In Ortega, E. & Ulgiati, S. (editors): Proceedings of IV Biennial International Workshop "Advances in Energy Studies". Unicamp, Campinas, SP, Brazil. June 16-19, 2004. Pages 409-417

INCIPIENT EMERGY EXPRESSES THE SELF-ORGANIZATION GENERATIVE ACTIVITY OF MAN-MADE ECOMIMETIC SYSTEMS

*Albertina Lourenci *[1], João Antonio Zuffo*
Laboratory of Integrated Systems, Department of Electronic Systems Engineering
EPUSP
Avenida Professor Luciano Gualberto, 158 - São Paulo SP CEP 05508-010

ABSTRACT

The tight coupling quantity/quality in nature reflects an efficient use of exergy in constructing biological material leading to a very effective storage of information per unit of mass maintaining homeostatic conditions. It seems the entity called incipient Emergy applied to the modeling of holarchic man-made eco-mimetic systems enables us to evince a sustainable basis for the design of our cities due to its explicitation of the relationship of the quantity/quality. Resembling autocatalytic feedback loops, the balanced trade-off between the knowledge of the knowing subject and the known (phenomenological) object is introduced in the eco-design model and underlying geometric and computational models precisely because its nature tunes in to the premises of incipient Emergy.

1. INTRODUCTION

The unconscious string of creativity that runs from concept to idea to sketch to finished piece is as unique as each of us and has led mainly to the creation of allopoietic artefacts. Yet nature also constructs unique "rock-like and life-like" material where the tight coupling quantity/quality reflects an efficient use of exergy leading to a very effective storage of information per unit of mass maintaing homeostatic condition of the piece as well as of the whole (for example crystals in crystalline matter and allosteric enzymes). Let us say there is an abyss between the cognitive processes of a craftsman that builds allopoietic artefacts and a biochemist working as a scientist trying to predict how natural proteins will fold. However when the same biochemist works as an engineer designing proteins from the start with the goal of building short chains of a few dozen pieces that fold and nestle onto the surfaces of other molecules as planned he/she is building a bridge between allopoietic and autopoietic artefacts.

It is beyond the scope of this paper to survey the trends in culture and nature that blurs the difference between inanimate systems and animate systems [1, 17, 16] well as allopoietic and autopoietic (rather semiotic machines) [14] that is pervading human and natural/exact scientific fields. Likewise to cover the vast amount of information about creating works of art such as the Greek temples, the Gothic cathedral and the Hindu temples as well as the attempts of contemporary art that hinges on moving the work of art in a museum to the garbage of the streets of New York transformed into Rauschenberg's combines [2] on one extreme and at the other extreme the graphical art of the Dutch artist Maurits C. Escher [12] is a desired prerequisite for the reader to have a glimpse of the intentions unraveled in this paper: to dovetail emergent opinions focused on mirroring ever-evolving phenomenona like natural ecosystems and natural languages giving rise to creative collective work. Fortunately many people are able of semiotic reasoning which lies between the literary and the scientific reasoning. In other words, the same content might correspond to different forms of expression.

Likewise an expression might be interpreted as belonging to different contexts or

[1]Phone: +55 113091 5254 or +1 705 646 6469 e-mail address: lourenci@lsi.usp.br or Albertina.Lourenci@gmail.com

contents. Hence the reader acquainted with complex adaptive systems from any field of knowledge will have no problem in understanding the essence of this paper [2, 3, 4, 5, 6]: an attempt to establish the scientifc foundations of sustainable architectural and urban planning and design.

The main challenge is to transform this into a task where the balance between to express opinion (doxa) and to express truth (episteme) is reached. Or to to weave a “life-like” tapestry where the warp (architectural design) and the woof (urban design) are self-entailing each other's identity similar to an “impredicative loop” which is bootstrapping both the set of identities of its own components and the identity of the whole [7].

2. INCIPIENT EMERGY PAVES THE GROUND TO INTRODUCE MAN-MADE ECOMIMETIC SYSTEMS

To enable the reader to understand semiotically how the concept of an emerging Quality associated to any form of Energy during its generative process of formation tunes in to the intrinsic nature of man-made ecomimetic systems we will be faithful to Giannantoni’s own words in [8] in this section. Next section we build a similar reasoning within the context of self-organizing holarchic complex planning and design systems.

In classical Thermodynamics a form of Energy is considered as being ordered if it is completely available and transformable into mechanical work. Then heat is said to be a disorderd form of Energy. Natural processes always imply a transformation of ordered Energy into disordered Energy. It was easy to deduct they always evolve in the direction of continuous increase of disorder.

In the case of Living Systems the term order generally refers to a static structure, whereas organization or self-organization is generally preferred to indicate a living process. The term complexity is always used as a synonym. Order generally refers to the Quantity of information (negative Entropy) which is actually present in the considered System, whereas organization refers to the Quality of the same quantitative information.

The framework pertaining to the traditional concept of order and organization in Mathematical and Physical Sciences is based on a rigid deductive necessity, and thus is incapable of describing any increasing in Quality, because in any deductive process the level of Quality of the conclusions is the same as that of the premises (consequently it will never be able to describe a physical process in which the Quality level is continuously increasing). The concept of Order when understood in terms of Quality will be referred to as Ordinality: the essence of being ordered in terms of Quality.

Giannantoni defines Quality: “It can be defined as a set of emerging characteristics, which are surely observable, describable and measurable, but which can never be reduced to the basic presuppositions from which such emerging and spring characteristics are generated, even if all the basic and primary characteristics are also observable, describable and measurable, both in terms of Quality and Quantity” [page 96, 8]. He understands this is an introductory basis to understand the deep differences intrinsic in the concept of Order when passing from non-Living to Living Systems.

In non Living systems order is understood as static concept and is associated to the concept of Entropy. In Living systems the concept of order is more habitually referred in terms of organization or self-organization. In the attempt to describe Living Systems, we discover that the habitual static definition of order is only the result of a reductive quantitative perspective. Then even in the case of non-Living Systems there is always

an increasing level of Ordinality. In Classical thermodynamics analyses they neglect the concept of ordinality and always deal with order and disorder only in quantitative terms. Or better the considered (quantitative) order has no (explicit) reference to Ordinality (even if the latter is ever present, although not perceived as such). This tendency can never deny the existence of an ordinary tendency towards increasingly higher levels of Ordinality. This is literally the alternative formulation of the Maximum Em-Power Principle according to the distinguished lover of Nature Howard Odum [15] as: "The Maximum Empower Principle implies optimum working conditions for the Whole System which in general do not correspond to maximum efficiency conditions for each sub-System but to those particular and local working conditions that factually realize the reciprocal 'best fit' among subsystems in order to maximize the global behavior of the system as a Whole."

An important question that arises is: is such a Quality order (or Ordinality) the result of any form of causality? And consequently is this eventual causality necessary or not? [8, page 101].

Giannantoni shows that spring causality is that form of causality which is responsible for the genesis of Quality, recognizable on the basis of specific characteristics (observable, describable, measurable) which however can never be reduced to its basic presuppositions neither in terms of Quality nor even less in terms of Quantity.

To represent these loops one has to be able to consider simultaneously characteristics and events occurring at different levels and scales. This requires the use of non-equivalent descriptive domains.

Emergy can always be structured as follows:

$$Em_U = Tr_\theta \, . \, Tr_{ex} . \, Ex_U$$

where Transformity (Tr) as the Quality Factor which takes into account the emerging Quality associated to other forms of Energy is now seen as Tr_{ex} which compensates for the dissipation of Exergy, whereas Tr_θ accounts for the increase of Transformity as a consequence of the Emergy generated by the Source Terms of the Universe. We may assert that while the term Tr_{ex} takes into account the quantitative aspect of information, the term Tr_θ accounts for the Quality aspect of such information.

The latter assertion however is worthy of ulterior precision: up to now the quantity Tr_θ has been thought of expressing the increase in Quality (due to Emergy Source Terms) by means of its single higher numerical value. However we have to point out that the considered case represents only an extremely simplified situation, which reflects the fact that we have taken into consideration the global description of the Universe without considering its internal composition.

In reality if we perform the internal and intimate analysis of the system (as suggested by the Maximum EmPower Principle in adherence to its pertinent basic perspective) we can easily discover that the factor Tr_θ is much more articulated than a simple numerical value, because it is a mathematical entity much more intimately strucured. In fact its specific structure depends on the corresponding complexity of the dynamic differential equations which describe the System.

Giannantoni shows that such mathematical entity Tr_θ is a more complex entity made up of two distinct (although specular) functions, so strictly related to each other that they form something new with respect to the two distinct components and especially they form one sole entity. Such systems shows in the light of the empower principle that at the level of organization the whole has a degree of Ordinality which is not only higher

than the one which corresponds to the sum of their parts but it is also of different nature.

At the level of dynamic behavior the genetic Ordinality represents the harmonic chord (as a new and original novelty) between the k distinct but consonant evolutive modalities which characterize the System from a genetic viewpoint.

In this context Giannantoni refers to Emergy as Incipient Emergy. It blurs the difference between living systems and non-living systems while a difference of species not of genus. Moreover he points out: "the more Emergy is understood as an increasing adherent expression of the 'creative richness of nature' the more it will show itself both as a faithful starting point and at the same time as a valid criterion to possibly increase the harmonic consonance between 'knowing subject' and known (phenomenological) object".

Likewise Giampietro and Mayumi [7] analyse the serious systemic flaws of linear analysis of energy flows commonly named input/output analysis. Ignoring the issue of hierarchies and scales energy analysis should learn how to handle the inevitable existence of multiple legitimate ways of representing impredicative loops. It is necessary to obtain the right formal representation of a becoming system.

An autocatalytic loop means: a flow of useful energy stabilizing the energy input required by the transformer generating it. In more plain terms, this is the process through which dissipative systems can stabilize their own metabolism.

Especially when the unit of a system called eco-system with hyphen by Joergensen defines the ecosystem and is defined by it [13]. This implies an autocatalytic loop of different forms of energy which are self-entailing each other identity that can be seen as an impredicative loop which is bootstrapping both:

a) the set of identities of its own components, and b) the identity of the whole.

Such analyses ignore that a dissipative process emerges, becomes established and manifests itself as a structure. These structures provide a new context, nested within which new processes can emerge, which in turn beget new structures, nested within which...In other words they ignore that in nature physical and biochemical processes are transformed into morphogenesis. Sunlight stimulates chloroplasts and the guard cells to open their stomata in the leaves to make possible photosynthesis and evapotranspiration of water. This autocatalytic loop gives rise to the web of life and maintains the homeostasis of the leaf and the ecosphere while Gaia.

Hence any effective modeling of the political-physiological-ecological holarchies of man-made ecomimetic systems should reflect a nested organization where the holon is the basic unit, as a cell within muscles, muscles within human body, individual people within ecohouseholds, ecohouseholds within a bio-region, a bio-region within larger cultural-socio-economic ecological systems of a continent, cultural-socio-economic-ecological systems constrained by the international organizations and the ecotechnosphere.

3. THE MODEL OF PRIMARY, SECONDARY AND TERTIARY WAVES (MPSTW) IN THE ENFOLDING OF MAN-MADE ECOMIMETIC SYSTEMS

The MPSTW together with its specular underlying geometric model inspired by the tilings of the Dutch artist M. Escher [12] and based on the subgroup relationships of the crystallographic groups and computational model developed as a Collaborative Aware Software Architecture is a ternary seed that enfolds the self-organizing holarchic poietic

complex adaptive planning and design systems.

Although the applied theories that have given rise to the MPSTW such as catastrophe theory [20], Hjelmslevian and Greimasian semiotics [19], graph theory and crystalographic groups in its beginnings orbited around the static conception of relation while product, later they have approached the dynamic conception of relation while production which is in tune with an ever emerging Quality. Lourenci has always been aware that if it were possible to show that architectural design could be considered a language, necessarily it should resemble the nature of a Chinese language [3] which is essentially emergent, relational and dynamic. Hence she has been choosing theories that reflected this nature or adapted them to display this potentiality. Likewise she has selected her collaborators.

The complex structuration of the MPSTW as well as its underlying geometric and computational models has been dealt with in [2-6]. The main issue here is the choice or creation of a language that expresses the analogy phenomenon-model. Kant insists while undetermined objects of empirical intuition, the phenomena do not speak. They speak only when transformed into objects. This objectivation is a semiotic and conceptual construction derived from theoretical imagination. The sense of object is determined by a system of regional categories. Paradoxically based on the principle that states the conformity to the things themselves, a model may not refer directly to the phenomena but only indirectly (mediating it) through the categories that subsume them (put them under a general principle). This factoring in the model must reflect the diversity of phenomena and lead to the unity of concept. In other words, the models must deploy an internal diversity due to the meaning of the regional categories. The words that describe these categories must be tailored in such a way to fit different contexts equally well as well as different scales. Figure 1 represents the system of regional categories that represents the generative seed of the ecosystem while recursive partitions from Gaia to ecocities to labor ecohousehold and owner/manager ecohousehold types.

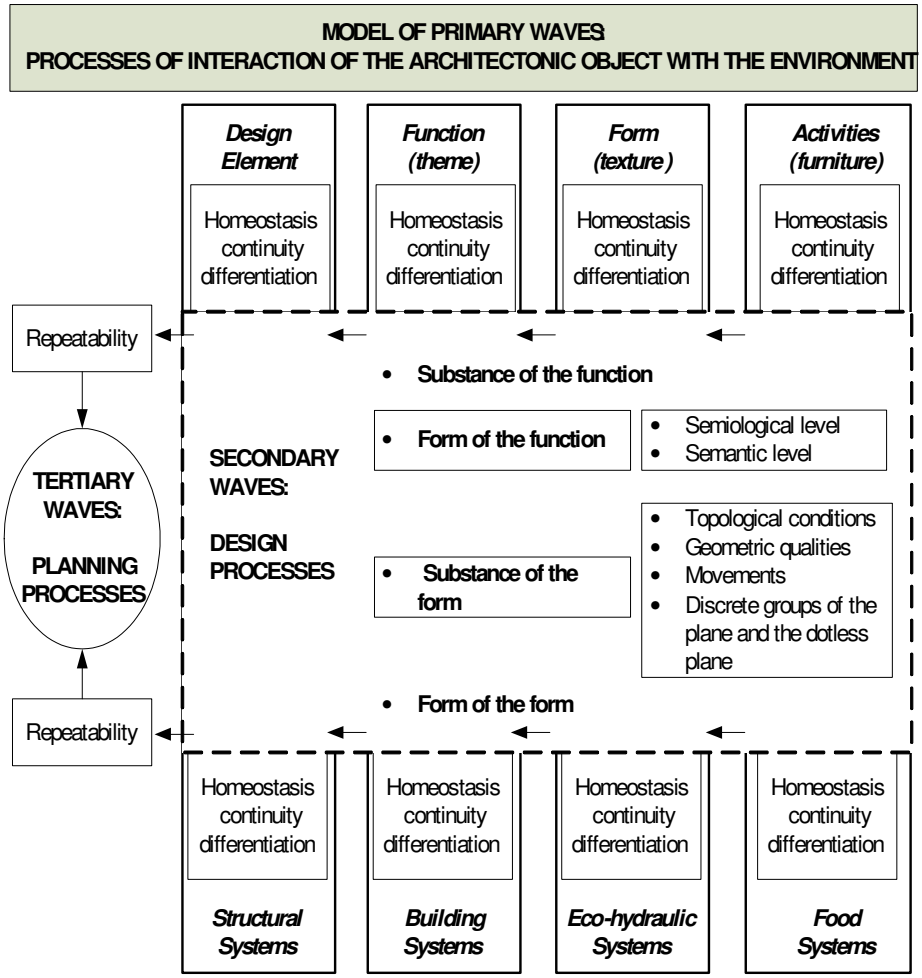

Figure 1. The MPSTW as the 'seed' of the holarchic man-made eco-mimetic systems

This ecohousehold type may be designed to maintain the survival potential of natural ecosystems due to:

1) the respect of the principle of bionics or mimicry of natural ecosystems
2) the function of a component be carried out by a subsystem of the natural biosphere or due to use of appropriate biotechnology
3) non-renewable resources used as capital expenditures to bring renewable resources in line
4) total use of a resource and zero waste dispose due to its embedding in the concept of bio-integrated systems [9].

This system of regional categories describes incrementally flexible churches, industries, houses, apartment buildings, hotels and so on. Likewise it enfolds different scales such as econeighborhoods, ecocities, bio-regions and so on. The latter represent a constellation of self-organizing human-centered dissipative processes/structures organized about a set of sources of exergy, materials and information where the planning and design team members adaptively self-organize to create a solution that reflects their individual opinions conforming to the intrinsic nature of this unfolding web of life.

The reader might have an impression that the MPTSW is a self-regulating system in its ability to generate an organism of different scales in the sense of Varela and Maturana. It transcends this because to transform dissipative planning processes into architectural and urban design processes in the context of mimicking morphogenesis and respecting each one's creative potential, implies the need for cultural morphodynamic models that detect the oppositions and contradictions intrinsic to the man made ecomimetic systems while emergent and creative systems.

Petitot-Cocorda [10] applies catastrophe theory to detect the catastrophic points when trying to describe an oppositive system as well as when such oppositions generate a contradictory space where one pole triggers off its contrary. Obviously to call attention to the fact that there is a plane of function and a plane of form which must reflect both the nature of the organism being designed as well as the designer's opinion or self-expression and how to solve the conundrum is important if one wants to design and plan efficient and effective man-made ecomimetic systems. This is an example of how theories unfolded in the sixties can describe the discontinuities of a system as well as cope with unanticipated events tuning to emerging Quality in Giannantoni's sense.

3.1. Emergence and Complex Adaptive Systems (CAS)

Before attempting to describe the interaction of the design team's members and the intrinsic potentialities of the MPSTW and underlying geometric model to tame the emergent contradictions inside the MPSTW, we shall describe parts of our approach that will lead to the development of a Collaborative Aware Software Architecture in terms of *emergence* and *complex adaptive systems* (CAS), well-known ideas discussed and applied in many domains, including natural systems and computational systems.

This is important because the nature of the subgroup relationships of the crystallographic groups displays these features outstandingly in the selection of the "father group".

Examples of emergence include flocking and swarm intelligence. Emergence arises in a CAS, a collection of autonomous agents with a common goal and simple rules that are individual to the agents, but in which there is no guiding manager or guiding plan. The agents interact via their simple rules and out of these interactions emerges an organized group-level structure or behavior. Another key element in emergence and CAS's is feedback: the agents are regularly adapting based upon feedback from the other agents in their group and from the environment.

As mentioned, examples of emergence and CAS's in nature include swarms and flocks; for example, a group of geese form the well-known beautiful V-structure when migrating. There is no overall plan or manager that defines this structure. The simple rules of a goose involve placing itself in relation to other geese to minimize effort when flying in air turbulence.

Furthermore, when the energy level or strength of a goose is low they fall back within the flock. And the stronger geese move forward. These simple rules result in the familiar V-structure with one goose at the head. Note that any goose has the potential to be at the head, and most importantly, the overall emergent well-organized structure did not arise from an overarching plan or guide. Also note that emergence and CAS's are distinguished from top-down command-and-control systems, such as a manager telling a team of people what to do and how to do it.

In human groups working towards a common goal, such as building a software product

or planning and designing a city, two project management approaches include 1) a command-and-control style such as a single (building or software) architect making the decisions and directing the team members, or 2) an emergent CAS style in which there is no directing leader, but in which the team members adaptively self-organize to create a solution by applying individual rules (and preferences) that are relatively simple and that conform to the overall goals and constraints.

The new generation of Agile Methods in software project management illustrates this approach [11]. Briefly, these involve defining to the team the goals of the new software production, but letting the team self-organize as a CAS to achieve the goals. In fact, these project management styles are relatively common in research-oriented product development.

Likewise, this emergent CAS-style of architectural urban design is illustrated by Lourenci's model for sustainable architecture and urban design and planning, combined with its underlying geometric model based on the subgroup relationships of the crystallographic groups.

A Collaborative Aware Software Architecture allows the design team's members to interact with each other independent of where they are, namely in the same place in the laboratory or in different cities. Each member can work separately until the specific task such as the planning processes related to thermal comfort are translated into architectural and urban design processes or may allow colleagues to witness what he/she is doing without interaction and in case it is necessary to exchange information, the targeted designer may interact promptly or delay interaction until the scheduled collective meeting where feedback is a must in order to start integrating the whole system as a musical harmonic chord.

3.2. The geometric model inspired by Escher and based on the subgroup relationships of the crystallographic groups of the plane

This is possible due to the potentiality of developing the fundamental region of the crystallographic group reflecting entirely the nature of the architectural or urban design element as well as reflecting the designer's personal opinion or expression and the infinite nature of crystallographic groups that allows a chosen so called "father group" to have subgroups that can be embedded into it. So the main hurdle consists in the fact that all designers must choose subgroups that belong to the same so called "father" crystallographic group. Hence the crucible of the system entails the many necessary collective sessions to select the leading "father group" and the redesigning of all tasks according to its subgroups. Obviously a collective session may be agreed by the members at the sketch stage of the form. As soon as everybody has finished the planning processes, they can interact in order to become aware which crystallographic group is in the mind of each designer. And before expressing the planning processes into shape if possible try to adapt their sketches to the subgroups of the chosen "father group" to dovetail each subsystem as a musical harmonic chord representing the whole System that obviously display different hierarchical levels of Quality in the shaping of an ecomimetic artefact. Of course when the team interacts again there may be designers that prefer to have other "father group" selected to express better their intentions. This change rather means to redesign what has been sketched according to the architectural element's nature (activities, structural systems, food systems and so on) simply through the effort of the click of a button for the new crystallographic group.

The whole system seems friendly, efficient and effective tuning to the Maximum

Empower Principle where each subsystem behaves to guarantee the optimal design of the Whole [4]. Likewise this geometric model extends to the urban design where the shape of a new artefact may change smoothly conforming to the previous shape to generate a homotopic environment. However besides the subgroup relationships of the crystallographic groups one can also apply similarity symmetry groups and conform symmetry groups to design cities [18].

4. CONCLUSION

The independence of each "holon" in a nested organization in terms of planning and design as well as the final dovetailing of its subsystems in the Holon as an emergent unique musical chord allows us to detect the play of exergy and information locally and globally respecting the chicken-egg loops.

ACKNOWLEDGMENTS

Thanks to the reviewers and Craig Larman whose insightful comments influenced the final version of this paper. Likewise to Folke Guenther, Enrique Ortega, Mark Brown and Corrado Giannantoni who provided the books and papers that guided us to the theme of the paper.

References

[1] Nicolis, G. and Prigogine, I. Self-Organization in Non-Equilibrium Systems, Wiley, 1977

[2] Lourenci, A. New computational paradigms reflect the nature of an ecodesign model. Devising a generative morphodynamic level. Scientific Report 3. FAPESP October 2002 also at http: //www.lsi.usp.br/~lourenci

[3] Lourenci, A. Espírito, Energia e Informação: Elementos Essenciais do Ecossistema Urbano. Um estudo de linguagens descritivas que evidenciam os processos dinâmicos no projeto ambiental. Dissertação de Mestrado. EESC USP 1985

[4] Lourenci, A. O desdobramento e o modelamento da consciência artística na infoera. First Postdoctorate Scientific Report for FAPESP.Laboratory of Integrated Systems USP 2000 in http://www.lsi.usp.br/~lourenci

[5] Lourenci, A. New computational paradigms reflect the nature of an ecodesign model. Second Postdoctorate Scientific Report for FAPESP. Laboratory of Integrated Systems USP in http://www.lsi.usp.br/~lourenci

[6] Lourenci, A. A proposal of a prototype based object oriented knowledge system to design and plan sustainable cities. PHD thesis. Faculty of Architecture and Urbanism University of São Paulo Brazil November 1998

[7] Giampietro, M. And Mayumi, K. An alternative energy analysis based on complex systems thinking (2): acknowleding the existence of hierarchies, scales and impredicative loop in Third Biennial International Workshop Advances in Energy Studies. Eds.: Ulgiati, S. et al. Porto Venere, Italy September 24/28 2002

[8] Giannantoni, C. The Maximum Em-Power Principle as the basis for Thermodynamics of Quality. SGE Editoriali 2002

[9] Kay, J.J. On complexity theory, exergy and industrial ecology: some implications for construction ecology. In: Kibert, C., Sendzimir, J.et al. (eds), Construction Ecology: Nature as the Basis for Green Buildings, Spon Press, pp. 72-107 2002

[10] Petitot-Cocorda, J. Morphogenèse du Sens. Presses Universitaires de France. 1985

[11] Highsmith, J. III Adaptive Software Development: A Collaborative Approach to Managing Complex Systems Dorset House Publishing Company, Incorporated (December 1, 1999)

[12] Coxeter, H.S.M. et al. (eds.) Escher: Art and Science. Proceedings of the International Congress on

M.C.Escher. Rome, Italy, 26-28 March 1985 North Holland 1988

[13] Joergensen, S.E., Patten, B.C. and Straskraba, M. Ecosystems emerging: toward an ecology of complex systems in a complex future. In Ecological Modelling, 62 (1992) 1-27 Elsevier Science Publishers

[14] Noeth, W. Semiotic Machines in Computational Intelligence and Semiotics - Editorial - Special Issue of S.E.E.D. Journal (Semiotics, Evolution, Energy, and Development), Volume 3, No. 3, December 2003

[15] Odum, H.T. Environmental Accounting: Emergy and decision making. New York. John Wiley 1996

[16] Giannantoni, C. Mathematics for quality. Living and non-living systems In Proceedings of the Second Biennial Emergy Conference December 2003

[17] Maturana, R. H. and Varela, F. J. Autopoiesis and Cognition: The Realization of the Living Dordrecht: D. Reidel, 1980.

[18] Jablan,S. Theory of Symmetry and Ornament. Mathematical Institute Belgrade 1995 in http://members.tripod.com/~modularity/mon.htm

[19] Schleifer, R. A.J. Greimas and the nature of meaning. University of Nebraska Press. 1987

[20] Zeeman, E.C. Primary and Secondary Waves in developmental biology. Lectures on Mathematics in the Life Sciences. Catastrophe Theory. Selected Papers. 1971-1977 Addison Wesley Publishing Company 1977.