The architecture of the future

Andrea Macruz[1]

Resumo

O presente trabalho procura ilustrar uma arquitetura não padronizada ou não uniforme que surgiu a partir do século XXI, com novos materiais, tecnologias, informações sobre genética e biologia, softwares e sistemas de computação extremamente desenvolvidos; em outras palavras, uma nova gama de possibilidades na produção da arquitetura. Isso permitiu uma outra perspectiva, na qual muitos arquitetos não estavam interessados apenas em projetar uma forma final, mas na criação de softwares e suas variações automatizadas, como programas de software genéticos que podem resultar em uma enorme quantidade de novas formas. Este texto é uma compilação da parte teórica e prática de um workshop lecionado pelo Prof. Karl Chu no Mestrado em Arquitetura Biodigital, na Universidade Internacional da Catalunha, em Barcelona e um convite à reflexão sobre a arquitetura do futuro.

Palavras-chave: Karl Chu, arquitetura genética, softwares generativos, metafísica.

Introduction

Prof. Karl Chu is an architect and teacher who uses the metaphysics of computation as a generative principle for his projects by exploring the manipulation of natural, mathematical and computer codes to design spaces and create forms. He has lectured, published and exhibited his work internationally.

“What we know as Metaphysics, in a strict sense involves transcendental philosophy and the physiology of pure reason. The first purely studies the understanding and the reasoning in the system of all concepts and principles that refer to a objects in general, despite the objects themselves (ontology); the second considers Nature, which means the conjunction of its given characteristics (through the senses or, if wanted, through any other type of intuition), and is consequently physiology (but only rational)”.110

So, based on metaphysical concepts, Karl Chu first conceived the contemporary notion of genetic architecture as an idea that would transcend its biological origin, thought as an extension of the philosophical concept of genesis, and explored with the creation of logical systems.

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110 “Lo que se llama metafísica en sentido propio comprende la filosofía trascendental y la fisiología de la razón pura. La primera estudia sólo el entendimiento y la razón en el sistema de todos los conceptos y principios que se refieren a objetos en general, no interesándose por

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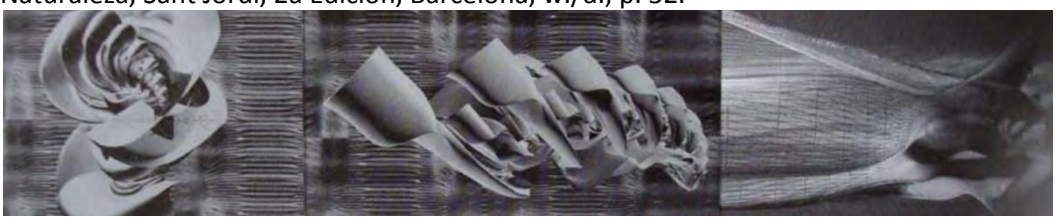
objetos dados (ontología); la segunda considera la naturaleza, es decir, el conjunto de los objetos dados (a los sentidos o, si se quiere, a otra clase de intuición) y es, consiguientemente fisiología (pero solo racional)", translated by the author. PETIT, J. Mª, Filosofía de la Naturaleza, Sant Jordi, 2a Edición, Barcelona, w./d., p. 32.



Karl Chu's works exploring the manipulation of codes; VV. AA (A), 2003, p. 254.

A logical system, or formal system, is the set of intrinsic properties, or its description, in an external phenomenon. It is the derivation of one expression from one or more other expressions antecedently expressed in a system. These expressions are called axioms. Hence, axiom is the first chain, in which a formal system starts to develop. These systems serve for the propagation and mutation of hereditary information (genetic codes) involved in the architectural design process.

"Genetic architecture is situated at the intersection of two complementary modes of development: endogenesis and exogenesis. Endogenesis pertains to ontogeny111 founded upon an axiomatic principle or code, which determines the development of phenotypes, or emergent forms of a species, and based on the interaction of genotypes. Exogenesis corresponds to phylogeny, the evolution and differentiation of species from a non-linear historical perspective.112

However, these genetic codes or algorithms113 are used merely as conceptual tools in Karl Chu's experimentation for the reconsideration of the essence of architecture and genetics. He therefore suggests an architecture that fulfills the needs at the convergence of computation and genetics.

As a consequence, he treats morphogenesis based on some absolutely abstract principles, such as code chains and mathematical formulas which consider just the elemental part and leave aside information on the material and its physical and geometrical properties. This is the result of fully comprehending the principles of physical systems and material self-organizations that occur in nature.

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111 "Ontogeny refers to the initial process in the generation, the form as opposition to shape". Extracted from Karl Chu's lecture "The Architecture of Possibles Worlds", III Jornadas Internacionales Arte y Arquitectura Digital, Net, Art y Universos Virtuales, Universidad de Barcelona (UB), Barcelona, March 2008.

112 VV. AA (A), The Metapolis Dictionary of Advanced Architecture, Actar, Barcelona, 2003.

113 "An algorithm is a process of addressing a problem in a finite number of steps. In doing so, it serve as a codification of the problem through a series of finite, consistent and rational steps…Traditionally, algorithms were used as mathematical or logical mechanisms for resolving practical problems. With the invention of the computer, algorithms became frameworks for

implementing problems to be carried out by computers", translated by the author. TERZIDIS, Kostas, Algorithmic Architecture, Architectural Press, Great Britain, 2008, p. 15.

"The meanings of both terms, 'genetics' and 'gene' are sufficiently abstract and general to be used as concepts that have logical implications for architecture without being anchored too explicitly to biology. Implicit within the concept of genetics is the idea of the replication of heritable units based on some inherent rule within the genetic code, and embedded within this mechanism for replication is a generative function: the self-referential logic of recursion. Recursion is a function or rule that repeatedly calls itself or its preceding stage by applying the same rule successively, thereby generating a self-referential propagation of a sequence or a series of transformations. It is this logic, encoded within an internal principle, which constitutes the autonomy of the generativeness that lies at the heart of computation".114

It is important to see that, in this type of architecture, a project is more dependent on information than its materiality, due its level of abstraction. Therefore, the architect must design the formula and set the parameters. Then, the resulting forms emerge from this set of rules drawn from a totally objective decision and far from a subjective morphological analysis.

With that objective in mind, the Studio conducted an exercise to explore the generation of axioms embedded with the recursive method, its evolution through diagrams, and to create a formal system and its translation into different morphologies.

For that purpose, it was necessary to do a series of preliminary exercises for the understanding of these new concepts in architecture and design based on the genetic paradigm. Thus, different recursive systems were introduced: linear and cycle branching systems, matrix systems, and even the invention of some recursive rules was proposed.

According to Karl Chu, information is the currency of life115. Therefore, in order to better understand the construction of this new possible world, there was a need for extensive study on computers and procedures, from the invention of the Turingmachine and the Internet, DNA computing, self-replicating and recursive systems, to algorithms, phenomenology, metaphysics and architecture.

We begin with the definition of some important concepts for the explanation of this Studio, and some works that follow this line of thought. Then, the Studio exercises will be presented in a chronological order, for a better understanding of the procedures and concepts explored, and will be divided into: Linear Branching System, Matrix System, Topological Surfaces, Matrix Mapping and Cycle Branching System.

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114 CHU, Karl, "Metaphysics of Genetic Architecture and Computation" in, CASTLE, Helen (Ed.), AD Architectural Design Programming Cultures: Architecture, Art and Science in the Age of Software Development, vol. 76, nº4, Wiley Academy, London, August 2006, p. 45.

115 Extracted from Karl Chu's lecture, Biodigital Architecture Master, ESARQ (UIC), Barcelona, 2008.

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This Studio is the most experimental current of all Master, leading to a totally innovative and abstract way of thinking architecture. It suggests new paths ready to be opened, providing their necessary theoretical and philosophical basis.

Due to its general and abstract nature, it can also support many variations of form inherent to its generative logic; a universal system able to compute all kinds of forms through the application of different algorithms (like a universal form calculator). With this logic, minimum information is required to generate a maximum outcome, allowing for an enormous amount of results.

Studio Metaphysics of Genetic Architecture and Computation

"Computation is a term that differs from, but it is often confused with, computerization. While computation is the process of calculating, i.e. determining something by mathematical or logical methods, computerization is the act of entering, processing or storing information in a computer or a computer system… computation is about the exploration of indeterminate, vague, unclear, and often ill-defined processes; because of its exploratory nature, computation aims at stimulating or extending the human intellect".116

In an ample manner, computation is a system that processes information through a sequence of steps by taking the results of its preceding stage and transforming them into the next stage according to a recursive function, based on algorithms.

In 1936, Alan Turing described the Turing machine, which is a basic abstract symbol-manipulating device, which could be adapted to simulate the logic of any computer algorithm. Furthermore, the Universal Turing machine (UTM, or simply a universal machine) would be able to simulate any other Turing machine. According to Turing: every function which would naturally be regarded as computable, can be computed by the Universal Turing Machine.

Turing machines consist of a line of cells, know as the "tape", together with a single active cell, known as the "head". This head can have several possible states (represented by several possible arrow direction in the first picture bellow). Also, the rule for the Turing machine can depend on the state of the head and on the color of the cell at the position of the head.117

Seventy years after the invention of the Universal Turing machine, an information revolution has occurred with the rise of Internet, which can be considered the most significant and now indispensable event in the history of communication. The Internet, or what could also be regarded as the universe of the Adjacent Possible by Stuart Kauffman, is the expansion of networks of reaction within an interactive system of connectivity.118

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116 TERZIDIS, Kostas, op. cit., Prologue.

117 Extracted from: WOLFRAN, Stephen, A new kind of science, Wolfran Media, Canada, 2002, p. 78.

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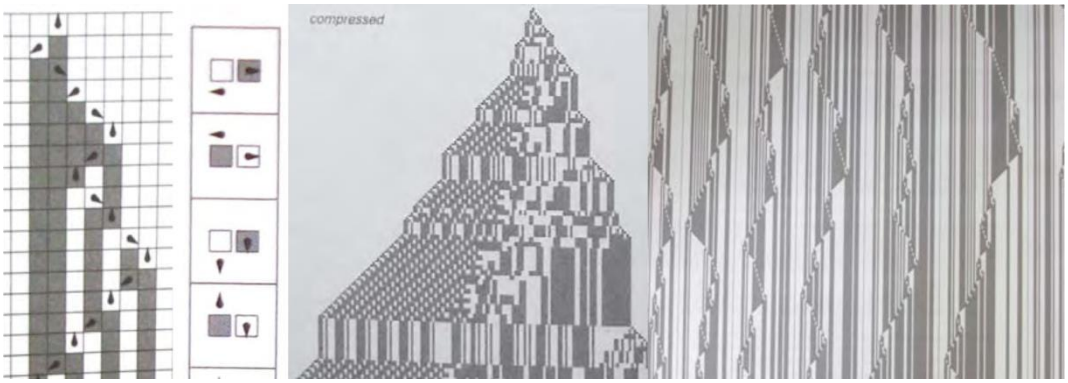
118 Extracted from: CHU, Karl, “Metaphysics of Genetic Architecture and Computation” in, CASTLE, Helen (Ed.), op. cit., August 2006, p. 39.



An example of a Turing machine (photos1-2) and a Turing machine that exhibits behavior, which seems in many aspects random (photos3-4); WOLFRAN, Stephen, 2002, pp. 78, 81.

This is how the Internet has marked a new World Order by reconfiguring the planet with a virtual, interactive, intelligent and autonomous space that will connect people, buildings, objects, surroundings, etc.

It is at this level of the construction of possible worlds that its architectural implications are more visible: “architecture is becoming increasingly dependent on genetic computation: the generative construction and the mutual coexistence of possible worlds within the computable domain of modal space”. 119

Therefore, the ambitions of a computation that will provoke these changes in architecture and in the world are already apparent: computing machines are connected to artificial life and intelligence systems, either through abstract machines or through the creation of new substances, in order to understand the complex patterns and structures of behavior observed in systems of nature.

All of this leads to the transmutation of the physical world into the domain of possible worlds: a computation monad.120 The computational systems today could be constructed at an atomic scale: groups of nanobots would function in accordance to a simple set of rules.

The search for a Universal Language that could contain all the necessary attributes and functions to inscribe the form and structure of all computable worlds was the origin of computation, and once again now, it is becoming one of the most persistent wills in the history of computation.

Considering computation is about information processing at the most fundamental level, John Wheeler, initiated a theory, in the latter half of 20th century, that the laws of physics are based on mathematics, which makes those laws computable. This intrinsically means that physical processes are in fact forms of computation.

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119 CHU, Karl, “Metaphysics of Genetic Architecture and Computation” in, CASTLE, Helen (Ed.), op. cit., August 2006, p.39.

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120 A monad, presented by Leibniz in his “Monadology”, is the active unit as the principle of Nature. CHU, Karl, “Metaphysics of genetic architecture and computation” in, VV. AA (D), op. cit., p. 170.

This notion was specified in the formulation of Stephen Wolfram: “All processes, whether they are produced by human effort or occur spontaneously in Nature, can be viewed as computations”.121 This proposition reflects a fundamental shift in the way we think the physical universe.

Rather contemporaneous to the development of computation in the beginning of the 20th century, the discovery of the DNA code was made, and with it the consequential development of the Human Genome Project. With the convergence of computation and biogenetics, now the world is finally moving into the so-called Post-Human Era, which will bring forth a new kind of biomechanical of organic and inorganic substances and the creation of new species.

As a consequence of this radical shift in some prevailing paradigms in sciences, there is now room for the potential emancipation of architecture from anthropology, (which has always been one of its subfields), enabling us for the very first time to think about a new kind of architecture with its own autonomy and own will to be, and one which more adequately adapts to the demands imposed by computation and biogenetics.122

However, architects are still operating under the same old kind of architecture even though have incorporated computer systems, for they use computers simply asdrawing tools; in other words, “architecture has still yet to incorporate the architecture of computation into the computation of architecture.”123

Within this contemporary scenario of architecture, it is possible to find two divergent currents with different theoretical formulations: the morphodynamical approach (which deals with programmatic issues and is itself divided into two more scopes) and the morphogenetic system (which is based on the direct construction of objects).

The most influential architectural proposal within the morphodynamical approach is that by Rem Koolhaas, who is concerned primarily with the organization and modulation of the forces that operate on the global market economy and their relation to architecture.

Like this, he calls attention to the general economy of abstract machines that regulate monetary flux, systems of production, new markets, supply chains, shopping centers, modes of distribution, shifts in demography, traffic patterns and the proliferation of wastelands and JunkSpace, among others.

Unlike the real dynamical systems that are found in Nature, Koolhaas’s vision of architecture is a consequence of the market economy and does not lead to the dynamical construction of architecture itself, but it is a kind of architecture of sublimation, criticizing the system in which it is inserted.

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121 WOLFRAN, Stephen, op. cit., p. 715. 122 Extracted from Karl Chu’s lecture, Biodigital Architecture Master, ESARQ (UIC), Barcelona, 2008.

122 Extracted from Karl Chu’s lecture, Biodigital Architecture Master, ESARQ (UIC), Barcelona, 2008.

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123 Karl Chu's lecture "The Architecture of Possibles Worlds", III JornadasInternacionales Arte y Arquitectura Digital, Net, Art y UniversosVirtuales, Universidad de Barcelona (UB), Barcelona, March 2008.

For Koolhaas, MM&M (Money, Matter and Meaning) represents the supremacy of architectural capitalization, which suppresses its autonomy and liberty, evidenced by globalization.

Therefore, his main interest is neither the formal genesis nor the search for architectural autonomy, but the dynamics of the capital regime and its logotypes that affects the current architectonical construction.

The second current in the morphodynamical approach is represented by architects who work in the digital field, some of whom are interested in "the softmorphology", while others are into biomorphic representation.

They play with the use of dynamical features such as particle systems and inverse kinematics available in animation software and explore the idea of mobility and flow, influenced by Greg Lynn's animate form.

However, a problem with this method is that virtual forces are considered as to behave in the same way as in the natural world. Consequently, and sometimes due to the lack of a more critical posture in the use of these software, architectural projects may seem like Hollywood animations, without real content.

"The characteristic feature of dynamical systems in general is that they are fundamentally not equipped with constructive processes. The formal constitution of these systems is predicated on the quantitative properties and couplings of interacting elements, which are constructed as unformed matter, and they fail to represent elements as objects with distinct internal structures that can give rise to behavior."124

The morphogenetic current of thought prescribes the idea of an internal principle that generates architectural form and organization. It is the idea of an architecture which is more full of life (due its dynamics systems), and that diverges from themorphodynamical approach, which depends exclusively on exogenous factors to create shape in architecture.

The morphogenetic approach can be divided into three lines that somehow apply the concept of rewriting: a genetic hermeneutics of architecture, represented by Peter Eisenman, an algorithmic architecture explored by Cecil Belmond and others that look into the fractal systems, L-systems125 and genetic algorithms to generate recursively defined geometric objects and a genetic monadology126 of architecture that is based on symbiogenesis127 for the construction of possible worlds, explored, for instance, by Karl Chu.

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124 CHU, Karl, "Metaphysics of genetic architecture and computation" in, VV. AA (D), op. cit., p. 166.

125 For a more complete approach search for projects using L-systems.

126 Monadology arose the theory of an open-source architecture based on the principles of philosophical genetics from a metaphysical point of view (an abstract one), considering the fact that a monad is a metaphysical point, an irreducible level of an atomic entity, endowed

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with an immaterial substance. A computational theory of monadology would qualify each monad as one self-replicating, self-organizing and self-synthesizing BIT of information at the most irreducible level. Resume of: CHU, Karl, "Metaphysics of genetic architecture and computation" in, VV. AA (D), op. cit., p. 170.

127 Symbiogenesis in this case means the co-construction of possible worlds by autonomous agents within a symbiosis. 128 Resume of: CHU, Karl, "Metaphysics of genetic architecture and computation" in, VV. AA (D), op. cit. and Karl Chu's lecture, Biodigital Architecture Master, ESARQ (UIC), Barcelona, 2008. 129 VV. AA (A), op. cit., p. 585.

Peter Eisenman can be considered the precursor of morphogenetic orientation, exploring intrinsic aspects of architecture by using some generative concepts and rewriting rules through the use of diagrams. It is a highly mathematical, complex and synthetic process.

He follows a genetic hermeneutics current, which is a generative proposal that gives structure and organicity to the interiority of architecture (which is its strongest point), but at the same time it is not specifically enough when it comes to the exogenous factors, becoming fragile when confronted with increasing globalization.128

Through these examples, it is possible to identify the contemporary architectural tendencies that explore a similar path and its relation to the phenomenon of globalization. It is now necessary to try to intertwine all of these currents into one that is even more adequate to the demands laid by the convergence of computation and biogenetics: a monadology of genetic architecture that deals with the construction of possible worlds.

It is important to clarify that genetic architecture is not a representation of biology or a form of biomimesis. Its concepts are based on the logics of recursion and selfreplication, with a philosophical theory that was introduced by John von Neumann's work: the cellular automaton (its plural is cellular automata) and the von Neumann architecture for self-replicating systems.

"A Cellular Automata is a formal and dynamical system consisting of a collection of cells arranged on a gridded space. All the cells are identical in architecture and have an internal state. The system evolves by applying, in discrete time units, a transition rule that updates the internal state of all the cells simultaneously. The inputs of the transition rule, for each cell, are the internal state of the updated cell inputs, which updates the internal state of all the cells. Different arrangements and space dimensions can be considered, as well as different sets of possible internal states, neighborhoods or transition rules, in each case a different Cellular Automata may be produced".129

The von Neumann architecture is the idea of a machine that replicates and constructs copies of itself.130 It is a precursor of genetic architecture, since a selfreproduction system is organized, and therefore contains a complete description of itself and uses that information to create new copies.

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127 Symbiogenesis in this case means the co-construction of possible worlds by autonomous agents within a symbiosis.

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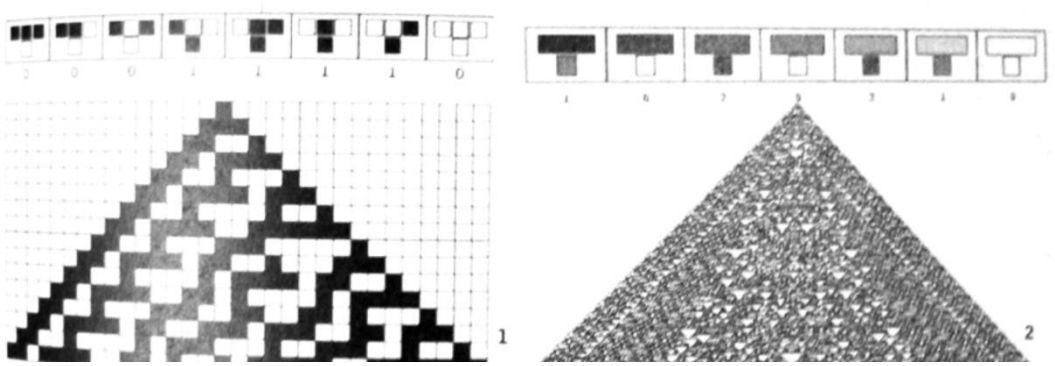
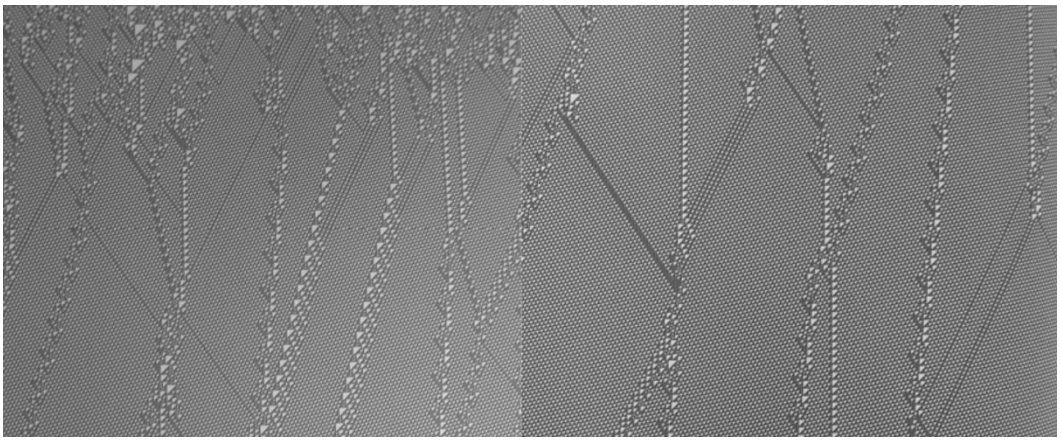
128 Resume of: CHU, Karl, “Metaphysics of genetic architecture and computation” in, VV. AA (D), op. cit. and Karl Chu’s lecture, Biodigital Architecture Master, ESARQ (UIC), Barcelona, 2008.

129 VV. AA (A), op. cit., p. 585..

130 It consists of two central elements: a Universal Computer and a Universal Constructor. The Universal Computer contains a program that directs the behavior of the Universal Constructor, which, in turn, is used to manufacture both another Universal Computer and a Universal Constructor. After this, the newly manufactured Universal Computer is programmed by copying the program contained in the original Universal Computer, and program execution would then begin again. Resume of: CHU, Karl, “Metaphysics of genetic architecture and computation” in, VV. AA (D), op. cit., p. 171.



Cellular automata, Stephen Wolfram’s Rule 30: the space is a one-dimensional grid (each row is the output of the upper row), internal states are binary (0 and 1 or black and white). The neighbors of the cell are its adjacent ones, and the transition rule is the little squares above (figure1). Stephen Wolfram’s Code 912: the same case of figure 1, but internal states are 0, 1 and 2 or white, grey and black (figure2); VV. AA (A), 2003, p. 585.



Complex behavior in the rule 110 cellular automaton starting from a random initial condition. The system quickly organizes itself to produce a set of definite, localized structures, which then move around and interact with each other in complicated ways; WOLFRAN, Stephen, 2002, pp. 229, 230.

In this manner, the notion of genetic architecture is a philosophical abstraction explored with the help of computing systems, based on algorithms as dynamic rational patterns and self-replication elements. Like this, the computing machines can be seen as tools that, in an ample manner, are able to produce phenotypes from genotypes. Moreover, computer programs can

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be seen as tools that, through the use of abstract elements, concretize information and register it.

With this understanding, architecture is becoming less independent of its extrinsic factors and formal demands, taking into better consideration its intrinsic properties and its transformation. In this line, algorithms provide abstract information of rulesets, which are capable of creating infinite potential expressions.

Even though genetic algorithms constitute the mathematical basis of evolution, most of these systems are so far incapable of generating specified complexitywithout requiring the input of intelligence (fitness criteria) from outside of the system, because of its complexity. In this case, the idea of one-dimension cellular automaton is very efficient, proving the notion that simple rules can generate complex outcomes (there is a total of 256 rules in 1-D cellular automata).

However, these Intricacy, randomness and other chaotic features present in natural and mathematical systems turn genetic programs into open-ended systems that can incorporate new axioms and fit criteria into its existing chain of axioms in order to generate more complexity, even though their rules may be simple.

Intricacy, randomness and other chaotic features present in natural and mathematical systems turn genetic programs into open-ended systems that can incorporate new axioms and fit criteria into its existing chain of axioms in order to generate more complexity, which can led to novelties and surprise (emergence).

Nature, as a dynamic open system formed by networks of matter, energy and information, all in the edge of chaos, can lead to novelty and surprise (emergence) by self-organizing systems based on algorithmic evolution (as algorithms are responsible for this emergent dynamic behavior). Therefore, it is possible to apply this to computing systems in order to generate emergent behavior in architectonical projects through the use of simple algorithms. Under these conditions, resulting from nonlinear systems, the behavior of the overall system cannot be obtained by summing up the behaviors of its parts: “more comes out than was put in”.131

Pursuing this type of architecture, Karl Chu’s first genetic architectonical ambition was the construction of possible worlds generated by the universe of computational monads: a monadology of genetic architecture. Each monad is a system capable of constituting itself into a cohesive whole or a possible world, due its self-replicating and self-organizing power.

In that line of thought, these monads could be the generator of proto-species132 of architecture, and by exploring the idea of Adjacent Possible, an interconnected aggregation of computing monads could represent a viral dissemination. His second genetic architectonical ambition was the emerging concept of the global brain: sublimation of collective intelligence through architectural form.

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131 HOLLAND, John H., Emergence From Chaos to Order, Basic Books, United States of America, 1999, p. 13.

132 The term “Proto-architectures has to do with the investigation of various spaces of liberty, which potentially are non-spaces…Architecture, in certain cases, construct it’s own references; it is auto-referential. It is another facet of the immanent relation it presents with sites. Places, spaces that due to differences from which they are observed, can be considered proto-

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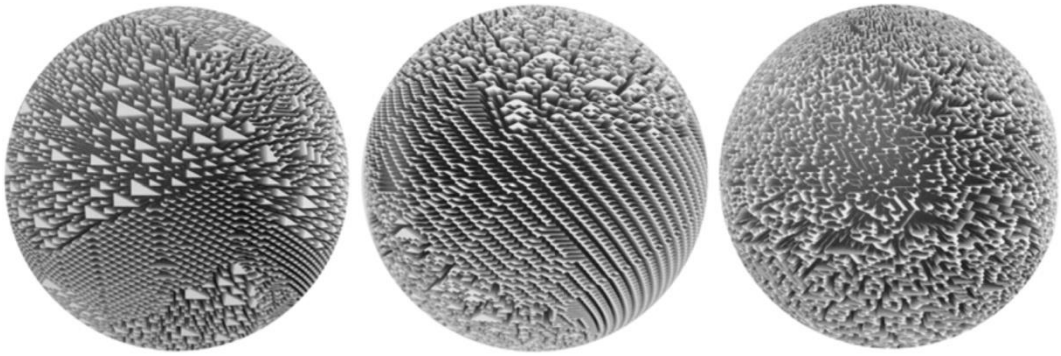
architectures. Or rather architectures that, due their originality with which they are thought, can be considered proto-places. A formal retro-feeding is produced between some proto-architectures and others. Architecture, thus, can construct its own references. These self-references are not due to the profession or discipline, but are derived from their own discoveries". VV. AA (A), op. cit., p. 502.

His second genetic architectonical ambition was the emerging concept of the global brain: sublimation of collective intelligence through architectural form. As Karl Chu says, architecture is not done only by one person, but it is a collaboration between a lot of them. Also, it is not immediate, as its remains for a long time, so people can see the constructions and learn with them. Therefore, this collaboration also presumes the time aspect…over time.133

One of his projects is Planetary Automata, in which each set of rules constitutes a genetic code that embodies the logic of self-replication: a system of recursively defined geometric objects.

Each planet is generated by a composite set of rules: a cellular automata (CA) rule is superseded by another rule based on either local conditions or random instantiation. 1-D CA constitutes a computational nomad.

Each nomad defines the virtual ontology of the set of possible worlds contained within a system of rules. Each sphere represents a proto-architectural universe that is potentially infinite in terms of variability and density regarding its composition; it represents an incomplete totality.134



Karl Chu's examples of Planetary Automata based on 1-D Cellular Automata. (the density of each sphere displayed is the result of 300 generations). First Planetary automata, CA programming and modeling by Kevin Sipes (figure1), second planetary automata, CA programming and modeling by Kevin Sipes (figure2), third planetary automata, CA programming by Chris Sandes and modeling by Christian Lange (figure3); CHU, Karl in, CASTLE, Helen (Ed.), August 2006, pp. 38, 43, 44.

As we can see, computation is not only a technological innovation, but a consequence of the metaphysical desire to uncover the Codes of Life and the possibility of the construction of abstract135 machines that could propose possible worlds, depending on information values, and based on logical and algorithmic intricacy.

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133 Extracted from Karl Chu's lecture, Biodigital Architecture Master, ESARQ (UIC), Barcelona, 2008.

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134 Resume of: CHU, Karl, “Metaphysics of Genetic Architecture and Computation” in, CASTLE, Helen (Ed.), op. cit., August 2006.

135 Numbers in particular point to the use of abstraction. To come to the concept of number, almost all details must be dropped from multitudes of observations to arrive to essences. Eliminating details is very important to emphasize selected features and to gain a repetition that will enable us to build a repertoire of learned actions of the form ”IF the situation shows

feature (s) X, THEN take actions (s) Y.” Resume of HOLLAND, John H., op. cit., 1999, pp. 76, 202, 222.

More and more proof is subject to being computed. Architecture seems to be following this same path, as architects are trying to find some logic within it for the creation of an architecture that is more suitable for our contemporary needs.

Considering the recent trials in the development of the DNA computer, which is faster and smaller than any other computer built so far, we can see that the quantum computer, with its endless bits and networks with indefinite memory136, really opens new horizons for new possible worlds, as the fundamental principle to its construction is the conservation of information.

Regarding all that, the Studio exercises proposed in general terms, the generation of forms derived through substitution systems functioning on a base of algorithms to create of patterns of abstract information (data) translated into forms by the creation of rules.

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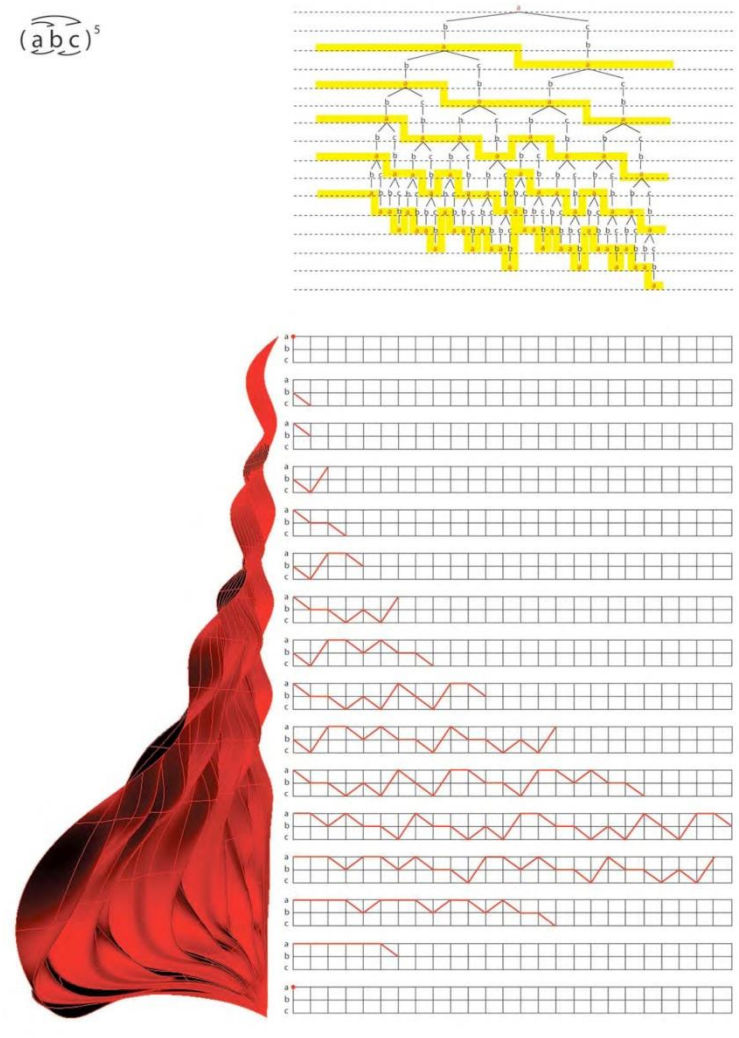

Axiom developed until its fifth generation, marked in the linear branching system in yellow are each of the generations (figure above), mapping of this axiom, resulting in lines to be used as sections for the 3D surface (right figure) and the 3D surface generated through a loft of the section's lines (left figure); created by the author and Julian Ardila, *Biodigital Architecture Master*, ESARQ (UIC), Barcelona, 2008.

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136 Indefinite memory is basically the ability to remember events that have occurred in the indefinite past, due to the presence of a cycle network (loop) that feeds output pulses back to the input. HOLLAND, John H., op. cit., 1999, p. 96.

A Substitution System is the production of new sequences by recursive replacement of each element. According to the initial set rules, the process will continue for as many generations as desired. Therefore, as in computers, these systems work though repetition.137

More specifically, some experiments were proposed as generative strategies to create topological surfaces and architectural forms (or proto-architecture). These surfaces were originated by the mapping of the axioms development, produced different visual results depending on the axiom utilized and the type of development presented: ramified theorems (linear or cycling), matrix systems, or even when some design rules were invented.

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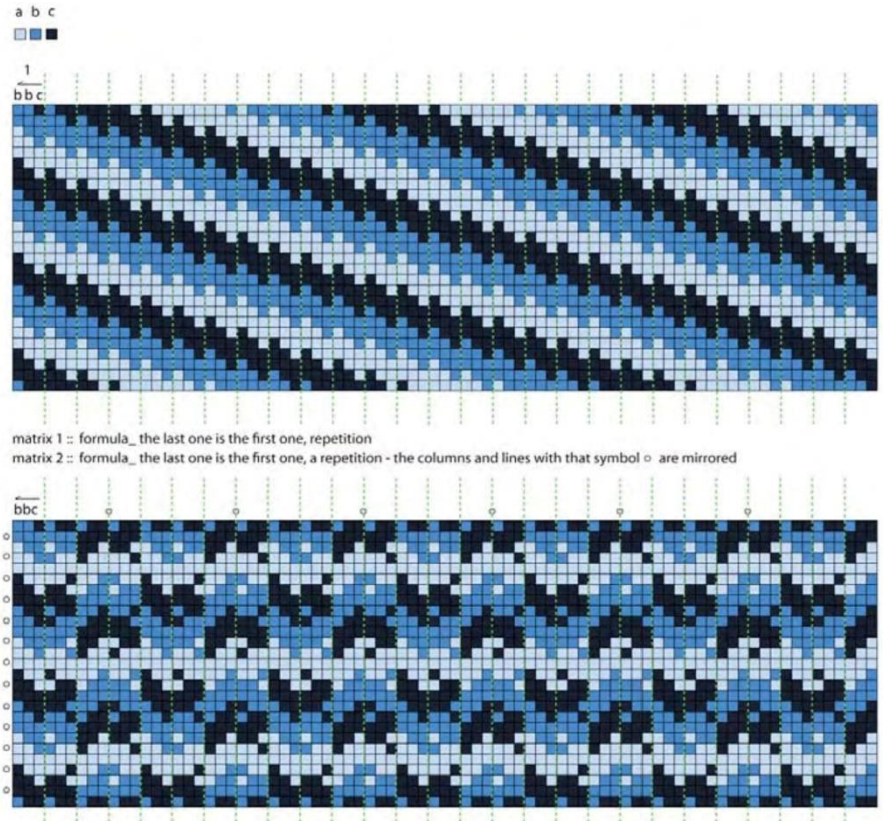

Homogeneous matrix (figure above) and a periodic one (figure bellow); created by the author and Julian Ardila, *Biodigital Architecture Master*, ESARQ (UIC), Barcelona, 2008.

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137 “The forte of a programmed computer is repetitive action. When we write programs, we write many subroutines—sequences of instructions that are executed again and again until some condition is met”. HOLLAND, John H., op. cit., p. 118.

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Tests with 3D elements using the matrix application; created by the author and Julian Ardila, *Biodigital Architecture Master*, ESARQ (UIC), Barcelona, 2008.

If Axioms are elements that serve as a starting point from which other elements are logically derived, theorems are all chains produced with the evolvement of a formal system. Like this, the Studio exercises also have an if/then relation as they are based on these abstract elements, “IF (new axiom) THEN (derivation of the theorem based on axiom)”.138

Also, an important aspect is that, the exercises should not be considered as closed, due to the fact that if any alteration in the initial data occurs, (for an added rule, as an example) its geometry would be reconfigured and readjusted to the new conditions. This represents an important characteristic of that kind of architecture because it is very effective on changing the project; architect’s interests now is in drawing data and not shapes to have a better control and flexibility over the object.139

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138 HOLLAND, John H., op. cit., p. 186. 139 For a more complete approach see parametric programs in the chapter “Studio Cyber-Eco Fusion Design” of this work.

139 For a more complete approach see parametric programs in the chapter “Studio Cyber-Eco Fusion Design” of this work.

General conclusions

In the latter part of the 20th century, the convergence of computation and biogenetics became possible due to social, political and technological transformations. Today, with these changes, it is possible to manipulate the genetic constitution of a species and to imitate living systems (Artificial Life). “Most active from the mid 1980s to the mid 1990s, the field of Artificial Life

focused mainly on showing that computer programs could be made to emulate various features of biological systems".145

It may be true that never in before has the relation between Logos (reason, logics) and Mythos (from Mythology, supreme form of fiction) been so questioned. This intersection, which seems irreconcilable, is being rethought. On the one hand, it is now possible to find all sorts of computers and computing systems; on the other hand, constant questioning about the soul of robots and transgenic species is occurring.

In this context, it is important to consider not only the physical aspect social, political and technological transformations, but the philosophical side...a current of philosophical genetic architecture. In the quest for this type of architecture, it is thus essential to point out Karl Chu and his projects: surreal and embedded with aspects seemingly of science fiction that show his concern about metaphysical and philosophical concepts.

Most interestingly is that, despite dealing with these concepts, Chu's primary focus was the architecture of the Real: a phenomenology146 of affects invoked through artistic modulation of the underlying logic of form, both in terms of its intrinsic and extrinsic properties and relations.147

In this context, it is relevant to mention the word Metaxy148 as the connection of the mind or nous (the divine mind) to the material world and, reciprocally, the connection of the material world to the mind (as a ground base of being, referring to a "consciousness of being").

Accordingly, this current has a truly experimental character, proposing an innovative way of considering the effects in the convergence of biogenetics and computation in architecture and how this architecture should be developed in order to absorb and to respond to this information.

The Studio exercises demonstrated some of these genetic principles applied in architecture by introducing concepts of dynamism, processes, abstraction, deduction, logical structures and complexity; but still, they represent an effort in trying to understand the power of such vast architectonical approach, laden with endless possibilities.

Nevertheless, it was clear that due to the general and abstract nature of these exercises, they can withstand many variations, an inherent feature to their generative logic. It was also observed that minimum information is required to generate a maximum of outcome, allowing for an enormous amount of results. Therefore, the system should be created with less internal control, like a chaotic factor, stimulating self-learning, cooperation and automatic re-adjustment to new conditions.

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145 WOLFRAN, Stephen, op. cit., p. 12.

146 Phenomenology is a philosophical method that explores the objective structures of consciousness. Extracted from Karl Chu's lecture, Biodigital Architecture Master, ESARQ (UIC), Barcelona, 2008.

147 Extracted from Karl Chu's official site: http://www.metaxy.com/infocontact.html, 2008.

148 Metaxy is the name of Karl Chu's office.

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Moreover, and despite the simplicity of the project, the concept of working with complex ideas through an extensive exploration of the subject itself yielded a more coherent and sound type of architecture.

"With the eventual proliferation of bionic beings and proto-species of genetic architecture populating the Sphere of Hypervirtuality, where the Internet will eventually be transformed into a self-synthesizing and self-organizing organ, virtual artifacts and ghostly phantoms will co-involve with humans societies in a symbiotic cooperation of freedoms".149

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149 VV. AA (A), op. cit., p. 180.

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Submetido em Ago 2017, Aprovado em Set 2017, Publicado em Fev 2018