Systemic Properties: acquisition and persistence over time

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1. Systems
1.1 What *are* Systems?

In the scientific literature a System has been defined in various ways. For instance as “A set of objects together with relationships between the objects and between their attributes” (Hall and Fagen, 1956) and “. . . a set of units with relationships among them” (von Bertalanffy, 1968).

A system has been intended as an entity *having* or *acquiring* properties different from those of what are considered elements by the designer (for artificial systems) or by the observer (for natural systems).

As we will see the observer selects the level of description where to detect a system as coherence between the behavior of component elements. This in the framework of a *construcvistic*, theoretical role of the observer, generator of *cognitive existence* rather than of *relativism*.

A necessary and sufficient condition for the establishment of systems is that elements, as *designed* (for artificial systems) or *represented* (for natural systems) by the observer, interact in a suitable way.

It is possible to distinguish between two conceptual cases:

- Systems are considered in an objectivist way when they are artificially designed, i.e., we know the component parts and how they interact because they were designed that way.

- Systems are considered in a *constructivist* way (as for natural systems which have not been artificially designed) when the observer decides to apply a level of description (i.e., partitioning and interactions) to those systems, as if they had been designed as such. In this case, the observer constructivistically models phenomena as systems, by assuming elements and interactions. When this level of description *works* for applications, it is often assumed to be the *true* one within the conceptual framework of a *discovery*, thus resuming an objectivist approach.

1.2 Modelling Systems behaviour

The theory of dynamical systems is based on the fundamental intuitions introduced by H. Poincaré (1854-1912). A dynamical system is based on two different kinds of information:

5) Information about the system and representation of its state;

2) The dynamics of the system, through a rule describing its evolution with time.

Let us consider an open interval *w*. A *continuous dynamical system* in *w* is described as an autonomous system of ordinary differential equations which hold for a vector of dependent variables *x*.

The meaning of *autonomous* relates to the fact that right hand members are time independent. An example is: $dx/dt = F(x)$.

Examples are models used to model simple systems such as the motion of the pendulum or planets moving along their orbits, by using the equations of motion of classical mechanics.

We remember that thanks to this way of modelling systems it was possible to identify the so-called *Three Body Problem*, i.e., the problem of computing the orbits of three separate masses resulting from their mutual gravitational interaction.

This problem represents the shift from classical physics to the physics of complexity.

If we consider simple systems like the pendulum, a state variable describing the microscopic behaviour of elementary components is sufficient to describe the behaviour of the entire system.

If we consider more complex systems, like mechanical and electronic devices, biological matter and social systems, we must consider macroscopic variables, like pressure, temperature and density, as state variables suitable for describing the system as a dynamical system using those variables. Ludwig von Bertalanffy (1901-1972), considered as the father of *General System Theory*, described a system *S* by using suitable macroscopic state variables Q_1 , Q_2 , . . . , Q_n , whose instantaneous values specify the state of the system. Evolution of the state variables over time is modelled by a system of *ordinary differential equations*, such as:

$$\begin{cases} dQ_1 / dt = f_1(Q_1, Q_2, \ldots., Q_n) \\ dQ_2 / dt = f_1(Q_1, Q_2, \ldots., Q_n) \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ dQ_n / dt = f_1(Q_1, Q_2, \ldots., Q_n) \end{cases}$$

In this way it is possible to formally represent how the change in the value of a given state variable affects all other state variables.

1.3 Transition from a state and acquisition of a systemic property

The two approaches mentioned above relate to the study of such entities, i.e., systems, able to acquire properties.

We will elaborate this point further, but for now I would like to focus your attention on this crucial aspect.

We do not refer to processes of *transition* from a state to another one whether stable, unstable or dynamic.

We refer to processes of *continuous acquisition and persistence* of properties like life due to biochemical processes, functionalities of electronic and mechanical devices assumed when suitably powered, and profitability of corporations continuously processing raw material.

A note on *phase* and *state* of matter

Phases of different states of matter like gases, liquids, and solids, when in correspondence with specific values of pressure and temperature, are characterised by precise values of density and specific heat.

Phases are sometimes confused with states of matter, more precisely thermodynamic states.

For instance, two gases at different pressures are in different thermodynamic states, but at the same phase of matter.

Two states are in the same phase if they can be transformed into one another with sample variations of thermodynamic properties.

Furthermore systems not only acquire properties thanks to the continuous interacting of components, but are in their turn able to acquire *subsequent* new properties through processes of emergence.

Examples of emergence of systemic properties in systems, named *complex systems*, are given by the establishment of properties such as cognitive abilities in natural and artificial systems, collective learning abilities in social systems such as flocks, swarms, markets, firms and functionalities in networks of computers (e.g., in Internet).

Systems scientists are devoted to the study of the second case from an enormous variety of disciplinary approaches like in physics, biology, cognitive science, informatics, medicine, and economics.

The problem to study, model and explain the establishment of general entities able to acquire properties became the problem of a *trans-disciplinary* approach in Systemics and related to emergence.

1.4 Multi, Inter, and Trans-disciplinarity

Multi-disciplinarity relates to the *use* of different disciplines to deal with the same problem like psychology, economy, laws and organisation to deal with a managerial problem occurring in corporations.

We consider *Inter-disciplinarity* as related to considering problems and approaches of one discipline for another one.

This take place when changing the meaning of variables and keeping the same model.

Examples occur when models of physics are used in economics and in biology to represent, for instance, markets and ecological equilibria in ecosystems. In this case, theoretical issues consist of formulating problems of a discipline by using models of another.

We consider *Trans-disciplinarity* as the study of systemic properties *per se*, i.e., considered in general as properties of models and representations without any reference to specific disciplinary cases.

Some examples are the study of acquisition of properties *in general* trough

a) processes of self-organisation and emergence;
b) generation -e.g., through design or induction- of suitable boundary conditions for the establishment of systems;
c) influence of systems through environmental changes;
d) transformation of open to closed systems;
e) merging of systems; and
f) replication of acquired properties in other systems.

The research for a general theory of emergence is a Trans-disciplinary problem.

Trans-disciplinarity also relates to the study of relations *between* systemic properties, e.g., between adaptability, chaos, dissipation, equilibrium, and openness.

2. The theoretical role of the observer

In the systemic literature the concept of *logical openness*, as opposed to *thermodynamic openness* has been introduced.

Logical openness relates to the constructivist role of the observer generating *n-levels* of modelling by assuming *n* different levels of description, representing one level through another and modelling a strategy to *move* amongst them, and considering simultaneously more than one level as in the Dynamic Usage of Models (DYSAM).

With reference to the concept of systemic complexity, i.e., the occurrence of the acquisition of new properties within a system through processes of emergence or multiple dynamic roles of components, as for MSs and CBs, the number of levels, *n*, of modelling adopted by the observer can be considered as a *measure of the complexity* of a system.

While a dynamical system is defined by the existence of a set of suitable state variables describing it, DYSAM relates to the dynamics of emergent properties of a system and to properties of MSs and CBs as well.

DYSAM is based on approaches already considered in the literature having the common strategy of not looking for a unique, optimum solution like, for instance, the

a) Bayesian method, e.g., *what is the probability of a hypothesis given the occurrence of an event?*
b) Pierce's abduction, *hypothesis inventing process*, i.e., *because B is true probably A is also true, since if A were true the truth of B would be obvious*;
c) Machine Learning, e.g. in Neural Networks;
d) Ensemble Learning, *combining an uncorrelated collection of learning systems all trained in the same task*, and
e) Evolutionary Game Theory, emerging of cooperative/competitive strategies.

The concept of DYSAM relates to situations in which the dynamical adoption of properties by the system is such that any single model is, in principle, unsuitable to model such dynamics, because single models are assumed to model a specific system.

Approaches of this kind are used, for instance,

a) in generic medicine when testing multiple pharmacological treatments to cope with an illness not exactly diagnosed or dealing with unexpected side effects and simultaneously considering the psychological, biological and chemical level of description;

b) when modelling biological systems, like the brain, as quantistic or not;

c) for the use of surviving resources in damaged systems (i.e., in case of disabilities managing balancing and compensation); and

d) for learning the use of the five sensory modalities in the evolutionary age for children not having the purpose to choose the *best* one, but to use all of them together.

3. Establishing systems

In this section we consider and distinguish between some possible necessary and sufficient conditions to establish systems.

Confusions of the two categories is typical of reductionism when assuming that processes establishing systems may be, for instance, *regulated* by acting on necessary conditions.

Sufficient conditions are listed only to introduce the reader to this problem and not to provide a comprehensive set of possibilities.

3.1 Necessary conditions for the establishment of systems

There is a general consensus that models adopted by an observer (for natural systems) and a designer (for artificial systems) explicating the process of establishment of a system are based upon, as a *necessary condition*, the interactions between elements.

We may assume, in short, that two or more elements interact when *one's behaviour affects the other's* as detected by the observer.

Examples of such interactions are processes of mutual exchange of energy (e.g., collisions and magnetic fields, where vector fields exert a magnetic force on magnetic dipoles or moving electric charges), matter (e.g., economic interchange) or information (e.g., prey-predator).

Interactions may occur in different ways.

For example short and long-range correlations are interactions between elements on short or long time or distances scales (even simultaneously) which can display coherence as in the famous *binding problem* (regarding the ***coherence*** of the combination of information from distinct populations of neurons such as for visual, acoustic, olfactory, tactile or memory systems establishing a unified perceptual experience).

Coherence is a concept having several disciplinary meanings.

For instance, in physics, the coherence of two waves relates to how well correlated they are, allowing the possibility to predict the characteristics of one wave by knowing the characteristics of the other.

Examples of other disciplinary meanings relate to usages in philosophy when considering the consistency of concepts, in cognitive science for cognitive states, and in linguistics with reference to semantics.

In Systemics (intended as *c*orpus of systemic concepts, extension of systemic principles by using, for instance, analogies and metaphors) we consider coherence, as in the binding problem and collective behaviour, as the **dynamic establishment and perpetuation of a property *continuously* established by interacting components**.

For instance, the property of a set of boids establishing a flock is continuously established and this *continuity* is considered as the coherence of the collective or coherent behaviour of boids.

It should be stressed that systemic properties are not the *result* of interactions. Systems and their properties are established by the *continuous* interaction among elements (e.g., an electronic device acquiring a property when powered on, leading to interactions amongst the component elements) and not as a *state*, as in the formation of a new colour by mixing primary colours (e.g., Red-Green-Blue), weight or age.

A very important distinction relates to the particular kind of interacting elements assumed to establish a system:

- Elements assumed as indistinguishable (*homogeneous hypothesis*). In this case elements are assumed to be particles. Their interaction may be modelled by mathematical equations and often by very simple rules.

  An example is given by gases consisting of particles and adopting systemic properties such as pressure and temperature.

2) Elements assumed to be different, and distinguishable (*heterogeneous assumption*). In this case each element interacts in a different way. This is the typical case of autonomous agents *processing* interactions and not simply reacting. Here, the processing is performed by the cognitive system and is computed *each* time.

A typical example is given by families of human beings.

3.2 Sufficient conditions for the establishment systems

A sufficient condition for the establishment of a system is that elements interact by respecting suitable relationships, or modelled as such, in some particular ways.

Moreover, it must be stressed that at the moment there is no way of demonstrating that the following ways (see Sections 3.2.1-3.2.4) of establishing systems are the *only* ones.

This point is particularly important given that new levels of description have emerged, such as the quantistic one, requiring new conceptual approaches in which the very concept of interaction needs to be properly redefined.

3.2.1 The structured way

In the *structured* functional way of establishing organised systems, organisation is intended as a network of pre-established functional relationships which control the manners of interacting.

Rules of interaction are determined:
- by following a design or
- *constructivistically* intended as such by the observer.

In both cases they are *sufficient conditions* for establishing systems.

Structured rules define *completely* the way in which elements interact, i.e., they define *all* the degrees of freedom possessed by interactions between elements, at the specified level of description.

Examples of case a) -following a design - include mechanical devices, such as machines, and electronic devices, such as circuits.

Examples of case b) - *non-designed* systems- are natural entities modelled as organised systems by the observer, such as organs performing given functions in living beings and eco-systems.

3.2.2 Self-organising way

In a so-called *self-organising* way, i.e., when a structure or a change in structure is acquired (change of structure may be considered *regular* for self-organisation, *coherent* for emergence).

Phase transitions are examples of *single* processes of self-organisation triggered by environmental perturbations (e.g., change of temperature or pressure).

Structural changes are not prescribed from the outside, as for theoretical models of phase transitions, by adopting the *homogeneity hypothesis*, i.e., neglecting *any differences* between the components.

Processes of establishment of *collective phenomena* such as swarming and flocking are examples of self-organisation produced by *non-homogeneous* agents.

Moreover, the same theoretical models adopted for phase-transitions are used to model processes of self-organisation of collective phenomena established by non-homogeneous agents by identifying *order parameters* as in Synergetics.

Examples of systems modelled in this way are flocks, swarms, industrial districts, lasers, ferromagnetic and superconducting systems.

Emergence deals with modelling such processes by considering the *heterogeneity assumption* and the process of hierarchically acquiring new properties as properties of systems of systems.

Moreover, models based on Dynamic Systems Theory and proposed for modelling emergence are the same used for phase-transitions.

Such models are *unsuitable* because based on suitable combination of dynamical rules and fluctuations, e.g., produced by noise, quantum effects, impurities or other effects instead of using *heterogeneity-based* models.

Heterogeneity-based models are necessary when considering differences between components such as in biology, e.g., life, or for cognitive systems, e.g., learning.

Examples of this kind for modelling emergence are Agent-based systems, Artificial Life, Neural Networks, and Immune Networks.

3.2.3 Unstructured, non-self-organising way

In an *unstructured* although non self-organising nor emergent way, i.e., when an interaction does not follow structure nor models of self-organisation nor emergence.

In the case of a) autonomous systems, i.e., provided with cognitive systems, interaction is due to the processing of input by cognitive systems. In this case interaction derives from the cognitive processing modifying, for instance, information, emotions, knowledge, inference and the making of decisions, which can affect the behaviour of the autonomous systems.

In these cases the system is produced by the way of processing and affecting behaviour. One processing affects the other.

In case of suitable cognitive systems, coherence is ensured by the cognitive processing and this is a sufficient condition for the establishment of a system.

Examples are social systems (e.g., families, classrooms, and micro-communities such as an audience).

In the case of b) non-autonomous systems, such as systems in physics, new systems and corresponding new systemic properties occur, for instance, by Spontaneous Symmetry Breaking (SSB), such as for the transition from paramagnetic to ferromagnetic phase.

SSB occurs when the system reaches a number of different *equivalent* equilibrium behaviors, which all have the same probability. We cannot forecast *which* of them will be chosen on the basis of the model we have, because all minima are equivalent to one another (intrinsic emergence).

Such processes are modelled within the theoretical framework of Quantum Theory and are considered by some physicists not only as non-structured, but also as the real models of self-organisation.

Moreover, as mentioned above, they are unsuitable for the heterogeneous case.

3.2.4 Evolutionary way

In an *evolutionary* way, i.e., through a process considered for species, when elements of a specific species interact amongst themselves (e.g., competing for food or territory, and for reproduction), with individuals of other species (e.g., prey-predator or establishing symbiotic processes) and the environment, for instance, by adapting and modifying their behaviour.

We may distinguish the cases where the process of interaction is ruled by

a) fixed evolutionary rules establishing a system acquiring a new property with reference to components. For instance, ants possess fixed evolutionary rules corresponding to a simple cognitive system having a very limited or no ability to learn, i.e., to improve it. An anthill displays multiple but non-evolutionary acquired properties, such as shape, food recruitment, defence strategies and an *ant cemetery*.

b) variable evolutionary rules, for instance, through processes of mutation and learning. Previous cases may not only occur in well-separated, well-defined ways and at different times. They may also occur in any combination and at any time, e.g., simultaneously, alternately, or in short- and long-term correlations.

Theoretical approaches towards this multiple combination in the establishment of systems have been introduced, for instance, with the concept of *Collective Beings* based on *Multiple-Systems*.

Multiple Systems (MSs) are set of systems established by the *same* elements interacting in *different* ways, i.e., having multiple simultaneous or dynamical roles. Examples are the Internet where different systems play different roles in being used in continuously new ways (e.g., the same software codes and services can be used to perform different tasks) and dynamic infrastructures of electric power networks adopting emergent properties.

Collective Beings (CBs) are particular MSs established by autonomous agents possessing the *same* cognitive system allowing them to decide different, simultaneous or dynamic belonging to the various simultaneous or dynamic systems. Examples of multiple, *alternative* belonging can occur when human beings give rise to different systems in temporary communities, such as passengers on buses, audiences at performances, and queues in general. Examples of multiple, *simultaneous* belonging occur when *same* human beings give rise to different systems over time as for workers in a company, families, traffic on motorways, and mobile telephone networks.

4. Systemic and non-systemic properties

What are *non-systems*? Depending on the level of description and on the model adopted by the observer, an entity is not a system when its properties are ***states***, *considered as not necessarily being supported by a continuous process of interaction amongst its components*.

Systems are thus entities assumed to be *continuously acquiring* systemic properties.

Non-systems are entities considered by the observer as *possessing* non-systemic properties.

Only systems may acquire systemic properties, while systems and non-systems may possess non-systemic properties.

What is a property?

In general a property is intended as a *characteristic* of an entity detected at some level of description.

Examples are the numbers of the Periodic Table of elements introduced by the Russian chemist Mendelejev; the Avogadro number; the speed of light; the pressure-temperature where water is transformed into ice and the period of the earth's orbit around the sun.

In Systemics we consider properties within the framework of the constructivist approach.

In this view we do not find properties *as they are* in an objectivist view.

To clarify this point, we can metaphorically say that we design experiments, intended as *questions* to Nature, and Nature *answers* by making them happen.

There are no answers from Nature without questions.

Repeatability of experiments, i.e., the receiving of *same* answers, is a confirmation about the consistency and appropriateness making knowledge possible.

The ideal is to consider properties as *context-independent*, i.e., having universal and constant values.

Non-dependence upon the context of observation, i.e., the level of description, is the objectivist view and it is often confused with the *stability* of the context adopted.

The problem is that there are no properties without a level of description, no statements without a language.

It is not merely a *relativistic* point of view, but a *generative* one, assuming reality has to be linguistically generated as for constructivism.

In an objectivist world the perspective is to make the model *coincide* with the phenomenon.

Systemic *properties* are intended as characteristics which can *only* be taken on by entities, i.e., systems, established by interacting components, when they are designed or modelled as such by the observer.

Systemic properties are not the *result* of the interacting components, but supported, as a *necessary condition*, by the continuous interaction of components.

Examples of systemic properties, adopting a suitable level of description, are: adaptiveness, chaos, dissipation, emergence, life, learning and openness.

Examples of non-systemic properties, adopting a suitable level of description, are: weight, age, geometric measurements, spatial position and speed in classical physics, and numeric properties in calculus.

Falsification of Systemics can be considered equivalent to the possibility of finding systemic properties as properties of non-systems.

The reason why we distinguish between systemic and non-systemic properties is that there are different approaches for managing them at different levels of description.

A reductionist view is based on considering a systemic property as non-systemic, i.e., using an inappropriate level of description.

5. Systemics, *Systémique* in French, Sistêmica in Portuguese, Sistémica in Spanish, *Sistemica* in Italian, …

Systemics

This term is used to denote a *corpus* of systemic concepts, *extension* of systemic principles by using, for instance, analogies and metaphors.

Systemic Approach

This expression is used to denote the general methodological aspects of Systemics, considering, for instance, identification of components, interactions and relationships (structure), levels of description, processes of emergence and role of the observer.

General System Theory

This expression has been introduced in the literature to refer to the theoretical usage of systemic properties considered within different disciplinary contexts (inter-disciplinarity) and *per se* in general (trans-disciplinarity). It also refers to applications in specific disciplinary fields. Current research identifies it with the *Theory of Emergence*, i.e., acquisition of properties.

System Theory

This expression, often inappropriately used as shorthand for *General System Theory*, relates to First-order cybernetics and Systems Engineering for applications such as Control systems and Automata.

6. Emergence as acquisition of dynamic structural *coherent* changing over time

In the literature it is also possible to find different definitions related to different kinds of emergence which will not be discussed here, including *strong* and *weak*, *computational* and *phenomenological* emergence.

Some approaches are based on considering the concept of emergence related and, almost, identified with that of *self-organization*.

In physics, processes of so-called *order-disorder transitions* have been identified as *self-organization* processes and, thanks to the works of I. Prigogine, related, for instance, to *dissipative structures* and of H. Haken, related, for instance, to *Synergetics*, the terms *emergence* and *self-organization* being considered as synonyms.

In the scientific literature conceptual models based on **structural changes** and *compatible* with available theories of the processes have been introduced. They deal with:

e) Phase transitions relating to single changes in structure, e.g., water-ice-vapour transition and ferromagnetism.

b) Processes of self organisations considered as phase transitions when a new acquired structure is dynamic and stable, i.e., repeated in a *regular* way. Examples are non-perturbed swarms, i.e., synchronised oscillators, established by suitable initial conditions, reaching stationary states in a non-perturbed way such as populations of synchronized fireflies.

c) Processes of emergence may be understood as phase transitions when newly acquired dynamic structures *coherently* change over time. The process of emergence relates to changes in dynamic structures over time.

The new conceptual approach

From

dynamical systems $dx/dt = F(x)$

to

dynamical structures when F is changing with time.

This way of understanding processes of emergence is suitable for modelling collective behaviours of entities provided with cognitive systems allowing the collective system to process internal and external perturbations.

The active role of the observer is fundamental detecting, representing and modelling emergent properties.

Coherence is a property primarily generated by the cognitive system of the observer.

An innovative approach to model continuous and coherent change of structure have been introduced by considering *Meta-structures*, i.e., mathematical properties of suitable sets of meso-state variables abductivelly identified by the observer.

7. Towards a General Theory of Emergence: From Dynamic Models to Dynamics of Models. the search for meta-structural properties

An innovative way to conceptually model processes of self-organisation and emergence is introduced as based on considering dynamics no longer referred only to variability of the behaviour of components with time, but to the structure between them.

Particularly:

8) Self-organisation is intended to occur when variability of the structure is stable, i.e., repetitive and foreseeable. An example is given by stationary waves in cyclic swarms iterate the same cyclic configurations over time; as in phenomena of *cyclic behaviour* in flocks and swarms, regular fluctuations and spontaneous synchronization in biological systems.

2) Emergence is intended to occur when variability of the structure is, dynamic, irregular, i.e., non periodic, but coherent. An example is given by swarms and flocks adopting variable non-regular behaviour as in the presence of any suitable environmental condition, but displaying the same property to the observer.

3) Emergence of hierarchies of systemic properties occur when variability of the structure is not only dynamic, irregular and coherent, but also generates hierarchies of systems like for cognitive abilities emerging from physiological levels.

This theoretical approach to modelling processes of emergence is under investigation and based upon considering *meta-structures*, i.e., on mathematical properties adopted by sets of *mesoscopic and global (macro) variables* used by the observer to model collective behaviours

In this approach we consider *coherence* generated no longer by dynamics between *state variables* related to components, but by properties of mesoscopic and global variables and of their inter-relations.

Multiple variable structures are those established between mesoscopic and global (macro) variables.

Making reference to collective behaviours established by agents, examples of suitable macroscopic and mesoscopic variables changing over time are: *D*, density; *V*, volume; *Su*, surface; *Mx*- *Mn* maximum-minimum distance between two agents; *Nk* number of agents having the *same* value of some variables and levels of ergodicity of the sets of values adopted by single mesoscopic and global variables in a given timeframe.

If this approach will be successful it may be a suitable step towards a general theory of emergence, trans-disciplinary based on meta-structural properties independent from any particular disciplinary field.

Today models of phase transition are generalised when transposing from physics by changing, when possible, the meaning of variables.

The meta-structural approach is based on considering relations between variable structures regardless to variables and their meaning.

8. How to keep acquired properties

The emergence of hierarchies of systemic properties is *necessarily* established by other lower levels. We already mentioned, as example, how cognitive properties are based on necessary lower levels such as the physiological ones and for properties of MSs and CBs.

A research issue relates to the possibility of *sustaining* a systemic property acquired from subsequent processes of emergence *without* keeping the lower levels involved. In our models lower levels are *necessary* and are as well influenced by the higher ones.

One approach can be based on ***substituting*** lower necessary levels by suitable other ones, in order to **reproduce** acquisition of same properties through different processes.

Examples are software systems when the process may even be reproduced because of the *virtuality* of the system. *Virtual systems* are established by resources *instead* of others unavailable at that particular moment. Indefinite numbers of copies of the *same* system are possible by reproducing the process of acquisition of properties from equivalent resources.

Another approach is based on *reproducing* emergent properties without reproducing the process of emergence.

For example, it is possible to reproduce some effects without reproducing the generating processes, for instance when recording and reproducing music.

Another case related to natural systems considering the process of *reproduction* together with the representation and transmission of knowledge.

In this case processes of transmission from one supporting system to others take place through representation of knowledge and education.

We may also consider different kinds of processes characterised by *gradualism* in the replacement of supporting lower levels.

We may consider, for instance, teams replacing over time their members, in the same way new cells replace dead cells in living matter replacing in time mostly of the entire body.

We may consider a new concept, that of *re-emergence*, related to reproducing emergent process of acquisition of properties supported by the presence of new replacement elements.

By considering emergence of mind and consciousness, the subject relates to the general problem of *qualia* introduced in 1929 by Clarence Irvine Lewis.

Moreover, in the same theoretical framework we may consider the similar problem consisting in the ability to maintain emergent *mind* without the original living biological matter.

Religions refer to that when dealing with the concept of *eternal life*. We may understand this expression as referring to the adoption of mind as an acquired property by another, biological (metempsychosis) or not, system.

Science also may have a non-reductionistic approach to human, spiritual needs. Explaining doesn't mean to reduce.

Also see the project *THE BIOCOGNITIVECONVERTER* studying the *turning* of biological needs of living matter *in* acquired emergent cognitive properties and behaviors, www.gianfrancominati.net

Conclusions

Some of the advanced border problems that we have deal with in Systemics were introduced.

We have to deal with systemic problems

a) in disciplinary ways,

b) in a interdisciplinary way when approaches and modelling successful in a discipline are applied in another by changing the meaning of variables, and

c) in a trans-disciplinary way when dealing with systemic problems non in specific disciplinary contexts, but in general.

This general conceptual framework is especially considered for the problem of emergence, acquisition of properties and new possible theoretical approaches.