Dissipative structures, complexity and strange attractors: keynotes for a new eco-aesthetics

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Abstract

There is a new branch of science strikingly at variance with the idea of knowledge just ended and deterministic. The complexity we observe in nature makes us aware of the limits of traditional reductive investigative tools and requires new comprehensive approaches to reality.

Looking at the non-equilibrium thermodynamics reported by Ilya Prigogine as the key point to understanding the behaviour of living systems, the research on design practices takes into account the lot of dynamics occurring in nature and seeks to imagine living shapes suiting living contexts. When Edgar Morin speaks about the necessity of a method of complexity, considering the evolutive features of living systems, he probably means that a comprehensive method should be based on deep observations and flexible ordering laws. Actually designers and planners are engaged in a research field concerning fascinating theories coming from science and whose playground is made of cities, landscapes and human settlements. So, the concept of a dissipative structure and the theory of space organized by networks provide a new point of view to observe the dynamic behaviours of systems, finally bringing their flowing patterns into the practices of design and architecture. However, while science discovers the fashion of living systems, the question asked is how to develop methods to configure open shapes according to the theory of evolutionary physics. Taking into account the aesthetics of a dynamic nature, is it possible to frame places according to their role in a complex living context?

Finally, the issue of this research should be the investigation of those patterns able to improve the cohesions between anthropic and natural systems and to develop harmonious relationships between human settlements and the environment.
1 Introduction

This paper is an observation on some scientific theories and, overall, on the innovation they introduced in practical disciplines concerning with design and planning. In particular, the non equilibrium thermodynamics and the theory of dissipative structures by Ilya Prigogine represent a significant revolution by changing expectations and perspectives and finally laying the foundations of evolutionary physics. Prigogine’s theory is the key point for explaining the paradigm shift occurring in science and also represents an authentic change of route in approaching nature and investigating its dynamics. As Prigogine said, “physics leaves its ivory tower of useless purity and comes to grips with nature, society, the bios and the oikos, the complexity of the true problems of humanity and our planet, without compromising its rigour and scientific character”.

Therefore, thermodynamics concerns with general universal laws able to explain at all many processes occurring in nature and, especially the concept of entropy is the main point to inquire in order to understand the behaviour of living systems.

2 Keynotes of non equilibrium thermodynamics

The second principle of thermodynamics concerns with entropy. Clausius recognizes the existence in nature of a universal, inescapable tendency toward disorder. It is a general trend toward an entropy maximum that is also a loss of usable energy availability. This spontaneous tendency takes to the thermodynamic equilibrium that Clausius highlights as a final status of “thermal death”.

Indeed, while the first principle of thermodynamics formulates the concept of energy in a conservation framework, the second formulates that of entropy in an evolutionary framework. It is the second principle and the concept of entropy that suggested the emergence of a broad branch of the physics concerning essentially with living systems.

The theory of dissipative structures enhances the intuition of Clausius and completes the second principle even if it seems to highlight its apparent failure in describing living system.

According to the "principle of minimum entropy" of Nicolis and Prigogine, a living system tends to a state of minimum entropy. Entropy varies with time during development that means the entropy of an organism decreases, reaches a minimum and remains constant in an intermediate steady phase and varies again in the senescent phase. The main feature of living systems is just that of behaving opposite to the universal tendency described by Clausius. In fact, they try to avoid the condition of thermodynamic equilibrium, keeping themselves as far as possible from that state. That’s why Prigogine defines living system as dissipative structures. They actually behave like open systems in a steady state (dynamicity, diversity, life) that maintain themselves in life (at high levels of order and complexity) by self-organizing due to material and energetic fluxes.
received from outside and from systems with different conditions of temperature and energy.

The importance of entropy is in its evolutive future. History and the succession of events are scientifically relevant according to any possible entropy assessment. Entropy provides the scientific evidence of the arrow of time. It is not intrinsically reversible and it has the broken time symmetry as Prigogine underlines. Therefore, energy is always conservative but entropy can change and increase or decrease according to the organization patterns of systems. Moreover, it exists a significant equivalence between entropy and organization and, consequently, between entropy and information. Prigogine highlights the theory of information flows, with that of organization and complexity, as a relevant factor in approaching every field concerning with evolutionary patterns or dynamic systems.

The concept of entropy and information takes place in science to recognize the importance of quality of energies also in natural evolution. Quality and information are concepts linked each other by the existence of entropy and also the aesthetic quality is a relevant factor within evolutive patterns and finally it strikingly assumes a significant scientific dignity.

This brief exposition gives just few keynotes which the observation provided by this paper is based on. They are also the few points to understand the meanings this new paradigm brings from sciences into design practices and disciplines.

3 The geography of invisible patterns

The impact of the human behaviour on the planet is a key point for the broad debate actually occurring in sciences and many technical disciplines. Many people in the world share a common target and it is rising more and more the consciousness of a global community. The global dimension is actually a tangible reality and the consciousness of a global citizenship in strikingly emerging. It is the growth of connectivity through the world that improves the capacity of sharing ideologies, projects, knowledge and information and that radically changes the perception of space and time through a net of relationships.

For instance, the theory of sustainability, dealing with global problems like the resources exhaustion or the emission of greenhouse gases, requires a global cooperation. The expected policy is based on the idea that sustainability is a global target that needs to be addressed at the local level. It effectively requires that every place, in a local context, improves a deeper perception of the role it plays at a broad and global scale. Furthermore, enhancing the importance of extended concepts like generational solidarity and global responsibility, the theory of sustainability is effectively framed on the relationships between places at very different dimensional scales (our actions happen here and also involve elsewhere) and also at various temporal scales (our actions involve future generations). Responsibility is conceptually deployed into broad spaces and times. How can this theory survive with so abstract terms? How is it to work according to these general and global directives and codes?
Designers and planners are certainly engaged in the debate about actions and strategies for the future development. Their attention has to be focussed on the relationships and connections existing in the global environment and the designed shapes have to suit a complex context with several levels and dimensions. Therefore, the observation of an urban environment easily shows how it is actually a full world with a high density of signals, actors and relationships. For instance, within a urban context, some places seems to suffer a chaotic saturation of information due to their being absorbed in a dynamic net of relationships. On the contrary, other places, suffer a lack of information, a deployed homologation with their context and an absence of any identity because they are not involved in any connection pattern.

In conclusion, the subject of the design is not an isolated static shape but, on the contrary, it is a whole system strikingly interacting with a huge context.

For this reason the starting point has to be a deep perception of the dynamics occurring in any system-place and of the role it plays in its connected environment. Consequently, the outcome is not an imposed shape but a management of existing patterns and signals in order to enhance local identities and, at the same time, to improve their connections.

Accordingly, Mascarucci says the limits of actual design and planning tools suggest the passage from mechanical approaches to holistic planning models. The new way to act is based on strategic choices, on projects flexibility according to dynamics that take place in the environment, on relationships improving by “paradigm of space organised by networks”.

Therefore, new geographies have significant implication in design practices. Every place behaves as an open system and its dynamics are those of a living evolutive system or, at least, of a dissipative structure. Taking into account its network of relationships, the real subjects of the design practices are effectively the all fluxes of energy and matter and those of information going through the system. This kind of flows are often invisible and the design techniques, that starts from processes of data collecting and data processing into maps, has to let their geography tangible in form of flowing fluxes through the inquired system, practically revealing their hidden patterns. These mobile geographies definitively open new perspectives for the design practices of urban systems that feed on connections and flows.

4 Suggestions from science

What results from the described approach, imposed by the awareness of environment deployed into complex connections, is the perception of a space made of a series of networks and nodes. Also the project of places provides shapes in form of nodes of a broad dynamic network. Furthermore, the frame of the networks achieved a high variety and diversity of signals and information. Networks are not always linear or continuous and the nodes are not just points where two lines collide. Otherwise, a node can be defined as a place where the intensity of multilayered relations, lines and flows, increases and achieves high levels of complexity. The role played by each place and its configuration can be
imagined and expressed according to this definition of node that is deployed in a specific area where relations became intensive and many signals coexist. The design of the place comes directly from the interpretation of the visible-invisible networks and its issue is to make them definitively tangible. Mascarucci also write that a place changes its sense according to the networks it chooses to own to: “when geometry of networks changes, at the same time, the sense of the place changes and the planning demand changes too”. For this reason, the investigation on the geographies of these dynamic patterns, always in transition, plays a significant role to define a framed shape that is conceived to suit its context of hidden connections and flowing fluxes.

Nowadays, it is not unusual to find architectural shapes that follow this kind of suggestions in approaching their context. It seems architecture is looking for new outcomes from this theoretical debate about global connectivity and the geography of networks and nodes. For example, the conceptual design of the museum of contemporary art in Rome by Zaha Hadid starts from the awareness of a pattern of hidden flows crossing through the empty area of the project and, following their directions, new astonishing shapes appear. The configuration of the project is conceived as a node of overlaid interactions and fluxes. This pattern is framed as it was iced in a shape absorbing the high density of signals from the environment and finally revealing the dynamic nature of the place.

Figure 1: The Museum of Contemporary Art in Rome by Zaha Hadid.

Despite this example is just an artistic interpretation of the theory of flows, what is now expected from science is to inform the design by investigating the complex behaviour of nature and its spontaneous evolutive dynamics. For instance, the amazing phenomenon occurring spontaneously in some chemical reactions, known as Belousov-Zhabotinsky, can be described drawing the evolutive behaviour of three parameters in a Cartesian space (three axis). The tridimensional paths so obtained are very amazing shapes called strange attractors because they follow chaotic orbits around an attractive area. Moreover, their strange geometry means their complex behaviour follow a kind of ordering
principle. This scientific practice in the field of evolutionary physics could be also a significant suggestion for applications in disciplines concerning the design of urban systems. The research on design and planning is now focused on the attitude to catch the complexity of the context and absorb its revealed pattern into the project. The most recent architecture probably seeks to follow the same rules, even if it does not follow any scientific rigour, and this is probably the reason why many of the recent architectures have been developed in form of blobs or strange attractors. For example the project for the virtual Guggenheim museum by the Asymptot Studio is shaped as a Moebius ribbon and very similar to the strange attractor drawn by Lorenz.

Figure 2: The strange attractor by Lorenz and the Virtual Guggenheim Museum by Asimptot Studio.

5 Conclusions

The issue of this paper is an observation on the theories of the new science and their influence on other disciplines. The paradigm shift occurred in science suggests the development of new attitudes in approaching reality and, finally, many applications in the field of design and planning provides non traditional shapes by investigating the environment from a dynamic point of view.

The research about design actually requires shapes able to reveal the basic idea of a dimension made of networks and nodes and deployed in several dynamic interactions. Therefore, the expected issue is especially the development of useful tools to inform the design processes by collecting data about multiple flows of energy, matter and information. These required tools have also to process data and provide information about the environment in form of new geographies focussed on the existing net of connections and finally aimed to show their invisible dynamic pattern. New geographies, revealing the living behaviour of inquired systems, are the key point to act in a full context where lot of signals, interactions and flows coexist. They look for a synthetic and tangible description of all these hidden dynamics. Indeed, information and flows of information through the place are more and more significant for the project despite their virtual dimension is a kind of abstract cyberspace.

The final question, maybe still unanswered, is how the paradigm shift occurring in science effectively suggests new approaches for design and disciplines of urban planning. Maybe Edgar Morin provides an answer when he...
says: “The method of complexity re-actuates the relationship between disconnections and fractures; it works to comprehend the multidimensionality and never forget the integrating whole”.

Perhaps, these suggestions provide a risk to achieve very abstract design issues related more to a virtual reality or to a cyberspace than to the real world. However, the aim of this paper is to inform how connections and invisible patterns concretely exist and constitute a significant context for every material action. Any project on the real environment has to take into account the flows of resources and the existing interactions (besides those ones it activates) especially concerning the natural constraints in resource exploitation. The final issue is to direct the pathway toward a correct sustainable development by improving the efficiency of any system according to its dynamics. Therefore, it is to avoid the tendency to an unconscious static growth of shapes and overlaid frames without any connection with the context. The expected environmental wisdom requires tools able to inform the design practices showing the hidden geographies of connections, networks and flows around the project. This perception of real world takes into account the Prigogine’s theories and the idea of dissipative structure is finally applied in those disciplines concerning urban planning and design practices.

References