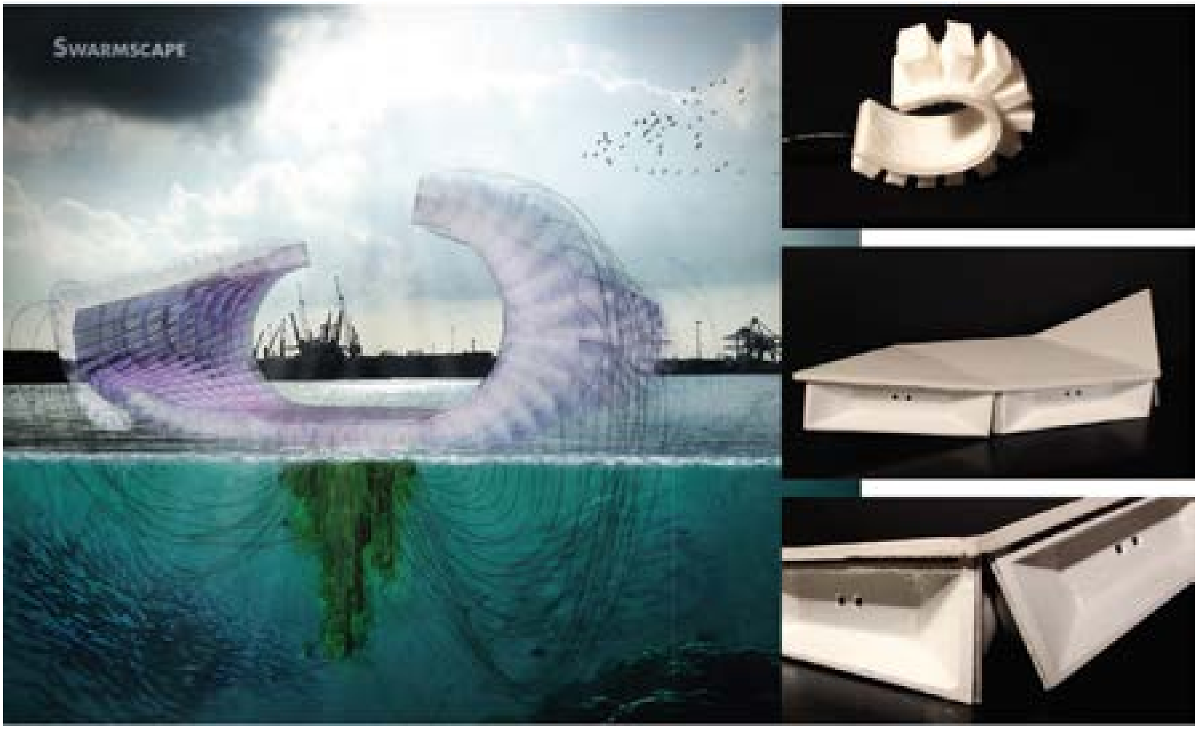

Fig. 1 Sensor-actuator mechanisms allow spatial reconfiguration according to environmental and human needs

Fig. 2 Design-to-Robotic-Production establishing a direct link between virtual modeling and physical fabrication.

is reflected, for instance, in the subdivision of buildings into rooms, the porosity at meso scale is generated by window and door openings, and at micro scale by voids in materials that are created to either reduce weight / material use, or in- crease thermal insulation, or accommodate integration of smart devices.

In order to, for instance, introduce porosity at material scale structural and environmental simulations are applied onto the overall geometry. The translation of the structural optimization results (fig. 2, left) from a finite geometry into continuous robotic paths for material deposition (or subtraction) is key aspect of the D2RP approach. With the aim to integrate computational methods such as Finite Element Method (FEM), Computational Fluid Dynamics (CFD), Particle Systems, etc. with robotic materialization methods, a chained approach for design information exchange is established. Various algorithmic form finding and optimization techniques, mostly in Rhino-Grasshopper and Python scripting-language ensure the systematic exploration of design alternatives, eventually providing the required information for production. Since material constraints cannot be fully modeled computationally, they are experimentally identified and are as well integrated[5].

D2RP connects physical materialization with virtual modeling and simulation by employing multi-performative computational design, multi-mode and –robot production, and multi-scale materialization. It, therefore, establishes a design to production feedback loop by linking the Rhino 3D model with Grasshopper plug-ins such as Millipede, Ladybug, etc. for simulating structural and environmental performance and then connecting it with the robotic arm[6]. The robotic motion, in terms of ranges of reachability, tools orientations and paths, etc. frames the digital design problem-space in relation to the physical solution-space thus contributing to identifying solution-space[7].

A variety of machinic processes implemented on all kind of materials that can be approached from all sides are implemented in multi-robot setups that allow operating several tools simultaneously, or in optimized sequences, e.g. one depositing 1st material, the next one depositing 2nd material or manipulating 1st or 2nd material. Such setups promote the vision of the robotised factory of the future in building construction. This requires development of a range of robots with specialized end-effectors able to implement different tasks, advancement of coordination scenarios for multi-robot operations as well as human-robot interactions, which will be focus of D2RP in the next years. If D2RP aims to achieve robotisation in building construction, D2RO aims to achieve robotisation in the operation of buildings.

Since D2RP and D2RO take place in more or less unstructured environments both involve similar challenges and opportunities. For instance, the D2RP employs laser scanning to capture the current status of the building process in order to establish a feedback loop between the virtual and the physical environments. Furthermore, the robots interact with humans, as for instance, human operators, who teach the robots to do certain tasks by guiding them with a tool or by hand, while dynamic safety systems are in place. Similarly, D2RO employs sensor-actuators such as light dependent resistors, infrared distance sensors, pressure and accelerometer sensors, etc. that are informing lights, speakers, heaters, ventilators, and/or reconfigurable building components allowing users to implicitly and explicitly customize the use of physically built space[8].

Integration of D2RP&O requires in addition to mapping structural, environmental conditions, mapping areas with distributed intelligent devices (fig. 9) onto the overall geometry. The resulting components are cyber-physical hybrids. They are conceived as porous systems, where the degree and distribution of porosity are informed by functional, structural and environmental requirements, while taking into consideration both passive (structural strength, thermal insulation, etc.) and active performances (adaptivity, reconfiguration, etc.). This implies that D2RP is informed by structural, function- al, environmental, and assembly considerations, while D2RO is informed by indoor climate and physical comfort requirements[9].

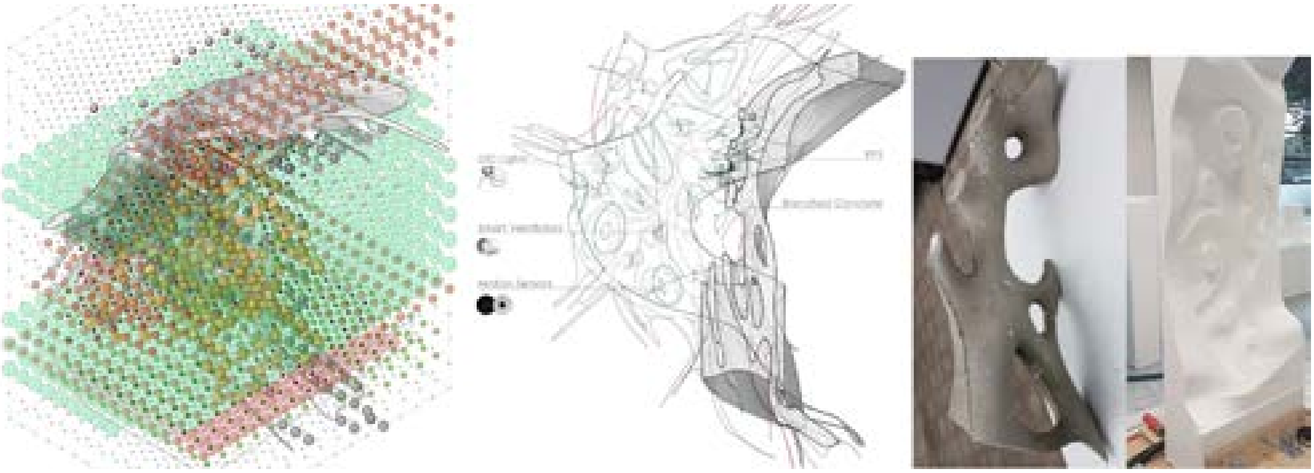

Fig. 3 Multi-layered point clouds (left) and D2RP&O integration logic (middle) of fragment made with concrete and EPS (right).

Fig. 4 Multi-layered D2RP&O allowing integration of smart devices into the building components.

The integration of D2RP&O has been explored in the project Hybrid Assemblies (fig. 9&10) that has been implemented with students from TU Delft and Dessau Institute of Architecture. The project focused on the development of architectural systems composed of hybrid components addressing mainly functional, formal, structural and climatic requirements. It explored the notion of embedded interactive or adaptive systems employed for controlling the climate and generating renewable energy. The distributed climate control has been conceived as a network of smart devices, locally driven by people's preferences and environmental conditions. In such a scenario the embedded devices would range from sensors detecting movement, temperature, humidity, etc. to actuators for opening windows, controlling sunshades or lighting, heating/cooling, and ventilation conditions.

The design took into consideration customizability of space and indoor climate by employing (not average but) real-time data. The design of the hybrid component relied on optimization strategies based on point-clouds, where each point incorporates both physical and non-physical information about the overall space. The sets of points provided different types of information corresponding to structural, heating/cooling, and lighting performances (fig. 9).

If the structural stress lines mapped onto the overall geometry generated the supporting structure, the required lighting with corresponding minimum / maximum thresholds of illumination in- formed the distribution of cavities enabling the integration of light-emitting diode (LED) lights. Heating and cooling requirements informed the distribution and integration of smart ventilation devices, and the position of required sensors for automated control. All these considerations determined the composition and arrangement of different materials such as concrete and expanded polystyrene (EPS) and identified optimal locations for the integration of smart devices (fig. 3&4), which collectively shaped the multi-layered hybrid component.[10]

D2RP&O aims to integrate a majority of requirements that a building, its production and operation have from the very beginning of the design process. This allows for streamlining processes, in- creasing productivity and product quality, which represents a considerable improvement of today's fragmented and sequential approach. It furthermore ensures increased capability for building on demand by employing multiple robots with changeable and customizable end effectors / tools, robot motion tool path components, micro-controllers and robot controller units.

While D2RP employs a variety of robots involved in the production and construction of buildings, D2RO utilises a multitude of computational and robotic devices that ensure smart operation of buildings. Even though they have different foci both rely on man-machine interactions involving dynamic control systems that are partially or completely automated.

Conclusion

D2RP&O links design and production with smart operation of the built environment. It advances computational and robotic applications in architecture and relies on the integration between D2RP and D2RO processes through human and non-human or cyber-physical interaction in the design, production, and operation of buildings. It, furthermore, relies on the understanding that the on-going fusion of the physical and the virtual generates a physical-virtual continuum that is containing hybrid degrees of physical and virtual conditions where the distinction not only between physical and virtual but also between natural and artificial is increasingly blurred.

The presented work highlights recent developments in D2RP&O that prove relevance of interaction and/or collaboration between human and non-human or cyber-physical agents in architecture, which is fundamentally changing the role of the architect. Architects design increasingly processes not objects, while users operate multiple time-based architectural configurations emerging from the same physical space that reconfigures in accordance to environmental and user specific needs.

In this context, D2RP&O research is relevant because of its impact on architecture with respect to material- and energy-efficient building and demand-driven production and operation of buildings. This implies that buildings are not demolished, remodeled, or newly constructed to fit changing needs but are reconfigured and built space is efficiently used. Furthermore, climate control and energy management respond not to average but real-time data ensuring customizable conform, while energy-loses through excessive or unnecessary illumination, ventilation, heating or cooling of little or even unoccupied spaces, etc. are considerable reduced.

The ambition is to further advance D2RP&O methods in order to not only increase process- and material-efficiency and improve interactive use of physically built space but advance human and non- human or cyber-physical interaction in architecture. In particular, artificial intelligence, i.e. machine learning that has contributed to the development of the Internet of Autonomous Things (IoAT), is of interest because of its potential to introduce autonomy in robotic devices. This implies that robotically driven building processes and buildings would to some increasingly operate without human intervention, which is the next step to take in D2RP&O.

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Acknowledgements

This paper makes reference to previous publications by Robotic Building researchers from TU Delft as a way of grounding the presented work. Presented research has been implemented with MSC students from TUD and DIA. It has been sponsored by 4TU, TUD, Delft Robotics Institute, 100% Research, DIA, ABB, and KUKA.

A Personal Reflection

Karim Soliman

Over the past decade, DIA has adapted a new and promising culture in Architecture that focuses on both research and experimentation using computational tools in design. This post-CAD culture has been achieved by adopting parameters and algorithms to aid design whilst implementing various digital fabrication methods in order to take advantage of the most advanced technologies. This was the core curriculum for several Experimental Design Studios founded at DIA. The DIA digital legacy began with leaders in the field such Prof. Neil Leach, followed by the co-founders of SPAN Architects, Matias Del Campo and Sandra Manninger; and Christos Passas, an associate director in Zaha Hadid Architects who established the Studio X at DIA.

This article is my personal reflection on the theoretical background of the digital design process and methodology that I embraced as a student in Passas' Studio X. I will also feature some of the projects that were conducted since the studio's establishment.

Computation is widely used to enhance our everyday life activities; it should therefore come as no surprise the same computational tools were adapted to further explores the architectural design processes. But what can massive computational power do in design? "Massive computer power allows: temporal compression of space, special compression of time, virtual prototyping to explore multiple design possibilities and direct computer control of fabrication tools and robotics"John Frazer [lecture at European graduate school-2014].

Temporal compression of space means that we can build models of very complex, physical systems, such as cities on our desktops; special compression of time means that we can manipulate time allowing us to witness the evolution of cities over hundreds of years in the space of a few seconds on our screens. We can create 4 dimensional simulations such as topological evolutions, site analysis, demographic analysis and geo-economics statistics through time for a specific city, country, continent or at a global scale.

In Figure (1). An algorithm was developed to calculate the optimal proximity between the

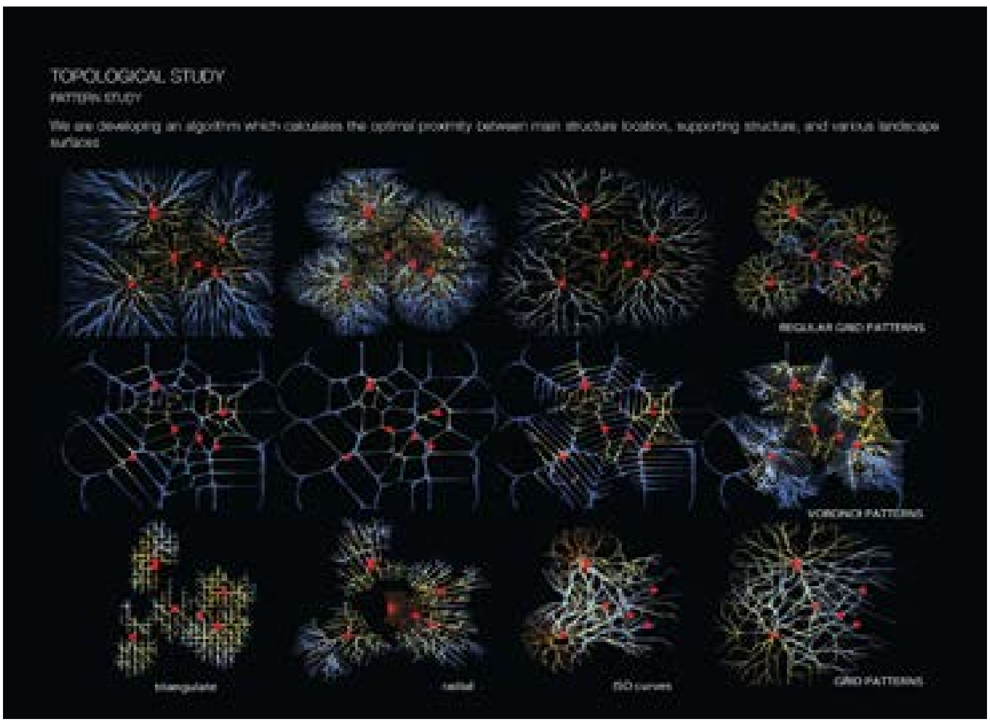

Fig. 1 Work of Asa Darmatriaji, Timothee Raison and Olga Kovrikova Project Dune-Lab Studio X 2012 lead by Christos Passas and Alexander Kalachev.

main structure location, supporting structure and various landscape surfaces.

We can employ computational tools to help understand our surroundings, building environment and nature. By mimicking natural behavior, we can learn from the performance of nature rather than from just its shapes. The term biomimetics represents the study of nature's methods, mechanisms and processes, studying the structure and the function of biological systems to influence design. For example, simulating self organized systems such as swarm intelligence, neural network or an ant's pheromone trail, has paved for agent based design models, where we can simulate crowd behavior in space. By utilizing branching systems such as voronoi diagrams, space subdivisions and fractals in 2d and 3d models helped inform different tessellation technique. Whilst learning from pattern logics such as reaction diffusion and cellular automata, we have even begun to create new and original spaces. By simulating these different natural behaviors in computer models, we have total control to manipulate its parameters and experiment infinite possibilities of iterations.

In figure (2), using reaction diffusion logic to generate different pattern formations.In figure (3), 3d printed necklace resulting from simulating the structure growth of coral reef.

Translating complex behaviors such as randomness, dynamics of chaos, genetic algorithms and networks into computer syntax allows us to understand the algorithms behind these behaviors and use them to address complex design tasks.

"Computational design has many generative techniques such as parametric (manipulating variable geometry), combinatorial (rule based systems), substitution (L system, shape grammars), agent based (swarm), mathematical (description by equation, algorithm) and others". [John Frazer]. Each technique has its own process and can be suitable for certain design tasks. The choice will be based on the specific design concept, the requirements of the project and constrains of its environment.

In 2011, Studio X lead by Christos Passas and

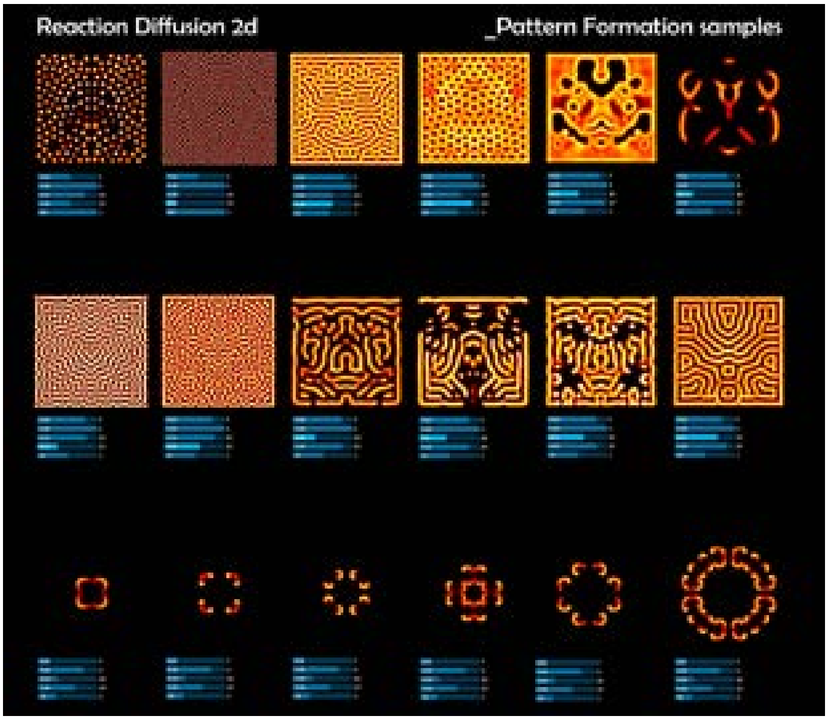

Fig. 2 Work of Ioana Ciobanu and Ahmed Eid Rihan Project Emerging Habitat Studio Nomadic Forms 2014 lead by Alexander Kalachev and Karim Soliman

Fig. 3 Work of Arpi Mangasaryan, Project Natur-Mort – Cad-Logic course 2016 lead by Karim Soliman.

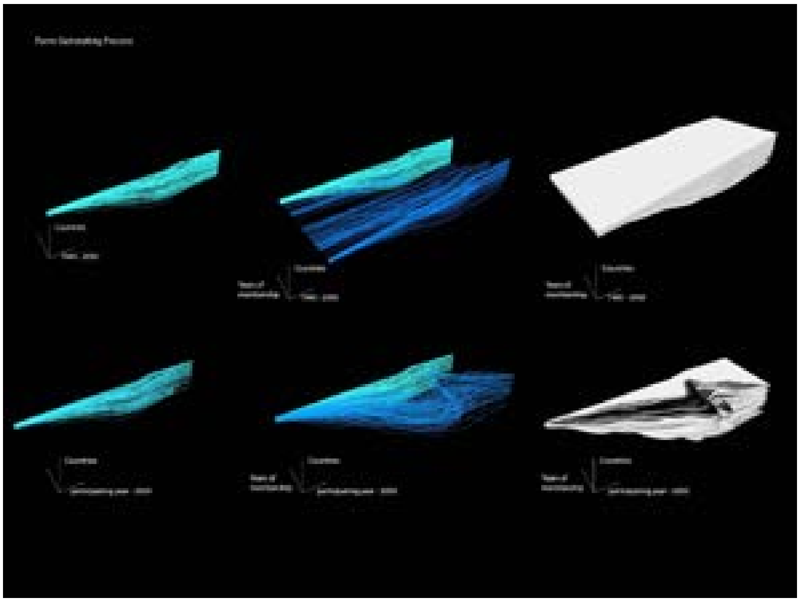

Fig. 4 Work of Karim Soliman and Mircea Mogan, Project Human Development city Studio X 2011 lead by Christos Passas and Teaching assistant Alexander Kalachev.

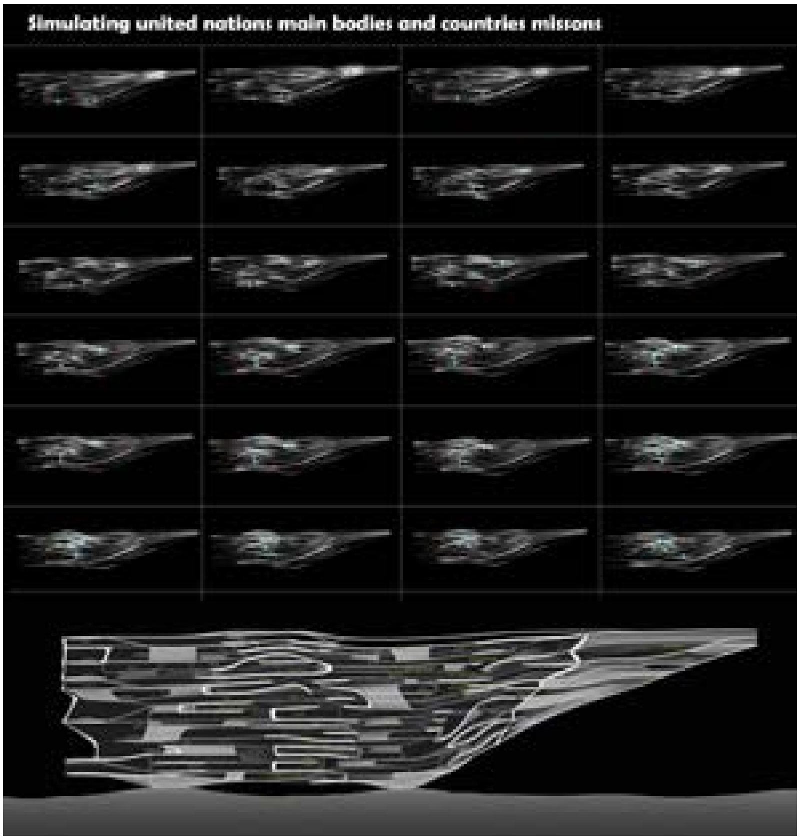

Fig. 5 Work of Karim Soliman and Mircea Mogan, Project Human Development city Studio X 2011 lead by Christos Passas and Teaching assistant Alexander Kalachev.

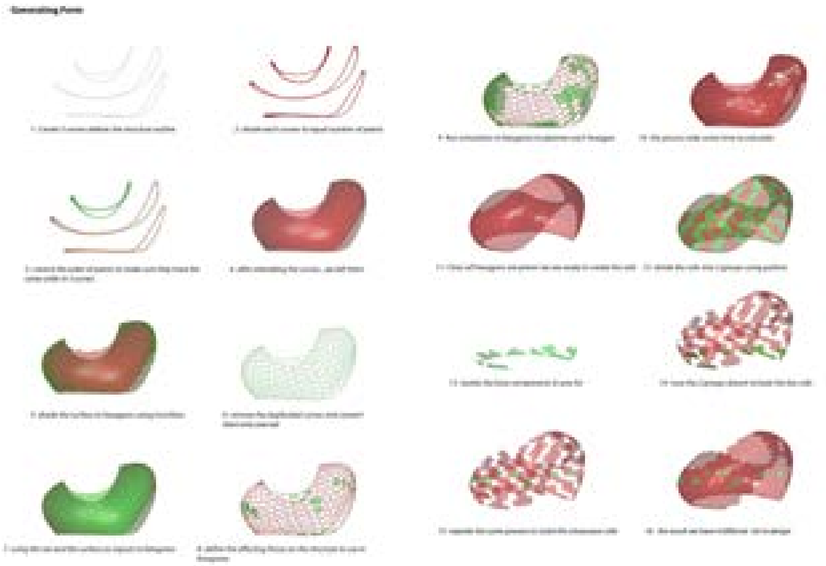

Fig. 6 Work of Michelle Chung Chien Yin, Leong Chee Chung, Pua Wan Ling, and Lee Xiao Hui project Hex 316 Pavilion CAD-Logic course 2017 lead by Karim Soliman.

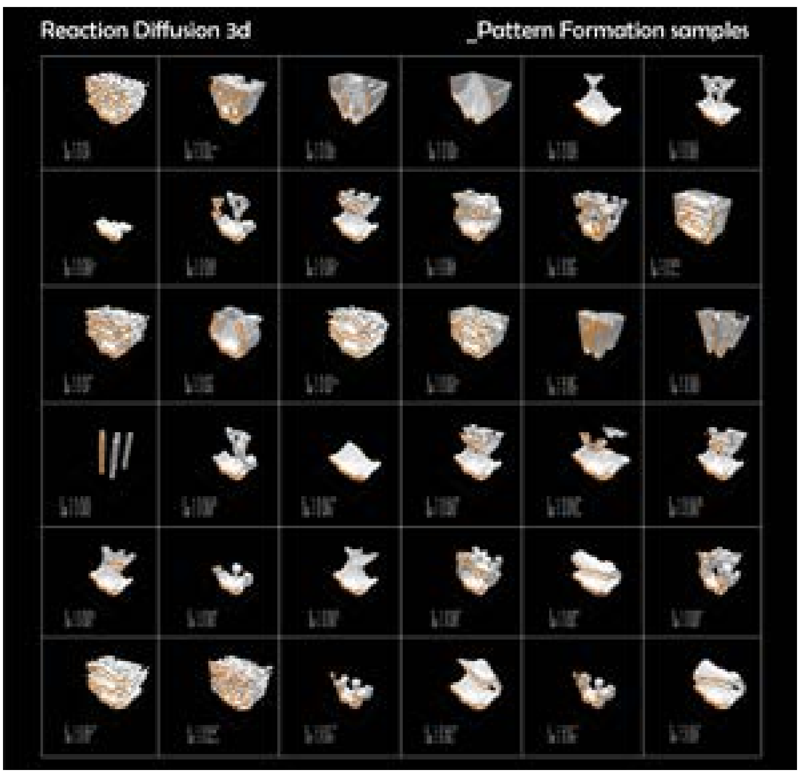

Fig. 7 Work of Ioana Ciobanu and Ahmed Eid Rihan project Emerging Habitat Studio Nomadic Forms 2014 lead by Alexander Kalachev and Karim Soliman.

assisted by Alexander Kalachev focused on re-designing the headquarters of the United Nations. How could we use computational tools in order to design a building that represents all the countries of the world and celebrate their diversities? Can this building be generated from completely new inputs such as tracing human growth and immigration through the history of the world? Can it represent the member countries of the UN by translating a statistical relationship that traces their progress based on the HDI (Human Development Index) since they joined the UN?

The answer is yes. Today we can build a logic of series of equations or an algorithm that controls the relationship between a building's spaces and their functions. In this project, we simulated different iterations until we reached the optimum distribution of functions inside the building. We defined an algorithm to determine the location of the UN main bodies (such as General Assembly, Security Council, etc) and another algorithm to periodically change the location of country-missions in the building. The idea was to keep the same neighboring condition between the missions of highly developed countries and low developed countries in an attempt to encourage informal communication between their missions.

Virtual prototyping allows us to explore multiple design possibilities and generate many design iterations as a result of changing one factor of the same operation. In this design loop we are required to ask the right questions that will become our Boolean gates: if condition 'True' occurs, then perform action 1; if condition 'False' occurs, then perform action 2. You always can add to the loop more simple yes or no questions to achieve the optimum result that answers your complex design task. Once we arrive at a design proposal, we can analyze their energy performance; simulate their spatial relationships within the surrounding context or analyze their structural efficiency and resilience to natural catastrophes to avoid failure. If the output is not satisfying, we can always go back into the process and change the variables to come up with more optimized solutions. That is what I would like to refer to as a design loop.

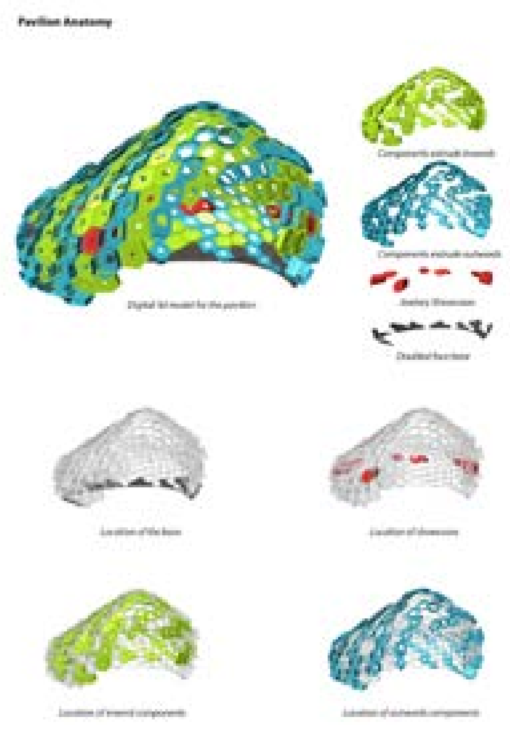

Fig. 8 Work of Michelle Chung Chien Yin, Leong Chee Chung, Pua Wan Ling, and Lee Xiao Hui project Hex 316 Pavilion – CAD-Logic course 2017 lead by Karim Soliman.

Today a construction revolution has manifested itself in digital fabrication. New technologies originally developed for other industries are being adopted by the building sector. This, coupled with the new design tools of the 21st century has pushed the boundaries of design to an extent we have never seen before: we have begun to use CNC machines, robotic arms and 3D printing technologies; using the latest materials to create structures with huge spans and double curvature surfaces along with BIM/CAM models to translate these designs into numerical language for machines to implement. Today as a result of direct computational control of fabrication tools and robotics, the quality of design work continues to develop and the margin for error shrinks.

Every day we rely more on automation in the design loop and fabrication processes. In the near future, the design processes of today might be automated and our job will be to program the machines.

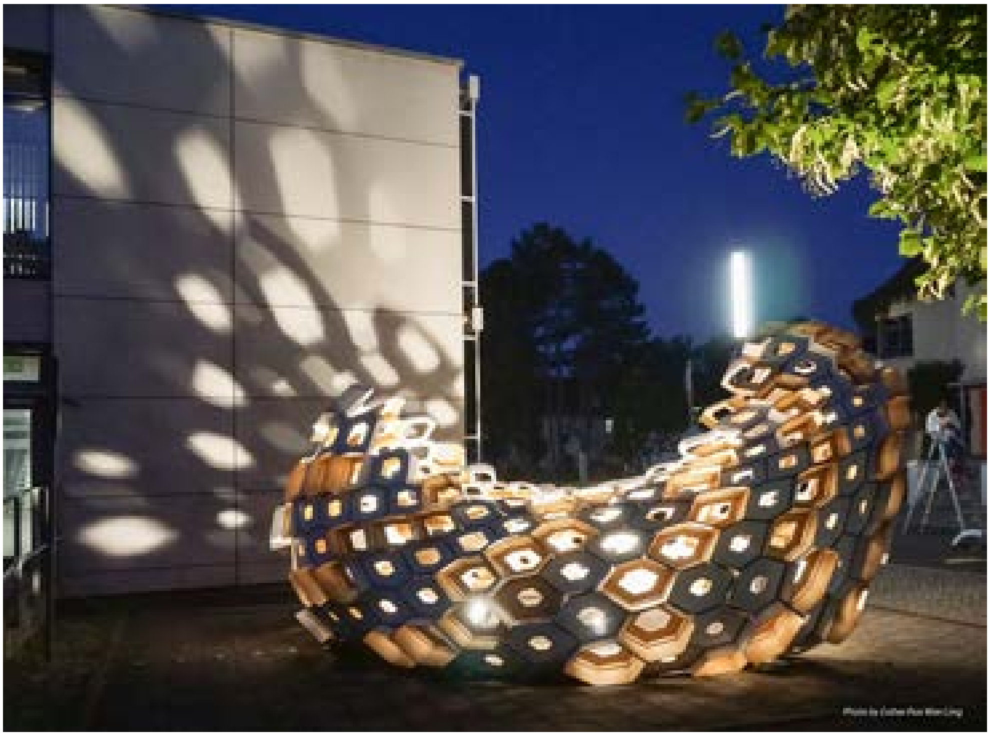

Fig. 9 Work of Michelle Chung Chien Yin, Leong Chee Chung, Pua Wan Ling, Lee Xiao Hui project Hex 316 Pavilion – CAD-Logic course 2017 lead by Karim Soliman.

The Dead Emperor: A farewell to representation?

Carlos Campos

Casus

The etymology of the Italian term goes back to Latin casus - us which means falling.

The Latin word corresponds to the Greek word πτώσις which has only a grammatical meaning.

Latin casus refers both to grammar and to ontological dynamics; in the second sense indicates something that unexpectedly happens, which falls in front of us.

Casus, WP, 2017

Architecture and the end of the Representation

In his tale The construction of the Chinese wall, Franz Kafka tells us how the Chinese Empire announced the death of an Emperor. Immediately afterhis demise, hundreds of messengers would depart in all directions across the empire, to spread the news. The messengers served as the oficial voice of the Empire. They had to get to every city, every village, every hamlet. However, the Empire was so vast, that usually it took years to complete this task. During these years, it sometimes ocurred, that even the successor had died. In that case, a group of new messengers travelled the same paths to announce the second in succession to the people. The Chinese Empire could thus have several Emperors reigning concurently, depending on whether the latest news had arrived to a place or not.

Gregory Bateson claims, that usual concepts and ideas about politics, religion, science, or art arrive at everybody's doorstep with a delay of 50 years, when viewed relative to academic, experimental or avant-garde thinking. It is the same situation that Kafka's narrative points to.

In this article, however, the allegorical concept an Emperor is not used to portray a tyrannical relationship between ruler and subject. On the contrary, I believe, that nowadays the paradigm shift of beliefs, could provide us with a stable system of references that offer safety, order and planning.

Yet, in our contemporary world, every generation calmly manages its everyday life still relying on diverse anachronistic, even antagonistic systems of belief. It seems that, our present-day societies, which encompass our cities and countries, we still have messengers, who update information. Step by step, they try very hard, to make us believe, that former times have given way to newer ones. They determine what our new rules are. Some people listen carefully to the Emperor´s messenger; others not so much. Some reject the new order, others avidly embrace it. Some learn to live their whole life side by side with this messenger, ignoring him completely. Others immediately change their custom in accordance with the new evidence presented to them. It seems very tempting, to think of the messenger and its Emperor as two completely different entities. However, it really is impossible to explain one without the other, as they are irreducible, as they are totally complimentary to each other.

This leaves us with an array of questions: Who are the Emperors? Who are the Messengers? How long can they rule the world? Are they visible? How can we recognise such messengers?

Their teachings and – as an outcome of it – the new results, do not differ much from the previous analogies. Especially when turning to a discipline such as Architecture or Design. Some Emperors gave the impression of trying to reign forever, others have been quickly forgotten. There are even some, whose powers were never subject to discussion. And not to forget: an Emperor is not necessarily a person. For instance in the case of designers, matters of style can rule supreme. This is likewise true for matters of Technology, Methodology, Representation, Tradition, Geometry, Innovation etc.

The 20th century had its great Emperor, called the Modern Canon. Criticism, Publications, Biennials and different Schools of Architecture and Design served as its skilled messengers. Just like the ancient Emperors, Modernity always wanted to be known, viewed, discussed, exhibited and recognized, within all corners of its Empire.

The Architecture of the future?

For several decades, we have enjoyed Contemporary Art. Its definition, its resources and its implementation cannot be distinguished from any other way of human expression. Today,there is literally no difference between something that is Art, and something that is not. Regarding such practice, Art is perhaps the most outstandingly democratic cultural condition. Because, at the forefront of its production, it is able to install figures with little or even no training in the field. Despite such revolution, Contemporary Art has continued to manifest itself in all its multiple facets. It has not disappeared, nor is dead; it even doesn´t seem to be in any kind of danger. We all know Art anticipates life, politics, technology and other practices as well. What if this statement was also valid for Architecture? What if the Architecture of the Future is one in which there is no difference between what is Architecture and that what is not. Just like a Casus that just incidentally falls before us? How would we produce such Architecture? How would we teach it? Who would be its messengers? and who its Emperor?

The old messengers always taught us, that Architecture produces control, conciousness, negative entropy, stability, budget, predictability. Simultaneously, they paradoxically demanded freedom and creativity for it. The computer programs through which all architects and its students generate and define their projects today, always respond to an absolute control, emerging from Cartesian coordinates of Space. They produce representational results by repetitiously running their programs over and over again. Everything is representation. In fact, schools of Architecture rarely confront students with the fascinating possibilities of non-representation.

Let us imagine that our contemporary Emperor sends us messengers, asking us to create several imaginary Architectures. Its images could exhibit no difference to those which we so far have classified as Non-Architecture. To arrive there, we could refuse the old canon, as a form of knowledge, or just admit that we have forgotten the old order a long time ago. So, can we really imagine an non-representational, random, unpredictable, entropic, unstable, unconscious, autonomous, non-compositional, non-referential Architecture?

Representation, our old Messenger

It is my firm belief, that, randomness which is produced with the help of computers never goes beyond its mere simulation. An algorithm will remain a tautology, since it operates within clearly discernible repetitive parameters. At least, as far as the the mathematician or the computer is concerned. So let's for a moment imagine, that we were sent images of some complex, unmanageable randomness. A randomness that neither leaves traces of its constitution, nor of the work needed for its production. A randomness that does not emerge from a computer or an algorithm. Such randomness is never simulated.

In fact, I have designed and built machines based on such imagination. The drawings that these machines have produced, have been exhibited in Berlin (Humboldt University, Grimm Zentrum Friedrichstrasse), Buenos Aires (FADU/UTDT), the Master Course at DIA in Dessau together with the work of students from many countries all around the world. The "Hello Wood" pavilion, the reconstruction of Giambattista Nolli´s Map of Rome, the project for the Argentine Pavillion at the upcoming Biennale di Architettura di Venezia in 2018: they all demonstrate several samples of complex non-representation. They are like an explanatory text of residue, event, life, art, architecture. Their basis is a non-mathematical generation of randomness, thereby producing totally uniqueness. Finally, it results in an architecture, that does not differ in any way from what is not Architecture at all.

Drawing Machines

Each one of these projects deals with two ideas. The first one is pure experimentation through machine-operation. Driving these drawing machines permits the user a low level of control only. The machine just produces some kind of to and fro movement, within a well defined field of operation. Its movement is usually circular or in a different way repetitive. All that is needed, is a dozen fine tip markers, which draw within a more or less stable environment. A flat surface like a table and a sheet of paper are the bare ingredients, that make such movements possible.

I call this step working without external information: Although there are countless external factors which affect the production of these drawings, they still are not activated by machinic work or specifically operational control mechanisms. (Fig. 1)

The second step, which I call working with external information, is one in which the machine movements are strongly controlled by the author, using a specifically designed pattern. The operator manages the time, the number of writting tips, the initial location of the machine, the number of cycles, the weight of the entire structure, the speed of the stroke, the location of obstacles, placed in the way of the machine, and so on. These factors are based on the abstract analysis of any natural or artificial system, and are fed to the machine via syntax diagrams (alphanumeric codes that encourage the repetition of various behaviors). Or in their absence, using a simple scheduled basis. (Fig. 2)

Together with the School of Engineering at the Federal University of Buenos Aires (FADU), I have addressed the project of an intelligent drawing machine in the past year. Using a small computer as a component, this drawing machine will soon be able to "read" such syntax diagrams by itself, outsmarting all my preceeding models. And this machine will be able to react to the same constraints of space, context or obstacles, just like the initial one. (Fig. 3)

Fig. 1 Work without external information. Drawing machines, FADU UBA Catedra Campos, student work.

Fig. 2 Work without external information. Drawing machines, FADU UBA Catedra Campos, student work.

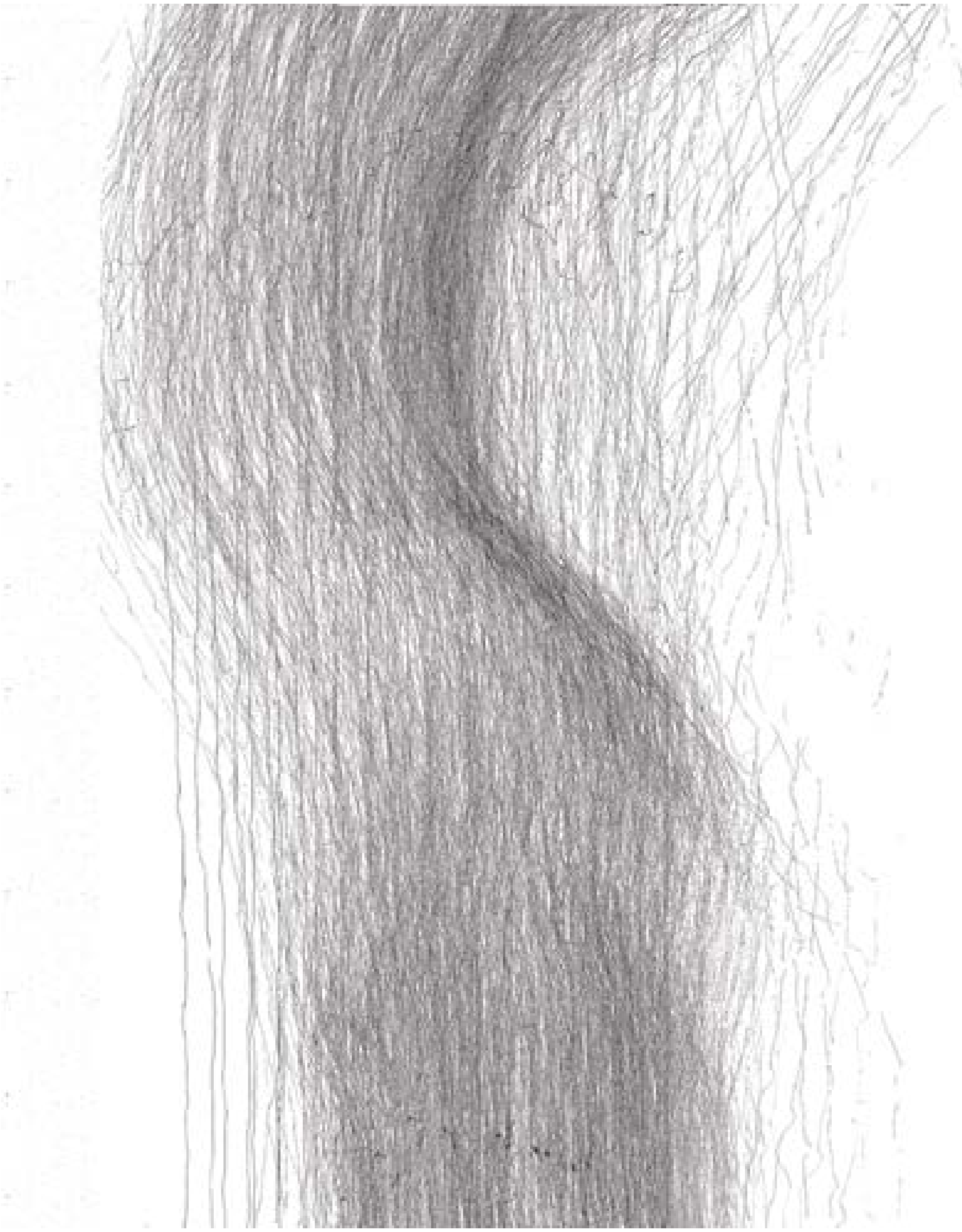

Fig. 3 Work with external information. Drawing machines, DIA 2015 WS Campos, student work.

Map of nodes

Drawing machines provide outcomes which resemble the view of a city, as observed from a satellite camera. Interestingly, both a city and a random mechanical drawings are artificial, yet human artifacts. They are both strongly linked to randomness. They always reflect the continuously changing contextual conditions in their search for balance. Continouosly working in this direction, we will enhance our knowledge about non-representation. We will study and learn of its modes of generation and growth. When observed through a magnifying lens, such results will provide us with amazing haphazard architecture,created through repetition and change. They will never produce a perfectly regular pattern. Instead, they always adapt to change. Just as a real city does.

Via a map of nodes and the method of polygonisation, such drawing machines transfer us to the complexity of the real world. These maps produce an architectural sense that lies beyond computers. They generate non-mathematical yet logical and traceable randomness, which is unique and not repetitious. These maps of nodes evoke real constellations. They can be converted into an Architecture ready for spatial structures. Such constellations are based on the concept of inter-semiotic translation, as their sign language produces cognitive similarity to other images familiar to us. By using syntax diagrams, their results often borrow informally from nature or from any other known cultural production.

Such an Architecture is produced through the generation of random structures. Its basis is spatial formation, composed of non-repetitious and irregular tetrahedrons. These random structures articulate the map of nodes in space, according to organizational patterns or other results obtained with syntax diagrams. (Fig. 4)

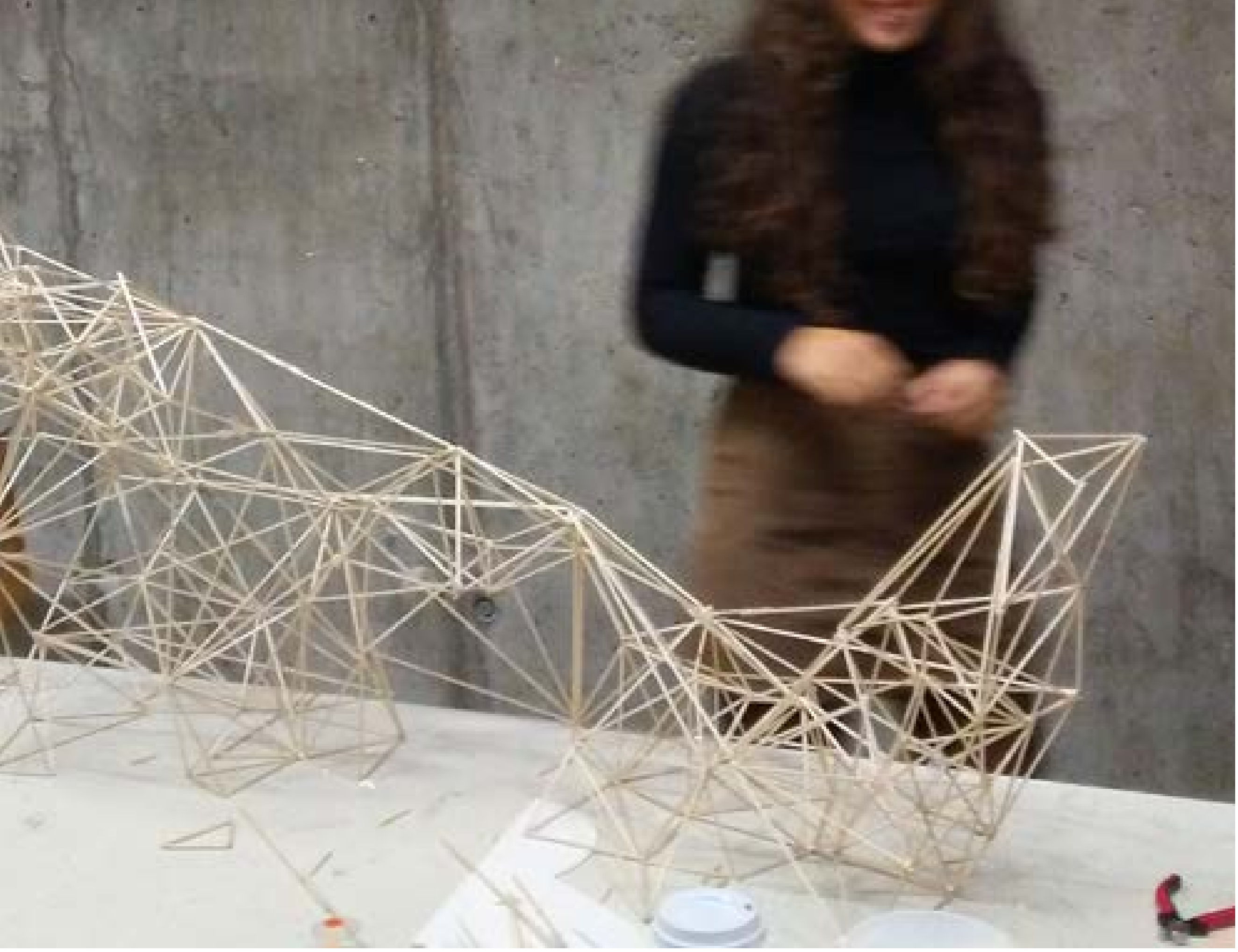

Fig. 4 Work without external information.The Irregular Pavilion, DIA 2017 WS Campos, students work.

Spatial organizations

A Map of Nodes initially always provides a flat constellation. By fixing hoisting points and using interlacing tetrahedral-shaped segments, it can undergo spatial transformation, whereby its emergence is steadily based on random logic. Much like the maps of Buckminster Fuller, which are geometrically always polygonal, we built a random emergence of several structures. Like Giambattista Nolli's Map of Rome, a Pavilion for the Biennale di Venezia as well as our irregular Pavillion at Hello Wood in 2017. These projects are carried out in different scales, but always follow the same logic. For the Nolli Map of Rome, we built a model made of wooden bars that were 1 square millimeter in section. While for the 2017 Hello Wood Pavillion, we used plywood bars with a section 2000 times bigger. Each step requires a different technology, from wood glue, to specifically designed blacksmithing for the Pavilion. Yet, strategies converting a flat random and unpredictable organization into a spatial context, are always personal. Thus, its results are always innovative and surprising. (Fig. 5)

Nowadays we have ample technical, intellectual and economic means to generate habitat in varying contexts, under different circumstances, for any user in vastly changing conditions. Given such availabilty, the problem of Architecture seems no longer a problem of technology or economics. These questions and their potential answers have predominantly moved into the realm of politics. To me, it seems time, to make space for the Messenger of Non-Representation. He was sent to us by the random work of Casus. With it, Architecture becomes an everyday democratic fact, which by its nature is completely unrecognizable.

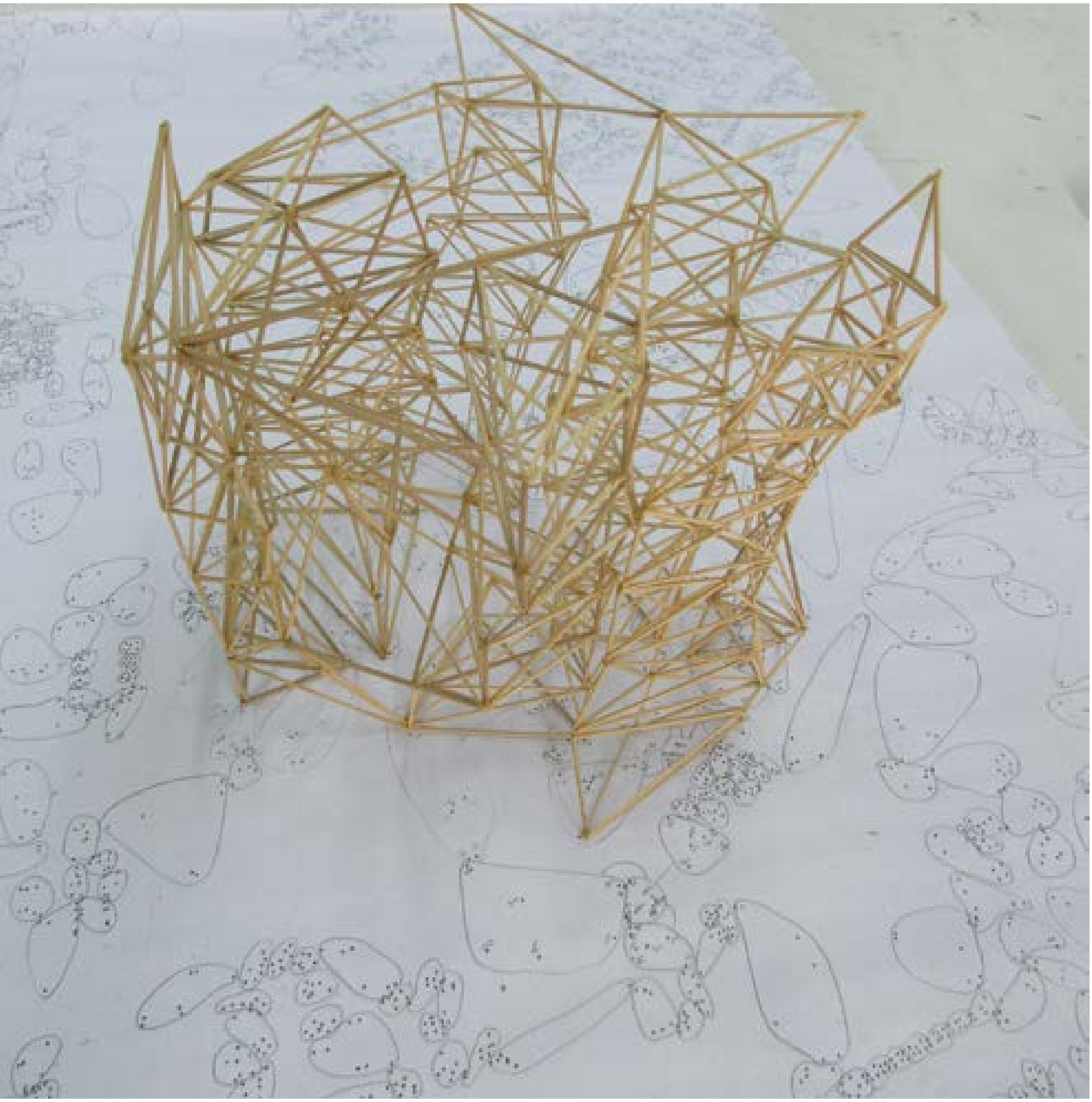

Fig. 5 FADU UBA Catedra Campos, Nolli Map of Rome.

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