Architecture complexity and reality. The art of conjecture

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The architect that is given the opportunity to design urban space, needs to take into account as much data as possible as well as his own unawareness . To do so, he needs the proper tools to handle the city complexity and when necessary, to control his lack of understanding. Modern theory of complexity developed in the region of hard physical or mathematical science can be used for a new fruitful extension of the architectural theory.For an architect, an urban designer, the final goal should always be the production of livable and vivid space within the city; Space that will satisfy the citizens' needs and reflect his own ideas expressed through his work, at the same time. While he tries to "decode" and understand urban space, conjectures are made by him, so as to create a simplified "image", a model representing in an abstract way a chaotic reality of infinite factors. His ideas, based on these "artificial" realities, represent an abstract approach to a desired goal. This procedure, even though seems the most logical or "sincere" approach, it always contains the risk of failure in the very primary conjectures made for the urban space. Concerning the urban dynamics the modern architect must be aware of their internal uncertainty of the urban dynamics produced by their non-linear character in accordance with the deterministic chaos included in nonlinear systems. An architect who seeks to re-connect his ideas, his personal theories, his beliefs with reality, while not becoming a mere facilitator of a fashion-style architectural approach at best, has to operate in the borderline between the two extremes. Moreover, establishing scale between them becomes crucial. Thus he will reach the golden ratio in the process of the production of space, choropoetics, and create high-quality urban space. Seeking the theoretical background that will answer how such a procedure could become possible, the theory of Complexity might be the proper tool that will define whether architecture is to be seen as an individual act, or an act of collective responsibility and involvement in which complex and infinite factors counteract dynamically.

Keywords: Non-equilibrium complexity theory, Architectural complexity, Architectural thermodynamics, Non-equilibrium urban dynamics

1. Introduction

Architecture and urban design, as biology or medicine have so far resisted to obtain a scientific formulation as was done with physics, chemistry or mathematics, because of its underlying complexity. The pioneering work of Christopher Alexander [Alexander , 2002] and Nikos Salingaros [Salingaros , 1998] showed three laws of architecture concerning the order on the lower scale, the higher scale order that reduces the entropy and a linked ranking of intermediate scales connecting the lower and higher scales. Under this understanding architecture as science and art at the same time reflects the complexity of spatial forms and the complex organization of urban space. On the other side the work of Nikolis and Prigogine [Nicolis & Prigogine , 1977], [Nicolis & Prigogine , 1989], [Prigogine , 1980], and Haken [Haken , 1983], [Haken , 1987] are used by many scientists in order to develop the modern theory of architectural complexity as for the urban development and the dynamics of cities [Portugali , 1997a], [Portugali , 1997b], [Portugali , 2000], [Haken & Portugali , 1996] [Benenson & Portugali , 1995]. The architectural complexity theory could somehow be related to the general physical complexity as nature works as a producer of forms from the very small scales of subatomic particles to the scale of biological forms and further to the cosmic scales. Also the architecture complexity must be related to the human brain complexity, which is heuristic, producing internal mental forms or mental icons (images) which are used for creating external or material forms (Lagrange, urban development, internet, etc.). Historically the "image" we have for space was based upon the view we had for the world. Philosophy and science, especially physics and cosmology, have been the two basic mental 'tools' of understanding how the world, and by so, pretty much everything, functions. Ancient Greek philosophers viewed the world as a battlefield between the powers of order, the gods that created the world, and those of disorder that came through Chaos, the initial cosmic situation. Hesiod's chaos had often been interpreted as a moving, formless mass from which the cosmos and the gods originated. Between them Eros represented birth, creation, life, synthesis. Science developed assuming that natural world's function reflected a "higher" order. Disorder was more likely considered a damaging, negative factor. Plato first, insisted in observing the world through ideal, perfect shapes and models. His though placed abstract icons above the more complex natural forms, that were mere reflections of these grand-designs. Even though these ideas dominated science and philosophy for centuries, newer theories might unveil that a re-thinking process is necessary, considering the way we understand the world, and therefore, us within it. The human brain with its millions of neurons is an extremely complex "machine". Cities, as a social group, is a system consisting of thousands or millions of men, with everyone being different and unpredictable. Probably, in a macroscopic view, it is the most complex system we have known until today. The Theory of Complexity (Chaos) could become the mean through which an architect will understand how a city works, before he intervenes. Furthermore, the theory itself could benefit from the study of such a highly complex system, as a city is. So far nature's complexity is considered to begin with the atom structure and inevitably result in complex biological organisms, thus implying the existence of a strict ranking. Applying the above logic in architecture, particularly in the critical areas of urban design, the architects of the 20th century believed that they could reach absolute conclusions which would lead to the long desired utopia. They would fully meet massive needs, through logical and inductive design. This kind of thinking ended up turning humans into "averages", according to which, design averages, average people, average expectations were set. Excited by the scientific and philosophical ideas of the era, they proposed solutions that would, by terms of quantity, reduce architecture to a more complicated form of simple engineering. New means of transport, height growth, low coverage, users-objects with quantitative needs, though sounded idyllic, led modern cities to an impasse. The design methods applied were based on the anthropometric and artificially constructed model of the average man (Modulor), which flattened the diversity of the citizens. Reaching its edges, the theory lead to some extremely absurd conclusions, so that a chair and a city of three million were designed after the same principles, as shown in Figures (1, 2).

The greatest architect-planner of the 20th century, Le Corbusier, summarized the reasoning in the quote "The house is a machine for living in.". By that quote, the cities of the 20th century were built giving first priority to the practicality, economy and standardization. As it was through time proven, this hunting for utopia mathematically led to "a-topia". Unexpectedly, the programming mechanistic data were capsized as soon as users begun to familiarize with space and seek to express their differences by and within

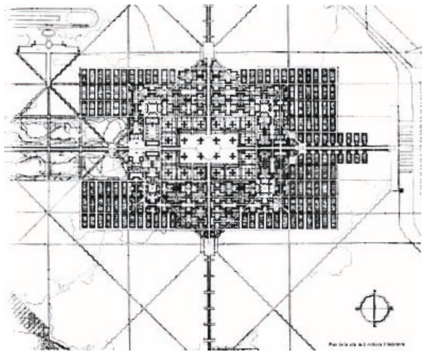


Fig. 1. Ville Radieuse (1924), a city designed from Le Corbusier, a typical example of international style urban design. The designer is the creator of the urban environment, thus leaving less creative freedom to the residents.

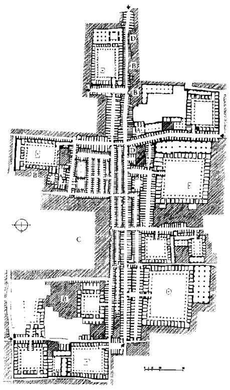


Fig. 2. The Bazaar of Aleppo city, Syria. Following the ancient Greek road of the city, this urban formation evolved continuously through the centuries. This kind of additive design, were new forms continuously emerge next to the old ones, creates an urban space which is literary shaped by the needs of its users.

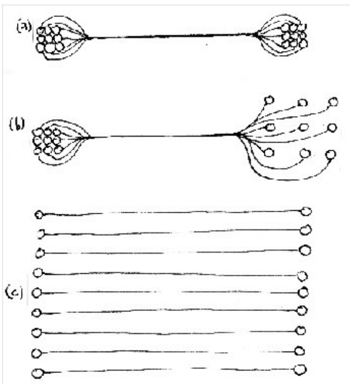


Fig. 3. The minimal connections in the Ville Radieuse, as proposed by Saligaros. (a) Office building is connected by overloaded channel to high-rise apartment block. (b) Factory connected to residential suburb. (c) Mathematically, both (a) and (b) are equivalent to parallel non-interacting strands that do not form a web.

it. Conditions that seemed to work in a statistic level turned up being dysfunctional or were even canceled, as displayed in the diagrams in Figures (3, 4).

In the meantime, new arose, completely out of the designer's provisions. The architect's inability to adapt to the new requirements led to the gradual isolation and the well known ghettoizations. So it became clear that we ought to understand society in a greater depth and obtain a new perception of the urban

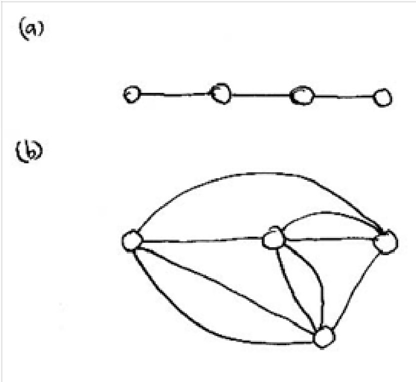


Fig. 4. Both the placing of the nodes and the connections between them has to be optimized for human activity. (a) Four nodes placed so that they look "regular" from the air; but this regularity forbids anything more than minimal connections. (b) Multiple connectivity between the same four nodes, seen in plan. Salingaros.

and social relations. If we accept that architecture is not limited to a simple contractor's type process, but as art and science at the same time creates human space and ultimately shapes the society in one way or another, we must develop new ways which will give us a better understanding of these processes. Eventually the city proved more complicated than a simple sum of individuals. Furthermore, a city, functioning as a system, created its own rules thus breaking the simplistic approach. Within the city new mechanisms arose beyond the architects' pursues, like self-organization and complex structures. Seeking a theory to explain those complex behaviors, the theory of complexity might be the answer. Its basic principles seem to explain efficiently the dynamics that govern human relations in the urban fabric. In a thinking, "stochastic", and philosophical level, the new theory of complexity, forms the basis of a thought that can describe the behavior of a sum of dynamic factors which co-act in space, as a whole. Cities are probably the most common example, in a macroscopic view, of systems of high complexity and diversity. At a social level, the theory might give us answers on how thousands of people function together, while maintaining a different and not standard behavior. At a political level it could give us an insight into the way we act as a whole, rather than as autonomous units. At an architectural level, however, we ought to take all the above levels into account and form the space that within which they could occur.

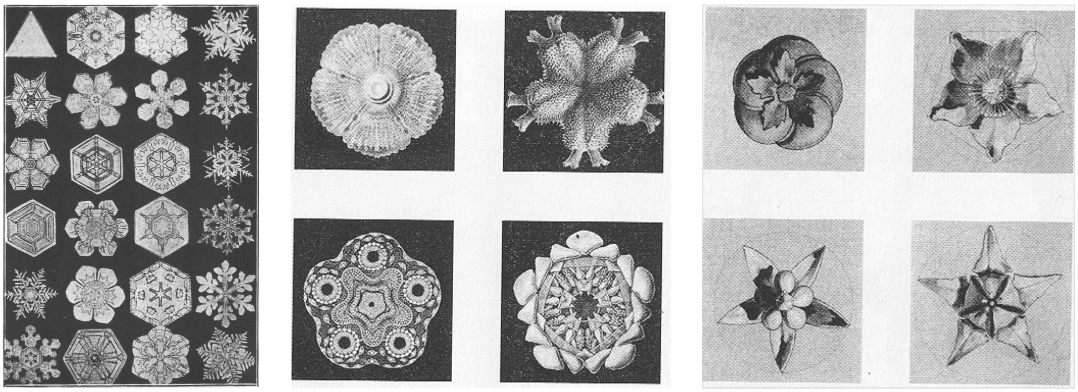
2. Architectural complexity

During the last two or three decades a strong current of concepts' flow, from the physical sciences and complexity theory to the modern architectural theory, exists, concerning either individual buildings or even cities or city webs. Subsequently we will summarize some evidence regarding architecture and complexity and emphasize on the importance of the science of complexity in the development of architecture in different size scales, during the past few years.

2.1. *Physical and Human architecture*

The importance of numbers and the theory of physics is increasingly felt in every level of architecture, buildings, urban networks, urban development. However, in addition to its scientific nature, architecture does not cease to be a form of art. The following analysis should not be regarded as an elimination of the element of art in architecture. On the contrary, complexity as a scientific language reveals the greatness of art; since apart from the mechanistic example of classical science, complexity shows us that nature acts like a natural artist, composing parts in a whole and creating forms of all kinds, physical or biological, as we show in Figure 5(a-c).

By ancient Greeks it was made clear that both art and science are based on numbers and mathematical forms. Now it is well known that the secret of biological growth is scaling, either via a Fibonacci series or an experimental series of the golden mean series. Ordered growth in physical forms or human constructions is



(a) (b) (c)

Fig. 5. (a) Snow crystalline forms (b) Marine pentamer forms (c) Pentamer plant forms

possible if there is a simple scaling so that the basic replication process can be repeated to create structure on different levels. For instance, the exponential scaling factor e fits both natural and man-made structures. An ideal, physical or man-made, reveals n sets of subunits with sizes corresponding to ever element of the following sequence:

$$x_{min}, e_{x_{min}}, e^2{}_{x_{min}}, \ldots, e^{n-1}{}_{x_{min}} = x_{max} \tag{1}$$

Figure 3 presents the function of the number ϕ in the human body. The number ϕ is known as the golden mean and can be found either in human or in natural creations.

Some of the properties of the number ϕ are:

$$\phi = \frac{\sqrt{5}+1}{2} \cong 1.618\ldots, \frac{1}{\phi} = 0.618\ldots, \phi^2 = 2.618\ldots \tag{2}$$

Also the sequence: $1, \phi, \phi^2, \phi^3, \ldots, \phi^\nu$ is a progress both multiplicative and additional containing properties of geometric and arithmetic sequence at the same time [Ghyka , 1927]:

$$1x\phi = \phi, \phi x\phi^2 = \phi^3, \phi x\phi^3 = \phi^4, \ldots, \tag{3}$$

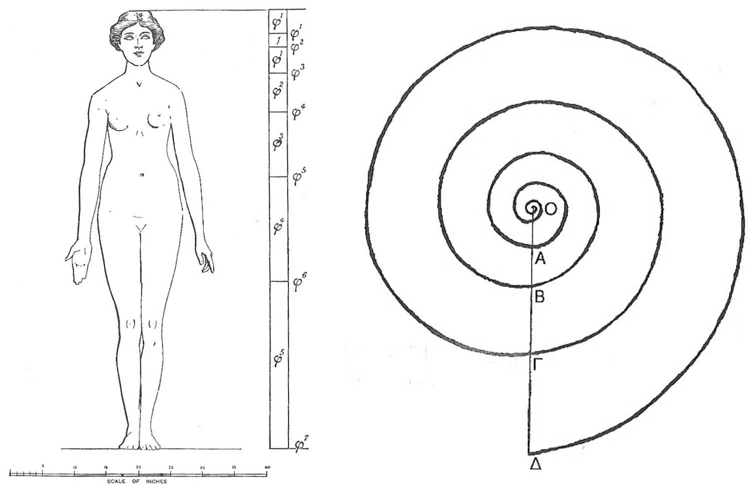
and

$$1 + \phi = \phi^2, \phi + \phi^2 = \phi^3, \phi^2 + \phi^3 = \phi^4 \ldots \tag{4}$$

Moreover, the number ϕ appears also in contemporary theories, which are related to the fractal structure of spacetime and the association of fractal theory with the elementary particles of matter, the quantitative characteristics of which are given as functions in the number ϕ. Particularly, according to El Naschie [El Naschie , 2004], under the smooth space-time manifold we can suppose a pre-geometry model after the transfinite extension of a projective Borel hierarchy in order to succeed the unification of Einstein general relativity and quantum theory. The El Naschie E-infinity theory, as the limit set of the Borel hierarchy includes or produces the four dimensional space-time manifold at low energy resolution. If the sets involved in the Boral set are taken themselves to be transfinite Cantor sets, then the Hausdorff dimension of the E infinite set at low resolution is given by: $4 + (\frac{1}{\phi})^3$ according to the relation:

$$< Dim(E - \infty) >_H = (\phi)^3 \cong 4.236\ldots \tag{5}$$

Also, the number $4 + (\frac{1}{\phi})^3$ reveals the remarkable self-similar continued fracture representation:



(a) (b)

Fig. 6. (a) The number ϕ and the human body, according to Cook. (b) The number phi measures the ratio of the successive distances from the center of the capital in the Greek Ionian style.

$$4 + (\frac{1}{\phi})^3 = 4 + \frac{1}{4 + \frac{1}{4+\frac{1}{4+\frac{1}{4+\dots}}}} \tag{6}$$

Moreover, according to [Datta , 2003] the singular role of the golden mean in present dynamical formalism of calculus suggests that a signature of the golden mean must be imprinted deep at the heart of every dynamical process in Nature.

The golden number ϕ as a measure of harmony is included in the human as well as in the natural creatures. Figure 6a reveals the human body constructed in accordance to the number ϕ according to Cook [Cook , 1914]. Figure 6b shows the use of number ϕ in Greek architecture, like the Ionic capital. In general, the use of mathematical forms by human architecture or physical theory, as Pythagoreans had first seen and then Plato, (Plato, Timaios) is now a fact directly related to the modern theory of complexity and morphogenesis. In situations where the thermodynamic potentials are minimized at equilibrium states or far from thermodynamic equilibrium then structures of natural self-organization and order expressed in a strictly mathematical way, are produced as shown in Figure 5. The forms of crystalline snow in Fig.5a correspond to stable states close to thermodynamic equilibrium, while marine and plant natural forms pentamers. Fig. 5b and Fig.5c, correspond to structures - forms of self-organization far from thermodynamic equilibrium. Furthermore, architecture treats all shapes to enroll the buildings according to the networks used by nature so as to achieve some kind of teleology, such as to support the plants, to raise them to light or for the fish to float stably in the water and for the bird to fly stably in the air. Thus, organs are appropriately designed or cells are classified in the tissues. For example, nature uses different types of geometric equipartitions and sorts the cells in space according to the square, the hexagon or the equilateral triangle, so as not to leave voids during the cellular building, as we can present in Figure 7.

Once more we see that both human and physical architecture achieve the optimum combination and coexistence of teleology, economy and aesthetic among the limits of the stable solutions of self-organized complexity far from thermodynamic equilibrium. Nowadays we know that metastable solutions of nonlinear Landau-Ginzburg equations describe the instabilities of fluids that lead to hexagonal or other forms of liquids far from thermodynamic equilibrium [Haken , 1983]. Finally, according to Kovacs [Kovacs , 1994] the spontaneous formation of spatio-temporal structures and modes is first of all a topological problem and it is the result of sudden qualitative changes known as bifurcations, where the initially quiescent system becomes unstable and insequence it restabilizes itself successfully in ever more complex space and time-dependent configurations. The above concepts reveal the novel significance of complexity and its

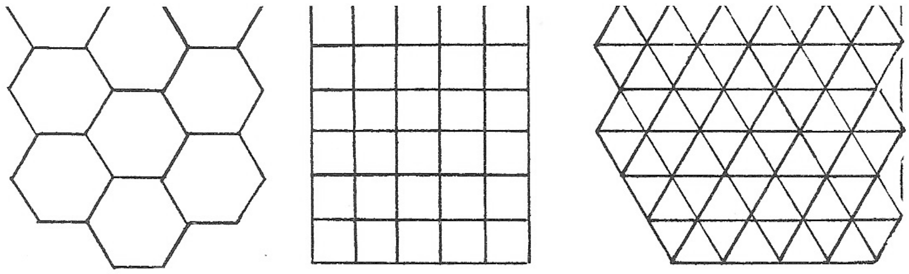


Fig. 7. Space geometrical equipartitions in biology and architecture.

mathematical aspects for the human or natural architecture, as we also show in the next sections of this study.

2.2. *Architecture and thermodynamics*

Complexity as a physical theory starts at the region of thermodynamics. At thermodynamical equilibrium system exists at the infinite dimensional Boltzmann-Gibbs attractor, with maximum entropy and without any macroscopic order. However, far from equilibrium the system is open and it can lives at different kinds of low-dimensional attractors with noticeable macroscopic order and self-organization character. Far from equilibrium the system can degrease its internal entropy increasing its macroscopic order. As concerning the architectural theory, according to Salingaros [Salingaros , 1997] the thermodynamic theory of physical systems can be included in the fundamental processes of architecture. Concepts such as symmetries and coherence that are well known in architecture can be combined into a sort of thermodynamic potential. Whereas in the past these concepts have been considered separately and qualitatively now the relevant qualities become measurable leading into a consistent and robust model with predictive value. The architectural entropy S, measured by some sort, shows the degree of architectural randomness in the patterns. The architectural harmony H is used in order to measure entropy indirectly as $S = 10 - H$ on a scale of 0 to 10. As the architectural entropy S represents the absence of symmetries, connections and harmony it is easier to measure the presence of those qualities than their absence. The architectural entropy is, like the thermodynamic entropy, an extensive function related to the average over the entire form. The architectural harmony H is the resultant of many components corresponding to rotational, translational and reflectional symmetries, or to degrees to which distinct forms have similar shapes, are connected piecewise or degree to which colors harmonize. As far as architectural temperature T, there is a loose analogy with where is the thermodynamic temperature and is the particle number density. The architectural temperature is determined by several intrinsic factors such as the sharpness and density of individual design differentiations, the curvature of lines and edges and the color hue. Lower scale randomness lowers H and raises T. As it is the complexity of an object that arouses a viewer's interest, complexity is the inverse measure of how boring a building is. The architectural complexity C of a building or a design can be expressed in terms of its architectural temperature and harmony as following:

$$C = T(10 - H), 0 < C < 10 \quad (7)$$

As the thermodynamic potentials characterize a system we define the architectural complexity as the product. This makes similar to the internal energy or the enthalpy. The architectural life can be directly perceivable connecting emotionally to an observer. The architectural life $L = 10T - TS$ would then correspond to something like the Gibs potential or the Helmholtz free energy. Moreover, Salingaros [Salingaros , 1995] extended in Architectural theory significant concepts extracted from the modern physical theory concerning the order on small or large scales as well as the natural hierarchy of scales. At architecture order on the smallest scale is established by pair contrasting elements, existing in a balanced visual tension similarly to the vacuum in quantum electrodynamics arising out of virtual electron-positron pairs, the nuclei formed from bound neutrons and protons with opposite isospin, or the atoms formed of bound electrons and nuclei of opposite charge. For the architectural theory the structural order is a phenomenon based on the fact that the fundamental building blocks are the smallest perseivable differentiations of color and geometry. At the large-scale the long-range interactions causes large-scale ordering and similarities between different subregions, so that entropy is reduced. Similarly, in architecture mimicking long-range interaction generate large-scale order in color and geometry and tie the small-scale structures together in a harmonious whole. At the natural hierarchy of scales the small-scale is connected to the large-scale through a linked hierarchy of intermediate scales with scaling factor approximately equal to $e = 2.718$. An architecture surfaces interact and define subdivisions creating structures at the appropriate scales. The different scales have to be close enough so that they can relate through structural similarities. Similarly in physics matter is not uniform. It looks totally different when the material structures are magnified by a factor of 10 or more. In fractal geometry, the Koch, Peano and Cantor self-similar fractal patterns reveal the similarity ratio $1/r = 2.7$. According to these concepts, Salingaros [Salingaros , 1995] postulated for the first time three basic laws of architectural complexity and produced their consequences for architectural structures. The laws of Architecture from the physicist perspective are as following:

- Order in the smallest is established by paired contrasting elements, existing in a balanced visual tension.
- Large-scale order occurs when every element relates to every other element at a distance in a way that reduces the entropy.
- The small scale is connected to the large-scale through a linked hierarchy of intermediate scales with scaling factor approximately equal to $e = 2.718$.

The architectural life L is related to the biological life and both of them are related to the thermodynamics of a living form or an architectural structure. Biological life as well as architectural life is the result of an enormous amount of purposeful complication, characterized by very high design temperature and harmony, . One class of examples of artificial objects that mimic living forms are the self-similar fractal curves. Both design temperature and harmony of the fractal curves are very high as they are self similar. Therefore fractal curves have a high degree of architectural temperature and fractal pictures provide excellent representations of natural objects. After all the architectural temperature mimics the activity of life processes which is highly organized and structured. From this point of view life mimics itself as the living beings instinctively copy the intrinsic qualities of living systems in their own creations. This suggests that human being have a basic need to raise the architectural life of their environment.

2.3. *Self-organizing cities*

While buildings are produced by an individual architect, cities are produced by many individuals. Because of this cities are characterized by spatial, social and cultural pluralism and complexity. As cities are spatially extended nonlinear dynamical system, the general complexity theory of distributed systems can be used for the scientific description and understanding of urban development and urban dynamics. According to Nicolis and Prigogine [Nicolis & Prigogine , 1977], [Nicolis & Prigogine , 1989] the far from equilibrium dynamics includes quiet periods with stationary patterns and bifurcation points where the system produces new patterns and new spatiotemporal structures. Prigogine's dissipative structures theory and Haken's synergetic theory can be used as a prototypes for the scientific modeling of the dynamics of cities [Portugali , 1997a]. The urban development includes evolutionary processes by which new urban centers emerge, grow and form the whole of the regional system of central places. As the system evolves, some old facilities grow, others decline or even disappear. Generally urbanism was a revolution in a sense that it globalized and stabilized the agricultural production. This was achieved by a system of cities distributed over vast territories. Each city is, on the one hand a local interactive component in a global system of cities. The internal stability of the local regional system and the stability of the global interregional system are interdependent and the system as a whole can absorb shocks. However, it is possible for this global system of cities or some parts of it to be destabilized resulting to the collapse of the entire system or regionally, creating global or regional crisis of the system. Thus, the urban system can live at critical states including second order phase transition process or other stationary states corresponding to first order phase transition process. This second order phase transition critical state concerning the urban development and dynamics is included in the general dynamics of self-organized criticality (SOC), developed by Bak et al [Bak *et al.* , 1988], for physical and biological systems evolving far from equilibrium. SOC dynamics or different modes of urban dynamics can be described by using the cellular automata (CA) method. Because of this we can speak for cellular automata cities. A standard two-dimensional CA model is a lattice of cells, where each individual cell can be in one of several possible states (empty, occupied, etc.) with several possible properties, (developed, poor, rich and so on). The rules which generate the iterative process and determine the CA state are local and they refer to the relations between the cell and its immediate neighbors. The local interrelations and interactions between cells entail global structures, behaviors and properties of the system as a whole. CA models of the urban dynamics are self evident as real cities are built of discrete spatial units such as houses or city blocks, the properties of which are determined to a large extend in relation to their immediate neighbors. The CA models of urban dynamics are a kind of zooming into the internal dynamics of self-organized systems. Application of CA models at real cities was done by Batty's project [Batt & Longley , 1994]. Generally, the self-organization character of complex systems is manifested when the system is in far from equilibrium conditions. There the sufficient flow of energy and matter through its boundaries allows the system not only to spontaneously self-organize itself, attaining certain structure and maintaining it far from equilibrium conditions but also it is possible to create or invent novel structures and novel models of behavior. Out of the self-organization of inanimate material systems application of complexity and self-organization of the animate system of humans and urbanism emerged. In such an application human and urban systems are open in a sense that that they exchange matter, energy, information and people with their environment. They are also complex in that their parts are so numerous and changing randomly so that there is no way to describe them neither in terms of cause and effect nor in terms of classic probabilities, as urbanists of 50s and 60s or the regional scientists of 70s and 80s, tried. Real cities and real urban dynamics are unpredictable as they organize themselves independent of our scientific predictions and planning rules. Modern or postmodern cities are characterized by spatial social and cultural complexity as the cities must be described as a special mosaic of coexisting cultural and social groups, old ethnic groups or new ones produced by the city's development and internal dynamics, as the city dynamics can generate the emergence of new cultural spatial entities. According to these concepts Benenson and Portugalli describe various city modes (city, city 1, city 2) as CA models including layers of models composed of migration sub-models and describing the inter- and intra- city migration movements, as well as the urban landscape itself. According to Haken synergetic theory, the far from equilibrium self-organization and pattern formation follows the slaving principle, according to which the order parameters enslave many parts of the system to their specific space-time motion. The order parameters of the system correspond to slow modes of the dynamics dominating on the fast ones and on the whole system on the macro-scale. For the urban system the fast modes typify the local urban microlevel of building sites, streets, subways, etc, whereas the slow processes typify the macrolevel of whole regions which are often described as systems of cities. The synergetic and self-organizing character of the urban system creates an non linear and circular casualty between the local and the global. Pattern formation and pattern recognition can be modeled as synergetic processes through order parameters and slaving principle, where as they can be included in the study of cities which are both physical and cognitive self-organizing systems. From this point of view individual's cognitive maps determine their location and actions in the city creating the physical structure of the city, which latter simultaneously affect individual's cognitive. This circular non-linear interaction produces the material and cognitive patterns of the city. Also, the synergetic theory predicts the existence of attention parameters for the city dynamic. The attention parameters can emerge by means of self-organization and become the order parameters of specific urban subsystems composing the urban pattern, as a state of multi-stability or an ambivalent pattern, defining the final attracting pattern. Concluding, we understand the possibility of CA cities, sandpile cities, or Free agents on a cellular space (FACS) and Inter-Representation Network (IRN) cities, introduced by [Portugali , 1997a], [Portugali , 1997b] as different manifestations of the non-equilibrium complex urban nonlinear dynamics.

Fig. 8. Saint Peter's square. The strict plan of the square and its connection to the city, leaves very few adds possible for the future. Even thought its architectural importance is unquestionable, it stands as a "single independend object" within the city.

Fig. 9. Piazza da Campo is Sienna. It's space and form have emerged through 200 years of constant changes. The structure of the city centre is complex and diverse chaotic.

3. The Architect's role in accordance to the modern theory of complexity

Theories and ideologies based in individualism are the norm. An architect acting as another individual develops his own ideas and personal beliefs and designs according to them. This way, the city becomes a vivid fabric of personal ideas, a mosaic of individual expression. However, in urban public space, a way of communication between them seems to be indispensable. For an architect who is trying to combine different ideas and beliefs that must coexist in harmony and not through conflict, questions will arise: If we have thousands of people with different wills how can we choose whom to suffice? Furthermore how can we redefine the role of the architect who on the one hand should avoid the over-design, acting as another small god establishing the lifestyle of the residents, while on the other he is required to design buildings, cities, space, suggesting something new? The architect must operate in the borderline between the two extremes. He ought to take into account the complex background and offer possibilities for it to adapt in his proposal. To avoid designing firework-cities such as those built in the middle of the desert, or museum-cities which have no room for anything "new", one must create the mental tools that will allow him to reach the "golden ratio" between those extreme situations. Unlike a computer or a machine, which can be replaced if malfunctions, it is impossible to do so with a city. Who can imagine cities like Athens, Rome, and Paris being demolished and rebuilt, each time with the necessary improvements done, until we get to an ideal form? Cities are dynamic systems, far from equilibrium, containing a high informational load. The architectural intervention is not an act neither separated nor isolated from its environment. Such complex rules and lack of regularity and order can be found in the city-scale more intense than elsewhere, due to the number of anomalies and interference of various factors. Clearly, these structures are not the result of conscious design, but more a natural product of evolution, as shown in the examples of Saint Peters square and Sienna square in Figures (8, 9).

We therefore need to design changeable spatial structures, not static, that can adapt to new data and meet new needs. We call these structures 'reflexive' and their organization, "dynamic". The "dynamic" organization refers to highly adaptable spatial formations, capable of unexpected future variations, con-

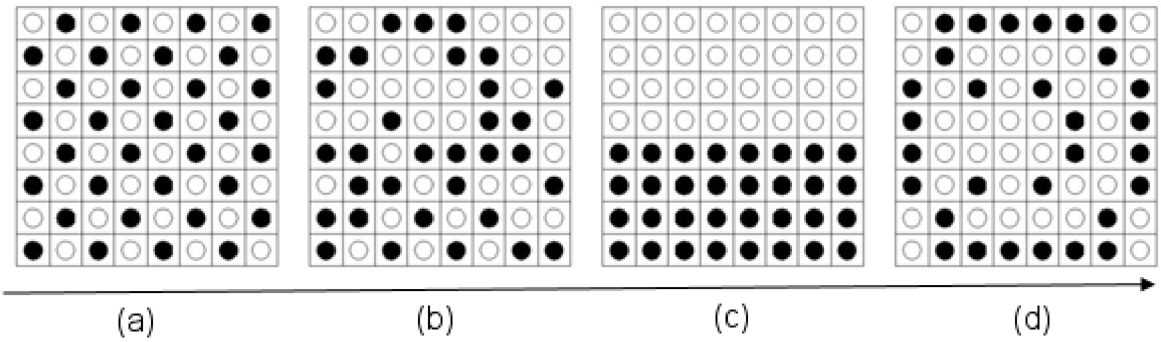


Fig. 10. (a) "Lower lever of order". The lack of structure-pattern makes the system look "random" (b) A self-organized structure, brings "the unexpecteded" order of lowest entropy and higher informational load (c) A strict structure : Containing a strict informational load. (compare with S. Peter's square) (d) "A higher level of order" comes from an unexpected emergence of a structure (a happy face). Informational load here is higher. (compare with Sienna Main square)

taining large-scale informational stimuli at different levels. The aim is to enable the inclusion of the random in the future, an option that enables the subject to determine the objects that will define its relational system freely. Potentially many, though finite, latent rules can simultaneously subsist and become dominant if activated properly. The rules which the user-resident will choose, according to one's own quality criteria, will interact with its environment and probably produce unexpected results for the user as the architect as well. Given the proper treatment and depending on the complexity of the matter and each one's abilities, the designer has the opportunity to combine two, three, or perhaps even more scenarios for a space, its users, its future, so as to create a "narrative" that proposes alternative future conditions. A story that is, which has the ability and flexibility to transform redefining the organization with varying results, while it is still unfolding. The strong structure of the story is broken and can be read in different ways. The nodes, the "keys" that fit those situations where the story branches off choosing an "end" and rejecting the rest, become the most important part of the design. The city takes the form of a collage and consists from fragments of ideas, history and statements. An architect trying to employ this new method needs to design flexible structures, capable of future variation, structures "reflexive" as we have called them. Even thought, such thinking process in buildings design might seem as a "luxury", when an architect is given the opportunity to intervene in a city-structure through urban design and thus affecting thousands or millions of people's lives, it becomes a necessity. In that case, the architect has to drastically limit the affect of his own ideas, his beliefs, his ego in his proposal, trying instead to take into account the greatest possible amount of factors that shape the city. Population needs, natural obstacles, political mechanisms, economical factors and more, become the true designers. These attractors, which draw evolution in one direction or another, work as general guidelines and can even be statements, facts or spatial memories. The urban designer should first act as a decoder of these attractors so as to locate and understand them and secondly adjust his proposals according to them. Persistent analysis of urban space could gradually surpass its phenomenically chaotic "image", unveiling an "organic net" of items, nodes and their connections that form the city structure. What before seemed as a result of lack, it could now be examined and analyzed as a net of "islets of order" in a "loose" structure that affects the form of the city and the density of the functions within it. An example of such structures and their categories is shown in Figure 10.

This new information, could give the urban designer a better understanding of the city, allowing him to intervene more accurately, while making his proposal adjustable to future variation. A space successfully designed through such a procedure, is not far from being described as "organic", and functioning as such, is capable of evolving in space and time, absorbing elements that proved useful and rejecting the rest. One could say that it functions in norms not idealistic, but in a general economy of "common good". Concluding, a form of organization and structure which is stabilized dynamically in a system out of balance will disappear if a better one occurs. From this point of views, evolution means continuous improvement of operational efficiency. Such systems result from a process of conjoining necessities rather than from an intelligent original and unique design. "This mixture of necessity and chance constitutes the history of the system". It also reflects its creativeness. Applying the theory in urban design does not necessarily lead to a strict formula of spatial production. However, the "random" as a scenario, an architect can propose more adaptable solutions.

4. Conclusions

Modern architecture theory for building or urban dynamics can be supported by concepts produced in the region of hard science as nonlinear mathematics, or fractal geometry, non-equilibrium thermodynamics and self-organization. Built environment cognitive maps and informational systems as well as the brain and its cognitive activities, the city and the artificial environment language and informational networks, in particular the internet, constitute the hard core of modern architectural theory. At 21st century we can understand the thousands of human, material and mental environments is a continuously developing self-organizing dynamical system including periods or structure as well as bifurcation points or short periods when the system re-organizes itself by creating novel structure, patterns, relations, correlations and novel processes. From this point of view self-organizing cities can be seen as a specific case of a more general phenomenon of the environment as a self-organizing system. That is the environment and its various ecological, natural and artificial subsystems can be seen as an open and complex dynamical and far from equilibrium system consisting of many subsystems. The human environment is a novel creation in the physical and natural complex system according to the general theory of complex systems.

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