city as organism

new visions for urban life

22nd **ISUF** International Conference | 22-26 september 2015 Rome Italy

edited by
Giuseppe Strappa
Anna Rita Donatella Amato
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Urban Form Reading and Design
Urban Morphology Theories and Methods
New Researchers' Forum
Local Networks Forum

U+D edition

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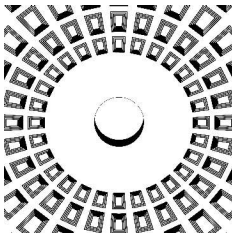

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Urban Form Reading and Design

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Urban Growth

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Urban Knots

New Trends in Urban Design

Public Spaces

Modern and Contemporary Urban Fabric

Typological Process

Urban Growth

Evolutionary design for BiOrganic Architecture

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Keywords: Shape generation, pattern-language, urban growth, algorithmic design

Abstract

A new design philosophy is based on the contemporary condition that allows architects to manage complex-systems science as a tool for the development of the project. Conventional analytical - reductionist - methodology is supported and sometime substituted by non-linear processes, including computer aided software. Generative methods for urban design are able to propose solutions to complex building settlements through the use of self-generated computerized programs; in terms of possibility, the use of the computer as a thinking support, let the designer's community achieve natural system employing artificial intelligence. The potentiality of this methodology is that of creating a city that will be as natural as a spontaneously generated as a living organism. The paper illustrates a tendentious point of view putting in continuity the "natural" growth of ancient cities and projects for new neighborhood made up with the support of generative methods. Makoto Sei Watanabe's Induction Cities project is based on the main concept that cities as living organisms have to be planned using tools supporting this BiOrganic innate characteristic. The purpose is to discover ways of making cities and architecture that provide better solutions to problems at the same time offering greater freedom to the imagination. A test case for Induction design methodology in a selected suburban area of Rome is foreseen.

Introduction. Organic is rational

Architecture is not just a figurative art, and this is more easily understood when we look at the processes of generation of cities: even when built cities seem to be spontaneous and unplanned, they highlight evolutionary and "natural" processes due to the will and the case.

According to Christopher Alexander, the renowned father of the Pattern Language theory, the organic unity of Venice, Amsterdam (Alexander 1965, 1987) and of almost all the cities of the past is appreciated because ancient cities didn't follow any abstract ordered drawing.

Apart from those cities designed starting from a precise geometrical figure in plan, as in the city of Palmanova, the fortress-city built at the end of the 16th century in the Republic of Venice with the form of a nine-pointed star, or other famous Italian cities founded, above all, during the Renaissance, or else those squared new towns typical of the New World, most part of these cities are seemingly spontaneously generated just like biological organisms, self-organized according to physical conditions, supporting the particular orography, and determining the shape of the blocks and of the buildings upon geographical settings and climatic necessities or similar natural aspects. What makes - for example - Palmanova different from the squared new towns, even if geometrically set in an abstract figure, is an increased degree of complexity of the geometry. In fact the complexity is exactly the characteristics of almost all the living organisms.

Thus, "natural growth" is unique and not recognizable in any other biological or physical structure and nevertheless obey some Rule of Nature. The substance (and fortune) of Mandelbrot's fractal curves is all – in fact – in its capacity of describing any kind of complexity, even if it is a process that indicates more the analogy and the impressive resemblance of mathematics to very well-known images, than the opposite possibility to "mathematize" something. That is: it is easy to rich a form from a formula. Not a formula from a form.

In the same way, urban growth seems to be something evolving (in a Darwin-way) rather than developing, so demonstrating the deep essence of the city as a living organism.

In 1986 Celestino Soddu, pioneer of the generative design in Italy, designed a software for creating 3D models of endless variations of typical Italian Medieval towns. He describes Generative Design as 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 (Soddu 1992).

And, because the city is a living organism, growing and developing over time, on several occasions, Luigi Piccinato, - the Italian Town Planner, co-founder with Bruno Zevi of the ApAO (Associazione per l'Architettura Organica) - had stated that the concept of organic contains that of rationality, but in a more complex way, and that the organic culture is particularly suitable for urban planning (Astengo 1988).

The idea of learning from Nature, observing and imitating it, is frequent and recurrent in Architecture: beginning from the growth of the trees, to the metaphor of the bee hives manufacturers, to the golden mean that we can find almost everywhere, as well as the self-similarity of fractal geometry, up to chaotic system analogies, nature and artifice coincides in the spontaneous or pre-organized creative processes.

Christopher Alexander, in his four-volume *The Nature of Order* made an effort to incorporate life-evoking geometry and step-by-step construction into a design process orientated towards sustainable principle of urban growth. His Pattern Language (Alexander 1977) is a method of describing good design practices, pinpointed according to a description of the problems and of the related items like settlements, buildings, rooms, windows, latches, etc., classified and then explained it to local population so that they could design among themselves their own houses, streets and communities. The method leads to a kind of "do-it-yourself-generation" of urban design that could be compared to the computer-aided automated process method - selecting and organizing amongst prime archived elements - which is the basis of Artificial Intelligence, applied to any compositional activity (Capanna 2006, 2015).

It is no coincidence that Alexander' book Notes on the Synthesis of Form, analyzing

the design process in itself, influenced the development of the theories of those who believed that there is not any conflict between the aesthetical creation of forms and the use of computer software to generate them.

This idea of making available a method and a list of solutions open to everyone comes from the author's observation that most of the wonderful places of the world were not made by architects but by craftsmen. The iterative process which he proposed to select the right configuration (formalized in 1977 in the voluminous book A Pattern Language: Towns, Buildings, Construction) had a huge success, as a matter of fact constituting the forefather of most of the computer programs working on auto-generative structures, integrated by selective processes.

Nevertheless, Alexander himself admitted the failure of pattern language to produce buildings (and consequently cities) of certain beauty, so an in-depth analysis of those fundamental properties which he defined "qualities without names" became the topic of a kind of phenomenology of wholeness, again driving the solution of aesthetical questions into the field of mathematics. In fact, the old, intuitive method of design seems to be no longer sufficient for contemporary design.

As a consequence and thanks to the advancement of human knowledge, fueled by the development of cybernetics and computer software, some research on new urban design has also focused on *organized complexity projects*, putting together organicity and rationality, because organic is rational, as we can find in every living organism its mathematical structure. Moreover, who is familiar with mathematical and logical symbolic knows that Fuzzy Set theoretical approach to numerous problems of applied mathematics and, especially, fuzzy logical analysis of those problems, become frequent in the modern mathematical modeling of the real world.

Mathematical structures as the seed of generative methods for urban design.

A City is not a Tree (Alexander 1965), to quote the title of a short essay published in *Architectural Forum* just fifty years ago. Or is it?

If we follow the metaphor of cities as living organisms and of the natural growth of forms, a city is a tree, a leaf, a flower, a shell and so on, thanks to its organic nature. On the contrary, from the mathematical point of view, it could be a tree or a semi-lattice depending on the complexity of the relationships among the parts.

Showing the differences between old and new towns, Alexander highlights the related mathematical structures applying the Set Theory to different urban systems.

Simplex urban structures, without overlapping of systems, are trees (not in the green sense of the term, but following the graphic representation of intersections among connections); whereas, those structures characterized by an increasing complexity, with numerous parts (areas and crossroads) in common, overlapping, are semi-lattices. A semi-lattice is a partially ordered set, with important mathematical properties, and relevant applications in fuzzy set theory.

The search for analogies and similarities in Art and Science, to make a parallel between "organic growth" in Nature and the "organic growth" in Architectural construction, dates back at least to the first half of XX Century. Cornerstones were the work by Sir d'Arcy Thompson (Thompson 1917), as well as the later investigations of Matyla Ghyka, who developed a whole theory where the notions of "Mathematics of Art" and Mathematics of Life" are (to use his words) *coincident […] under a condensed form that we can call «The Geometry of Art & Life»* (Ghyka 1977, Introduction).

The paradigm is to consider the design process as a result of organic growth. The evolution of information technology and, above all, the studies on AI (artificial intelligence) support the efforts to apply the computer science to architecture.

Shape generation is based on issues of regularity and/or irregularities and it concerns the locking on and the enforcements of laws, principles, rules and exceptions. It is also based on the correspondence between ideal forms constituting visual imagery and geometries. Finally it is based on the observation that our universe is not "simple" but rather formed by simpler fragments from which "order emerges from chaos" (Érdy 2007). So, the

aim of the research on generative methods to urban design is to overcome the imitation of the growth in itself, constructing not only forms that are natural or looks like natural, but even trying to work as Nature would work.

Trees and grids, set and systems, simplicity and complexity, linear and non-linear, patterns (bi-dimensional) and spatial (three-or-even-four-dimensional) organizations of cities or parts of them, are all ordered mathematical structures with different level of complexity.

So, what do we mean by "regularity" or "chaos" in the developing of urban form?

In Search of a "Free Order"

Almost everyone knows, at least at intuition level, what is an ordered event and what is a chaotic event. The simplest way to describe it is to define, following an instinctive geometrical approach, the physical position of objects or their parts. This is because Geometry, as a whole of relations between positions, quantities and qualities, has essentially to do with human acts, mainly performed according to organized schemes, oriented in Space and in Time.

Some elementary form of Order seems therefore to be always present, even if it easy to consider chaotic, for instance, the growth of a town, modern life, traffic, brute conglomerations of uncoordinated forces. When observing such events, considerations of perceptive and subjective character emerge and lead into the field of Gestalt Psychology (Wertheimer 1944). It informs us that Chaos cannot be seen until one looks at reality "from below", as being formed by fragments whose reciprocal relations often stop at relations with neighbors, in a short-sighted perspective, unable to govern as a whole the complexity of sets that can be unlimited or so large to be easily considered as with no frontiers. From such a viewpoint also Order will remain hidden. It is therefore necessary to work at a distance and look at structure from far away; an operation that allows to recognize schemes and rhythms, measures and reciprocal relations that, according to Rudolph Arnheim (Arnheim 1977) unavoidably determine "order relations".

In his short essay entitled *Entropy and Art. An Essay on Disorder and Order*, Rudolf Arnheim claims:

Order is a necessary condition for anything the human mind is to understand. Arrangements such as the layout of a city or building, a set of tools, a display of merchandise, the verbal exposition of facts or ideas, or a painting or piece of music are called orderly when an observer or listener can grasp their overall structure and the ramification of the structure in some detail. Order makes it possible to focus on what is alike and what is different, what belongs together and what is segregated. When nothing superfluous is included and nothing indispensable left out, one can understand the interrelation of the whole and its parts, as well as the hierarchic scale of importance and power by which some structural features are dominant, others subordinate.(Arnheim 1971, abstract)

In the same way some theorists of "esthetics of information" declare that Art (as such, Architecture) is located at the intersection point between Order and Disorder.

New urban settlements are generally characterized by the use of a (ordered) module as a technique and as a method. These are some of the major distinctive features of Le Corbusier's approach to the conquer of Order, that can be obtained by adopting suitable "regulatory paths": "*Un tracé régulateur est une assurance contre l'arbitraire: est une satisfaction d'ordre spirituel qui conduit à la recherche de rapports ingénieux et de rapports harmonieux. Il confère à l'œuvre l'eurythmie. Le tracé régulateur apporte cette mathématique sensible donnant la perception bienfaisante de l'ordre*" (Le Corbusier 1923, p. 53).

The aim of my research is to introduce the possibility of enucleating a logical form lying at the basis of the geometrical structure of the composition, in its transformations, in its discontinuities, in all the interruptions, in all passages, in the borders of a rule, in the force of propagation and in the ability of coexistence and superposition with reference figures that case by case are selected by the planner as those that are able to better interpret the "genius loci". Additionally, to analyze the application of self-generative software programmed for urban design as a tool for setting a *free-ordered* plan.

Even if streets are usually made to run straight, people take more pleasure to walk

in a medieval labyrinthine town. The figurative analogy with fluid circulation (sap of the leaves, lung tissue and capillaries in general) is so plain, and also its fractal nature, that compares our inner structure and the surrounding environment.

To synthetize:

- should Chaos theory explain the development of urban settlement?
- can we recognize a sort of entropic process observing the urban growth?

Entropy, as a generic explanation of "casual rules" in everyday's life, is part of our usual language. People with limited scientific knowledge easily understand the physical reasons of events that are related with daily problems. It makes also part of "common experience" the understanding that several phenomena, maybe most of them, happen exclusively and in an irreversible way because of a process that tends to pass from Order to Chaos.

- but, does the design process proceed from order to chaos or, vice versa, as designers, do we tend to organize our projects as ordering elements, proceeding towards a new order out of disorder?
- and, above all, can a computer manage regularity and irregularity with the aim of achieving better solutions for town design?

Another observation derives from analyzing the different levels of entropy. When this quantity has not yet attained a maximum (that we can imagine as corresponding to a static, homogeneous and totally chaotic configuration, that can be reached only after a reasonably long time has elapsed) we can still realize the existence of "complex regularities" that are produced by the transformation law. As is well known, in fact, the term "entropy" (from Greek en, i.e. "inside", and trope, i.e. "evolution") means "internal change". Accordingly, the above situation does not determine an effective degree of disorder, but rather the ensuing of "different internal configurations", something that Ludwig Boltzmann called "complexions", just to make clear the existence of a microscopic dynamics underlying the macroscopic dynamics in equilibrium. Such changes have therefore an evolutionary character and obviously describe in an almost perfect way those that happen in Nature but also, according to my tendentious point of view, in the "spontaneous" growth of towns, that is usually characterized by a regulating layout that (with notable exceptions) is unintentional rather than fully programmed.

Generative methods

The main purpose of generative software for architecture is not to discover forms, but to settle ways of making cities, neighborhoods or buildings and to provide better solutions for people and their wellbeing. It also offers tools for visualizing concepts and creating projects as if they were spontaneously generated. This is not enough, of course, because people (and designers) need to associate to the precision of the method a certain amount of aesthetical qualities.

Far from attempting to historicize the creative act of composition and the research on generative software as well, it could be useful to quote Michael W. Mehaffy's paper "Generative method in urban design: a progress assessment" (Mehaffy 2008). The paper describes the upgrading phases of generative methods as ancestors of a new urbanism for our present world, after the Modernism; it illustrates a kind of return to the origins and to the utopia of ideal cities, garden cities and painstaking basic plan drawing schemes - or standardized template - for urban designers, developed within the New Urbanism. The point is, according to Mehaffy, that the city cannot be a work of art - that is exactly what he consider the effect of the implementation of the advancement of computer science for architecture - and that, on the contrary, it could be advantageous a transition of modern information technology in a more adaptive organic direction.

On the contrary, in 1994 Makoto Sei Watanabe developed the Induction Cities program, essentially founded on two topics: visualizing concepts and providing a method.

Watanabe's approach tends to be similar to the principles of the biosystems more and more of which is being understood through research on artificial life. However, living organisms are not governed by a smart designer, so, what guarantees its self-organiza-

tion? The answers, although in terms of possibility, allow designers to use the computer as a thinking support and let the designer's community achieve natural system employing artificial intelligence.

The idea is not, of course, to automate design; the aim is to achieve higher quality by selecting among a large number of possible solutions using computers as an extension of the brain.

Forming process according to Makoto Sei Watanabe's Induction Cities

Makoto Sei Watanabe began the "Induction Cities" project stating that a city cannot be designed, an opinion that is not in contradiction with that of Alexander's about the fact that common people are (by nature) better than designers in knowing what the city needs to offer; so in 1994 Makoto Sei Watanabe developed a Program Aided Design, capable of proposing solutions to complex building settlements through the use of self-generated computerized programs. The potentiality of this methodology is that of creating a city that will be as natural as a living organism.

The first that has been built in Japan is Atlas (1995). It is a multi-unit housing complex based on the same concept generalized for the "induction cities" project, which basically underlines that the facts create a city.

Atlas is intended to be a collection of variation on the theme of the house that could fit all the possible needs in terms of dimension and facilities required. Watanabe prepared 16 different types of plans for the 20 dwellings to be built on the selected site, and combined them as individually unique volumes.

Computer combines units at random and sends sunlight to each, for instance, in the experimented case-study of Sun-God City. In Atlas, it combines as well the different housing types, providing the unit program called *Generated City Block* with a tool that generates street patterns efficient but avoiding monotonous grids. This process is repeated automatically until all the units are arranged. Of course this method can be applied to generate settlements fulfilling other important conditions such as privacy, accessibility, and other fuzzy criteria concerning the human wellbeing. "Feeling good", in fact is difficult to include in a common set of rules of required objective conditions, essentially because the concept is vague and above all it cannot be unified. What Nature teaches to us is that diversity is the "right answer". (Makoto Sei Watanabe 1998, 2002).

Conclusion. Selected case-studies to test the method

As the purpose of the use of generative software for architecture is not to discover forms, but to discover ways of making cities and buildings that provide better solution to problems, while at the same time offering a support to new frontiers of the imagination, it could be interesting to test the method in selected case-studies of regeneration of peripheries and of historical neighborhoods. The need to re-establish the relationship between man and nature should not only operate as an attempt to mitigate - through eco-friendly technologies, energy efficiency, use of recyclable materials - the negative human effects on the environment, but also encourage a radical cultural change with a new methodology. Instead of selecting patterns and organizing grids and geometries, or falling back on wistful ancient-style solutions, generative results rise from answering to the unquantifiable need of good and beauty that could not only correspond to what is right.

In particular for the regeneration of the historical Roman suburbs we can think about two different types of cases-studies:

1. Outdoor spaces related to post-war suburbs.
   Generative software can be programmed to satisfy fuzzy criteria such as: vegetation suitable for cooling the common open space, nice view from the inside of the houses, suitable areas for young and for old people, balance between paved areas and areas for rainwater harvesting, grey areas not too thick, etc..
2. Demolition and reconstruction of parts of the city in bad social and urban condition.
   Starting from the famous demolition of Minoru Iamasaki's Pruit-Igoe (city of Saint-Louis,

Missouri), to Chicago Cabrini Gardens, up to the recent idea to substitute the whole ro man settlement of Tor Bella Monaca with a New Urbanism project by Leon Krier, my tendentious point of view is that it could be interesting to test Makoto Sei Watanabe's method and the studies on Generative design, as the seed of what could be called BiOrganic @rchitecture (Makoto Sei Watanabe http://www.makoto-architect.com/books/book_yawara2_e.html), to the previous cases-studies(Tor Bella Monaca at first), programming the generation of a new urban form with fuzzy criteria to attain urban life style in sustainable, convenient and enjoyable places, without nostalgic style of past recoveries.
The research is in progress.

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