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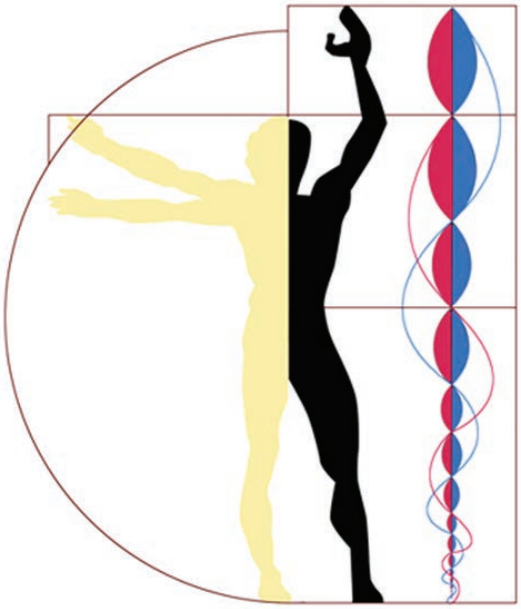
XIII Forum Internazionale di Studi

Le Vie dei Mercanti

Carmine Gambardella



HERITAGE and TECHNOLOGY

Mind Knowledge Experience

La Scuola di Pitagora editrice

Fabbrica della Conoscenza numero 56
Collana fondata e diretta da Carmine Gambardella

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Carmine Gambardella

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Mind Knowledge Experience
Le Vie dei Mercanti
XIII Forum Internazionale di Studi

Editing: Manuela Piscitelli

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Il Progetto "Ecoturismo urbano per la fruizione sostenibile dei Beni Culturali in Campania", in attuazione degli Obiettivi Operativi 2.1 e 2.2 del Programma Operativo FESR Campania 2007/2013 per la realizzazione e/o il potenziamento, nel territorio della regione, di forti concentrazioni di competenze scientifico tecnologiche, di alto potenziale innovativo, intende favorire la concentrazione di competenze scientifico-tecnologiche finalizzata a rafforzare la competitività dei sistemi locali e delle filiere produttive regionali non solo nei settori dei servizi associati al turismo e beni culturali ma anche in settori ad altissima tecnologia che possano rappresentare una svolta tecnologica e culturale all'approccio innovativo per lo Sviluppo sostenibile in aree ad altissima vocazione turistica.

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Heritage
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Culture
Collective Identity
Memory
Documentation
Management
Communication for Cultural Heritage
Architecture
Surveying
Representation
Modelling
Data Integration
Technology Platforms
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Safety
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Transformation Projects
Technologies
Materials
Cultural landscapes
Territorial Surveying
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Peer review

Scholars has been invited to submit researches on theoretical and methodological aspects related to Heritage and Technology, and show real applications and experiences carried out on this themes.
Based on blind peer review, abstracts has been accepted, conditionally accepted, or rejected.
Authors of accepted and conditionally accepted papers has been invited to submit full papers. These has been again peer-reviewed and selected for the oral session and publication, or only for the publication in the conference proceedings.

Conference report

357 abstracts received from:

Albania, Argentina, Australia, Benin, Brazil, Bulgaria, Canada, Croatia, Egypt, France, Greece, Iraq, Israel, Italy, Japan, Latvia, Malta, Mexico, Norway, Poland, Portugal, P.R. China, Russia, Slovakia, Spain, Turkey, United Kingdom, USA.

More than 500 authors involved.

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HERITAGE and TECHNOLOGY
MIND KNOWLEDGE EXPERIENCE
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Algorithmic Transformation between Heritage and Design Innovation

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Abstract
The spread of digital modellers based on the scripting of algorithms helped the development of an alternative method of design and representation, which is able to shape innovative configurations, which generate from the "growth" of a beginning cell by repetition with continuous transformation. The applications to design triggered the formal research and the debate about the definitions of these new processes that underline a deep change from the experience of the past. The generation of form by the drawing up of algorithms promotes the importance of the code-procedure concept: if the solution to a problem can be described in a finite number of steps, in the same way the identity of a form is the consequence of a series of discreet rules that define it. In fact, the use in the design of computers and algorithmic processes, does not preclude a strong continuity with settled theories and practices from previous centuries. On a careful analysis, the heritage that led to this innovative approach ranges across the history of the mathematics, art and architecture design. Then it consolidated in some fields that seem to be unrelated to the world of design, such as cognitive science, biology, linguistics, musical composition and philosophy. The range of historical, geographical and cultural contexts reveals the use of geometry's laws as a matter in which art and science merge to create regulatory formulas. This paper reconstructs the ties with the history of procedural design, by the comparison of examples with similar methodologies.

Keywords: lattice, scripting, symmetry, tessellation, textile design

1. Introduction

In the introduction to Machining Architecture, L. Spuybroek states that: "The computer has reached a cultural stage, finally. The years that it was used for dreaming of perfect shape grammars and design automation (...) or, worse, used for dreaming disembodied dreams of an architecture floating in cyberspace – those tears are over. Also finally and especially important for the architectural profession, computers have outgrown their servile function in the digital drawing room, where the real design was still done far away from the machines, sketched by hand, guided by genius."[1] The last few years revealed the effect of the information revolution on the project. The new generation grow up together with digital technologies, developing a different approach, which is apparently free from the cultural conditioning of the past. The professional maturity of digital natives matches the transition to a new concept, in which the design is no longer an addition of parts and phases hierarchically ordered and/or subordinate each other, but it is the concept of a developing form. This is governed by rules that are implicit in the process itself, as well as in the organic model. Digital technology adapted to designers' needs: direct interaction systems facilitate the access to the scripting, which is the information code that define the shape. The easy interface with the computer reference facilitates the evolution of Computer Graphics in Digital Design, reconstructing the identity between Drawing and Design. The computing controls the complexity of the Design, by the application of dynamic systems that are inspired by the Mathematics. Actually this science developed its models in the attempt to find a recognizable to explain chaotic systems that govern natural phenomena.

[1] L. SPUYBROEK, 2004. Page 4

The tools of the digital representation encouraged the development of complex forms just by organic inspiration. They are characterized by the reference to movement and transformation. These concepts are extraneous to Architecture's mood. The dynamic articulation of Deconstructivist Architecture, which refers to the mathematical concepts algebra and to the relational geometry of graph, involves three different innovation levels: conceptual, geometric and material. The first two ones are directly related to the mathematical process that controls the design to the final form. The third is an indirect consequence of the research on geometric properties of shapes, in its creative application to the development of new materials and/or their innovative uses.
This paper aims to reconstruct the historical roots of the Generative Design. The goal is to identify its disciplinary matrices, as an essential contribution to the renewal of the Design teaching. Only the knowledge of the rules of the form allows the management of the digital project without falling into formalism. In fact, the awareness of scientific references and cultural roots of digital tools helps the definition of formal parameters and transformation codes that rule the digital Design.

2. Form and Design, the Pattern.

The application of digital technology to the project changed the shapes of the Architecture as a consequence of the easier representation of complex shapes, but above all it is changing the Design methodology. The focus shifted from the layout composition to the development process: from the additive tectonics of building elements, to the shape-process that rules the articulation of a dynamic and responsive body. The form is born from the combination of codes and factors working together. This synergy defines growing lines and tectonic features that are able to interact with the environment. Digital technology supports topological transformations that subvert the proverbial static of the Architecture. The computing manages the complexity of the Design process by dynamic systems that apply the concepts of the Mathematics, which developed its models in the attempt to find a rule in chaotic systems that govern natural phenomena. They refer to the Biology, finally. Thus Design is closer to the organic reference of nature patterns that inspired the arts in the past. It does not only imitate the visible articulation of exterior shape, or the structural design and distribution as in the past; it goes further and applies just the growth process and the adaptation to the environment of the organic forms in responsive architectures.
The two approaches could be called "constructive" and "evolutionary". They apply design patterns that are related to antithetical archetypes that follow the classical theory of proportions:
- the modular aggregation of smaller units,
- the harmonic decomposition of the whole.

Both of them define the form by the transformation of basic shapes through dimensional- and shape-parameters that refers to common categories; a great variety develops from simple form. The two alternative concepts get a respective feedback in the "pragmatic" reference to the building activity that characterizes BIM applications and in the "conceptual" identity of the form as the result of a growth or a transformation. This organic process is ruled by reiterative algorithms, which apply elements related to the basic concepts of the Design theory and to the definition of the movement, then of the growth from a "starting" cell:
- the laws that control forms, their additive aggregation and/or harmonic decomposition;
- the categories of orientation and space-time movement;
- references to organic growth and diachronic transformation.

The "Shape Grammar" refers to the basic rules that govern the primitive concepts of Design Theory. They derive directly from the application of primary concepts of the Arithmetic and basic Geometry to Design. They are in symmetrical structures of the ornament and in the in modular and hierarchical concept of the Architectural Order, as well they are are evident in the layout of the decoration design:
- the rigid movements of the four elementary symmetries,
- the concept of serial or cyclic repetition or decomposition, following Cartesian or polar grids.

They are possible all possible combination of previous patterns. The regular combination of equal or similar elements in a pattern allows innumerable designs with a limited number of basic elements, developing a great variability of shapes from a single theme. In 1707 Douat[2] shows the permutation up to a maximum of four elements, developing the design possibilities in black and white patterns, alike the combination of the amino acids in the DNA chain, whose configurations variety codes a huge number of properties, trough the permutation of a small number of elements.

[2] S. TRUCHET, *Méthode pour faire un'infinité de dessins dif¬ferens avec de carreaux mi-partis de deux coleur par une ligne diagonal ou observation di Pere Dominique Douat*. Paris, 1722.

The pattern is the basic concept. It holds and drives and drives the structure of the beginning unit than as well the rule of the design process. Depending on the context, the term *pattern* can mean “design”, “model”, “scheme” or “repetitive structure”. This word is not normally translated in Italian, where curiously it has lost its Latin etymon *Patronu(m)* “master”, “patron”, but also “model to follow”. The word derives from *Pater,* which can be traced to the Greek πατήρ*,* “father”, he who generates and gives structure to the family[3]. As such, according to its original meaning, *pattern* means the role of those who shape and regulate the behaviour of a series of people or objects.
Its contemporary use mainly refers to those cases where one or more entities are distributed in an organised way in space or time. With this meaning the concept is widely applied in the most diverse of fields, form computer science, to biology and meteorology.
In basic design the word *pattern* define the ordered repetition of a series of forms, i.e. portions of space determined by boundary lines or external surfaces. Virtually every line or form repeated with sufficient frequency produces some kind of pattern. However complex or complete it may be, a single trace is not a pattern but a unit that may eventually form part of a more structured pattern.[4]
The specificity of a pattern therefore derives from the presence of rules necessary for combining the various units. If we go beyond the graphical and ornamental use to which they are often relegated in the design field, we can regard patterns as abstract devices that are able to describe and organise the relations between the components of a system and determine their essential features. The repetitive and redundant nature allow for gradual variations that allow them to adapt to and respond to changing conditions.
In the production of artefacts, patterns have always been used in decorations as a useful tool for highlighting the regularity and specificity of the cultural world compared to the natural world. The ability of human beings to recognise patterns in the reality that surrounds us, such as cobblestones on a little road, in the bifurcations of tree or in the clouds dotted across the sky during the day for example, is proof of the fact that the creation of patterns is one of the oldest known human customs. Ernst Gombrich believes that it is both the specific and repetitive nature of patterns that enabled us to perceive the “sense of order”, i.e. that ability that allows us to find our bearings in space, establishing a relationship between an unchanging object and a changing background.
These concepts lead the twentieth century experimental experiences that accompany computer birth and success. In fact computer offers *the chance to program the creation of any type of order and to study the effects*. Thirty years ago Gombrich himself highlighted the computer's ability to follow any organization’s complex rule, but also to introduce a dose of randomness exactly calculated. The great innovation was the possibility of obtaining configurations that admit casualness, within a grid of predetermined movements. These last are elements of aesthetic interest that offer unparalleled understanding of the operations of “our sense of order in the perception of complex schemes.”[5]

3. Rule and transformation. The organic model

Many authors have highlighted the role of natural examples in the development of mathematical concepts through which man tries to explain physical phenomena, and it is interesting to note how the mathematical models of natural structures have been revised and adopted as a means to solve constructive or formal design problem.[6]
The earliest documentation belongs to Vitruvius, followed by all the treatises of the Renaissance, but only D'Arcy, at beginning of the last century, reveals the scientific reasons, proving that nature uses efficient forms that anticipate man’s imagination and genius.[7]
In nature “*all changes are small changes. Though a transformation can have a large effect, it is always a relatively small step, and the newness of the new can never be appreciated right away*.”[8]
The organic inspiration design forms are once again result of availability of adequate representation tools capable of integrating natural processes of construction of the form in the modelling. Processes such as genetic algorithms and cellular automata are instruments that take from living organisms fundamental principles such as growth or self-organisation and inject them into the formal process.
Computer dynamic tools are able to transfer at artefacts the capacity to capture and metabolize complex interactions with the environment and the user. Employing same principles used by nature to shape a leaf, a shell, or an ecosystem allows you to design artefacts and living spaces in the best suitable form to respond

[3] See Oxford English Dictionary
[4] D. K. WASHBURN, D. W. CROWE, 1988.
[5] E. GOMBRICH, op.cit, pag 114.
[6] R. PENROSE, op. cit.
[7] W. D’ARCY THOMPSON, 1917
[8] L. SPUYBROEK, 2004, p. 9

to human needs. Digital form generation proceeds in a similar way to growth of the organisms and evolutionary process. Step by step it determines an unstable equilibrium, which ensures maximum efficiency to shape and shows its *concinnitas* in *euritmia* of design[9].
The difference from the past is the shift from static equilibrium, which arises from the periodic symmetries elementary of nineteenth century ornamental grammars, to a search of dynamism through a recognizable change of base module pattern. "*Our language of patterning is based on similar principles of translation, reflection and rotation, though it can reach a higher level of complexity since there are no exact borders between figure and configuration. All figures have internal and external transformation that interact with effects like merging, hooking, crossing, sliding, opening, nesting*."[10]
According to Gombrich sense of order is a innate category and our perception captures the contrast between order and disorder, reading *regularity* as an index of *intentionality*. The design is configured in recognizable forms ordered according to rules related to the adoption of uniform repeating modular pattern, whose conception derives from the construction with minor elements, such as weaving and texture[11]. Pattern produce ordered drawings, generated by regular repetition of forms, according to preconceived but variable schemes, based on the laws of symmetry, which apply rigid elementary movements.
The module, repeated according to sequences, identifies a reference grid based on elementary forms who apply serial periodic combination serial with undifferentiated cyclic repetitions.
All periodic plane tilings adopt grids with equal quadrilateral or triangular/hexagonal mesh, which can be both regular or irregular.[12] The different systems provide a serial or polar organization, where the hierarchical arrangement of forms involves two distinct and related phases: *the framework*, namely the definition of the domain with an edge (frame) and *the filling*, or the organization of field defined from the domain.
Christopher Alexander was the first to introduce the term pattern in relation to a design process that deconstructs the design determinants and then recomposes them using language. In accordance with systemic theories, Alexander regarded pattern as a tool for interpreting and describing the organisation of the phenomenal realm. The academic conceived of the designed environment as a complex inanimate system, which, however, takes the form of a living system thanks to its continuous interaction with man. According to Alexander, contemporary design does not take sufficient account of the concrete experiences that derive from construction traditions and the peculiarity of the places, meaning that in the end the projects do not meet the real needs of the users. For eight years he studied the shared languages of different social groups in various nations, extrapolating patterns that could organise and produce the form of artefacts and buildings. These patterns were then reinserted in a hierarchical dependency context: every pattern is connected with a higher level and a lower level. The result is a language in which patterns are words and the designer can freely use or modify them, developing their own design syntax.
In his book *A Pattern Language* Alexander proposes 253 specific patterns, each one to solve a specific physical and social problem, which can be combined to offer infinite combinations and possibilities. These include patterns that organise the configuration of the roof, the ceiling, floors, pillars, the heating, ornaments and seating.
The distinctive feature of Alexander's studies is way he starts by looking at human behaviour and analysing the archetypes of various cultures before developing the design process, acknowledging that it has the ability to create ordered emerging structures that are the fruit of the interaction of the parties involved. His mathematical training contributed to reducing the design process to its invariants before extrapolating formal roots that can generate coherent morphologies.
Paradoxically, Alexander's studies have not been developed yet in the design field, enjoying notable success, rather, in the field of computer science. In fact, in 1995 his theories were taken and adapted to computer science by four researchers: Erich Gamma, Richard Helm, Ralph Johnson and John Vlissides, authors of the revolutionary book *Design Pattern: Elements of Reusable Object-Oriented Software* and universally known as the "Gang of Four". The method proposed in the book stems from Alexander's idea of generalising the relationship between the context and a set of conditions related to that context and a solution that solves the problem, which can later be applied to other situations. In any case, after forty years and thanks to computer science, Alexander's theories have sparked new interest in the field of Design. Computers allow us to manage increasing amounts of data and the use of algorithmic modelling software arranges the determinants necessary to define the relations between the parts.

[9] According to Gottfried Semper Man, in his creations, builds a miniature world that evokes the unreachable perfection of the wonders of nature. By the discovery of rules that generate forms of ornament mankind satisfies his cosmogonic instinct, frustrated by the inability to explain the deep essence of reality.
[10] L. SPUYBROEK, 2004, p. 272
[11] See E. GOMBRICH, 1979.
[12] The composition of quadrilaterals tile derived from the decomposition of the regular pentagon, with which it is not possible to cover plane without interstices. *Darts* and *kites* tiles instead produce aperiodic tilings such as those patented by Penrose, but also present in the Persian *girih* sixteenth century.

One of the key operations of procedural design is the choice of the parameters on which the design depends. This process of identification coincides with that of the recognition of the patterns proposed by Alexander. The language of patterns has finally returned in the world of design thanks to generative modelling tools.
Shape grammar is the name assigned to systems algorithms that generate geometries from Stiny and Gips[13] that in 1971 applied to computerized graphics the linguistic principles of Noam Chomsky.[14]
Digital grammar consists of a set of rules and a generative engine, which applies them to primitive element, repeating n times the same process. In this way the rule defines the transformations due to subsequent applications. A generative grammar consists of at least three rules:

- a starting rule that triggers the process,
- one or more transformation rules,
- the final rule that stops it.

The parametric structure of the rules allows the definition of the relative size of the parties and controls transformation process through mathematical functions, enabling the creation of a wide variety of possible variants of a single model.
Same mechanism can be applied to elements of increasing complexity, in which the final shape is the result of various parameters and algorithms. The application of the rule is thus a combination of factors in synergy with each other, acting repeatedly to produce more and more complex configurations, as in fractals.

4. Conclusion. Linguistic-mathematics legacy.

The same laws applied to digital generative form creation were center of interest for mathematician Andreas Speiser, founder of *Group Theory.* His research will be further developed by the experiences of Basic Design theorists at the School of Ulm, which was the real incubator of *Shape Grammar* and *Generative Design*[15].
The historicised definition of ornamental grammar anticipates the current concept of "formal grammar" in the exposition of design composition laws and emphasizes the reference to decoration as expressive language.
Nineteenth-century ornamental grammars have applied to design the rules of permutations theorized at the beginning of the previous century by Dominique Douat and published in 1722 by Sébastien Truchet, listed as the author of the first treaty explicitly dedicated to design theory.[16]
Reference concepts and designing results of digital innovation have renewed interest in principles and rules of classical treaties and historical theory of the project, focused on the concepts of form and proportion, repetition and variety, similarity and change.
Taken cyclically and updated, basic design concepts, which derive directly from mathematical rules of symmetries on which is built the design technique for ornament, have reacquired importance in primary methodological process of the digital project. The multiplication of studies on design pattern laws and on aggregative rule is reflected in the statement by Owen Jones[17], according to which the secret of ornamentation success derived from the production of a general complex motif with repetition of a few simple elements. Gottfried Semper[18] believes that these fundamental laws of form in which nature operates are: symmetry, proportionality, directionality.
Theoretical basis of design are then the first cultural reference for contemporary design culture, which has upgraded the concept of organism, evolving his interpretation of natural pattern, made of harmonious regularity, but also made of dynamic transformations, adaptations to the environment and movement. Thanks to technological innovation, the imitation of nature has shifted from formal similarity to resumption of growth process that characterizes life. Remain valid, however, the requirement of formal laws for design and project.
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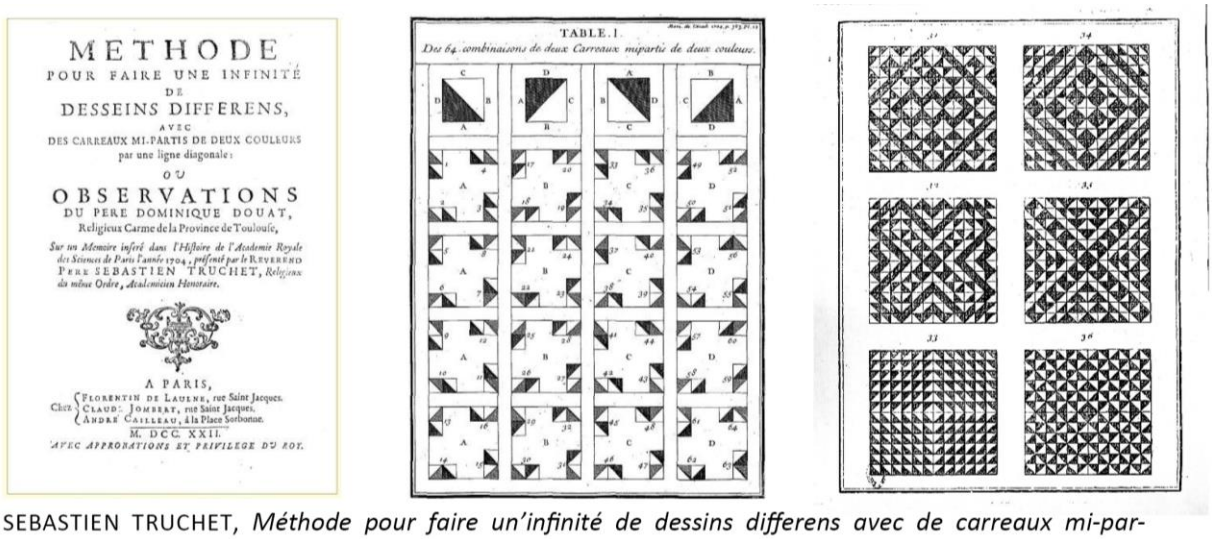
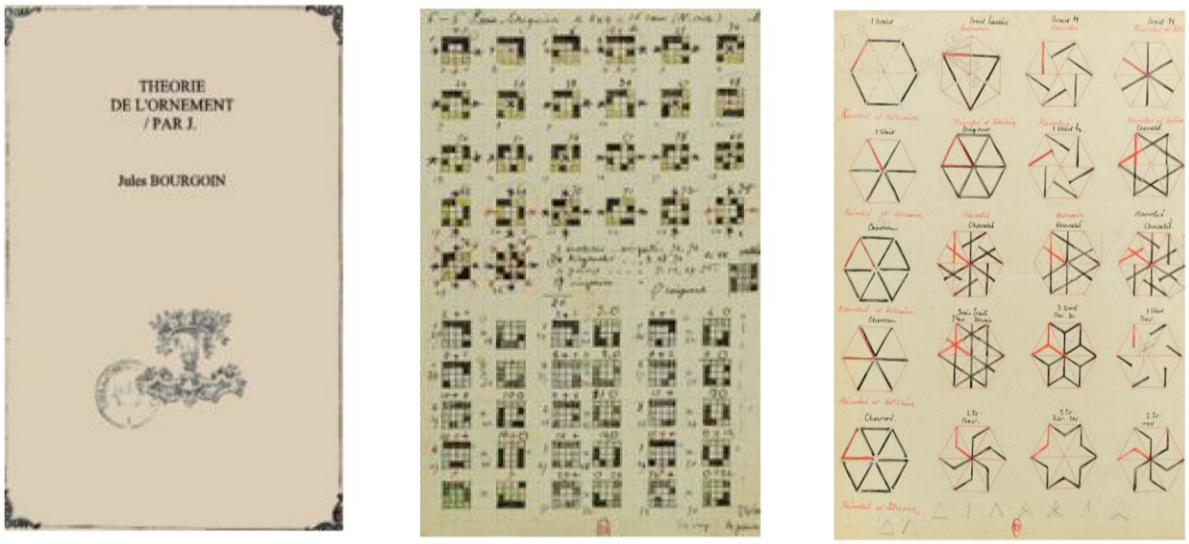
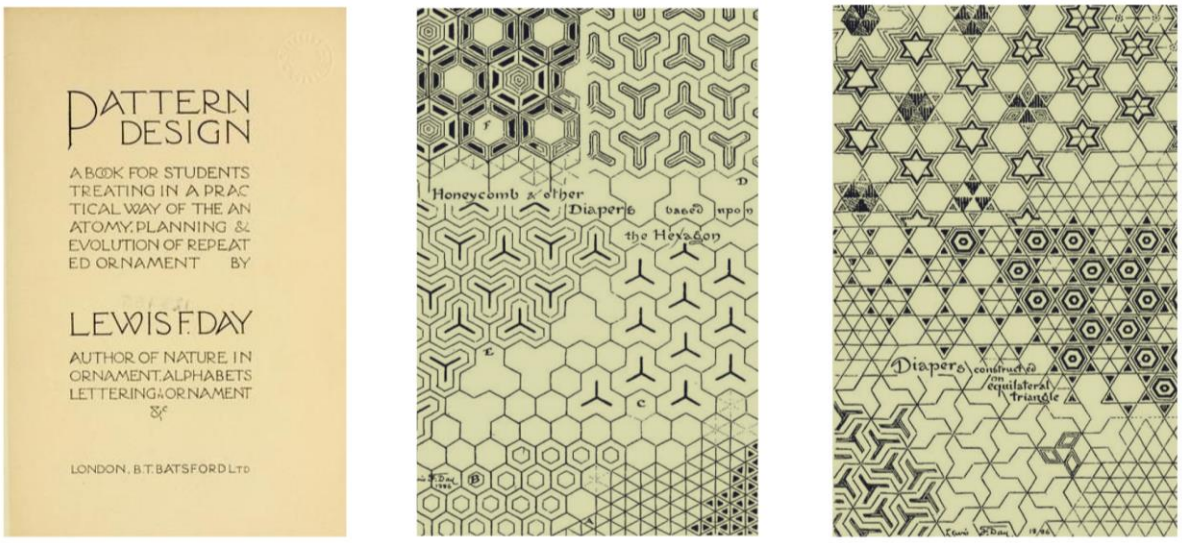
[13] STINY, G. E GIPS. 1972
[14] N. CHOMSKY, 1980.
[15] *"Generative Design is a morphogenetic process using algorithms structured as not-linear systems for endless unique and un-repeatable results performed by an idea-code, as in Nature*", www.celestinosoddu.com
[16] E. GOMBRICH, 1979, p. 90. Truchet is also the inventor of the system to measure in points the size of font.
[17] O. JONES, 1856.
[18] G. SEMPER, 1860.



SEBASTIEN TRUCHET, *Méthode pour faire un'infinité de dessins differens avec de carreaux mi-partis de deux coleur par une ligne diagonal ouobservation di Pere Dominique Douat*. Parigi, 1722.



JULES BOURGOIN, *Théorie de l'ornement*, Parigi,1873.



LEWIS FOREMAN DAY, *A Pattern design,* Londra, 1887.

Fig. 1: Some of the main historical treatises concerning the creation of pattern.

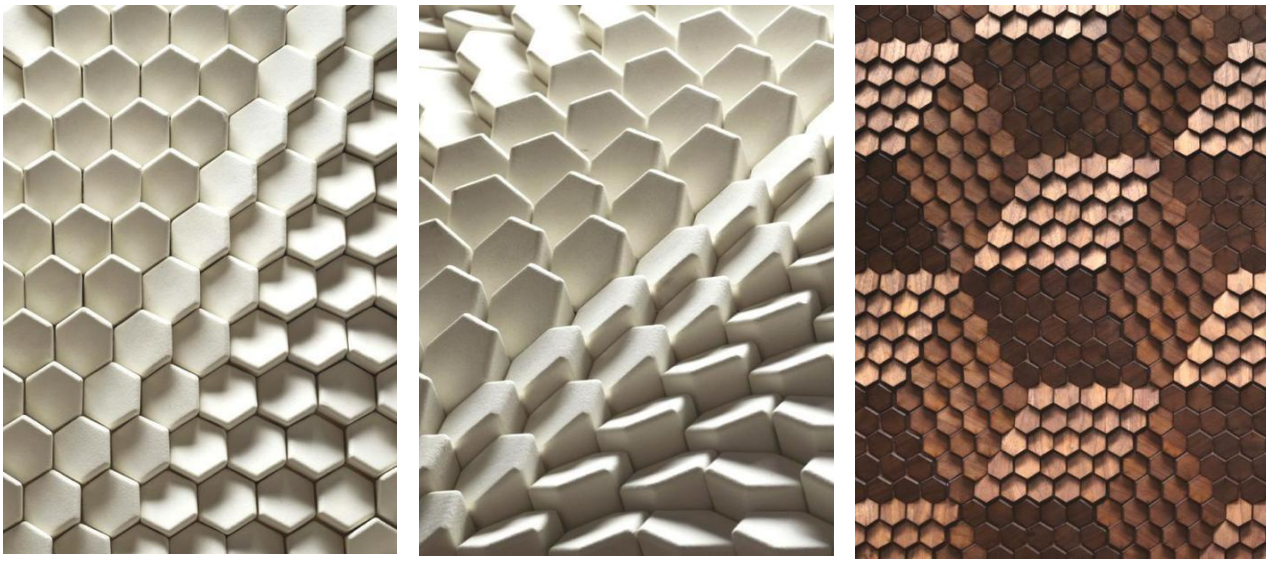


Fig. 2: Innovative surfaces for interior design created thanks to generative systems.

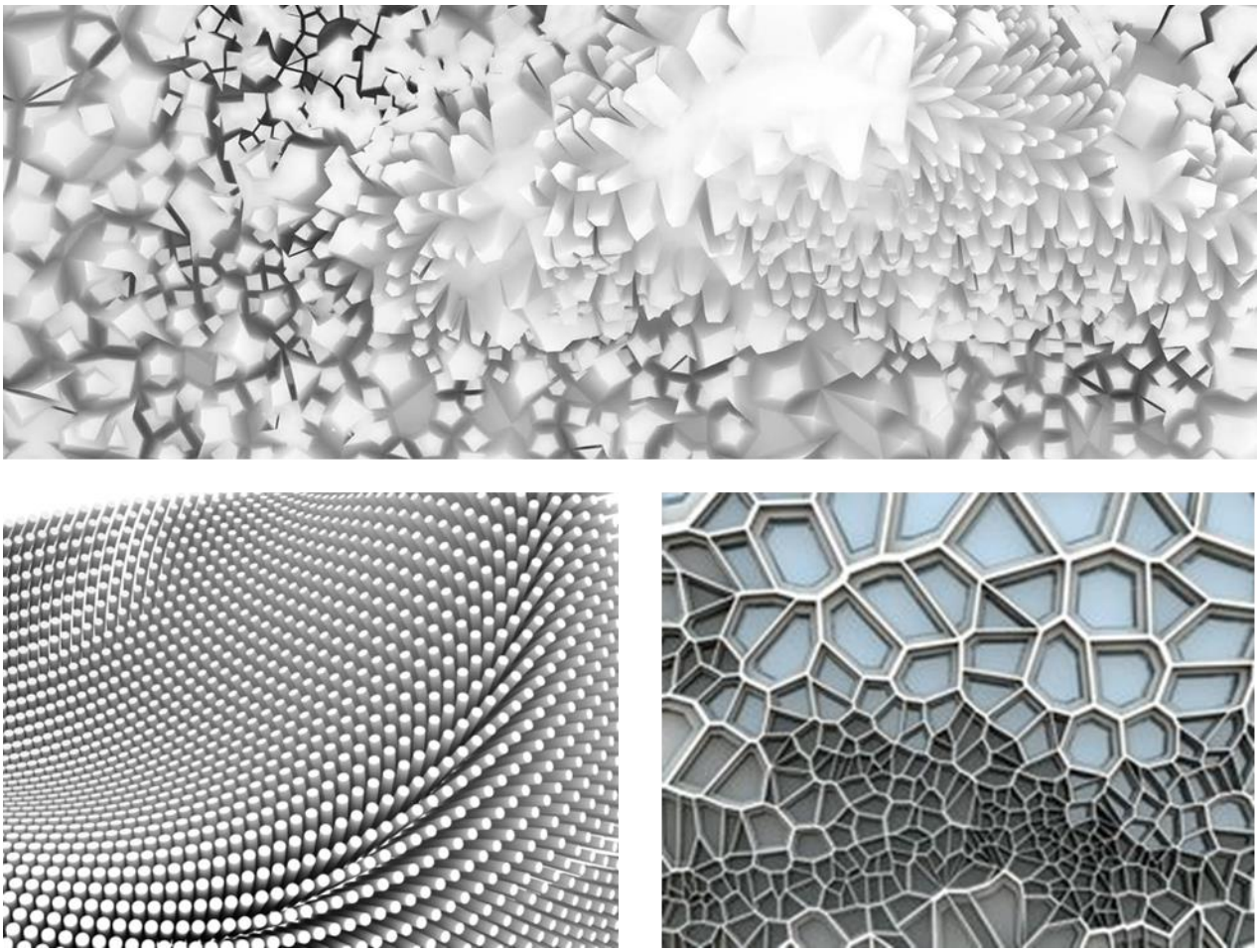


Fig. 3: Results of algorithmic modeling based on morphogenetic principles of nature.

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