Metamorphic Thinking in Cartesian Systemic Emergence

Marta Franova, Yves Kodratoff
LISN, UMR9015 du CNRS & INRIA Saclay
Bât. 660, Orsay, France
e-mail: marta.franova@lri.fr, yvekod@gmail.com

***Abstract*— Cartesian Systemic Emergence (CSE) is a theory developed in order to formalize the process of a human *creation* relative to particular problem-solving systems. Its final aim is to enable to design (semi-) automated tools that favor this creation. The creation process considered here concerns the context of informally specified systems and working with underspecified notions in incomplete environments. The aim of this paper is to show that this non-standard research approach is epistemically justified. In particular, the paper focuses on justifying inspiration-conduciveness of the CSE-experiments-generation-and-handling process relative to the invention of primitive notions needed in order to create the intended problem-solving system.**

Keywords*— Cartesian Systemic Emergence; Symbiotic Recursive Pulsative Systems; Metamorphic Thinking; deductive-like problem-solving systems; systems design methodologies.

I. INTRODUCTION

The design of a problem-solving system S is usually based on the well-known 'divide-and-conquer' strategy. Such a particular design can thus be expressed as a paradigm (called here P1-paradigm) represented by the paradigmatic formula

$$\forall \text{ pb } \exists \text{ st solves(st,pb)} \quad \text{(P1)}$$

in the following sense: Some already existing different tools T_i are recognized (maybe after a relevant adaptation) as suitable for solving a subset Pb_i of the set {pb}. An adequate modular composition of these different tools T_i (or, rather the systems st_i obtained from each of these tools) then constitutes (a subset of) the system st.

Instead of this usual modular approach, in this paper, we consider a system design paradigm represented by the paradigmatic formula

$$\exists \text{ S } \forall \text{ pb solves(S,pb).} \quad \text{(P2)}$$

Relying on this paradigm (called here P2-paradigm), the intention is to build a system S that *solves all problems in the same way*. This means that such a system S is not built as a modular composition of independent sub-systems. An obvious question is:

How to design S? (1)

Cartesian Systemic Emergence (CSE) introduced in [15] attempts to answer this question for particular systems (specified in Section II.D). CSE is a generalization of

- c1. the experience acquired in an exploration of the genesis of ancient deductive systems [11],
- c2. the experience acquired in the design of a P2-system (i.e., a system that is built relying on P2-paradigm) for Program Synthesis of Recursive Programs Specified by Formal Specification in Incomplete Domains – PS for short [14],
- c3. the experience acquired from an original construction of ack [17] and a study of its computation process [16],
- c4. the experience coming from the use of Descartes' method [10] for PS mentioned in c2.

These experiences confirm that the experiments-generation-and-handling process belongs to the important topics to be considered *before* a P2-design (i.e., before the design of a P2-system).

The primary goal of CSE experiments is the invention of primitive notions needed in order to create the intended P2-problem-solving system. In particular, we are concerned with the creation of Symbiotic Recursive Pulsative Systems (SRPS) intended as P2-problem-solving systems (see Section III.F of [18]). One of the suitable P2-design strategies for the experiments-generation-and-handling is called Resonance Thinking (RT) [18]. RT is based on a particular 'oscillation' between P2-paradigm and a simultaneous consideration of the formulas (P1) and (P2). We call RT-oscillation this process. This paper will justify that RT-oscillation is an inspiration-conducive one, i.e., it provides useful ideas concerning the parts of an intended P2-system S. The justification presented is 'epistemic' in the sense that it follows mainly from the active knowledge of c1. This paper, therefore, presents a minimal knowledge description necessary for building such an active knowledge. We say that knowledge is active when it is acquired through its active (re-) construction requiring the same effort as its first construction. We call 'Metamorphic Thinking' the particular 'epistemic justification' constructed here. It is on-purpose created for and in the framework of CSE. As a by-product, the epistemic justification presented in this paper provides also an epistemic justification for CSE as a non-standard, but justified, scientific way to do research in the context of informally specified systems, while working with underspecified notions in incomplete environments. Such a justification is necessary as many modern computer scientists and experts usually lack epistemic knowledge related to *creating 'from scratch'* new scientific pluridisciplinary theories.

The paper is structured as follows. Section II contains the fundamental notions used in this paper. Section III presents Metamorphic Thinking. Section IV briefly discusses related work, some applications and challenges. We conclude the paper in Section V.

 ISBN: 978-1-61208-838-9

II. FUNDAMENTAL NOTIONS

Roughly speaking, the goal of CSE is to formalize strategic aspects of human creation of *informally* specified *symbiotic deductive-like problem-solving systems*. In this section, we recall three terms by which this goal is expressed, namely

- informal specification,
- symbiosis, and
- deductive (deductive-like problem-solving) systems.

Since, in the CSE-context, the rigorous definitions of these terms are highly interdependent (more precisely, they are symbiotic), let us give first a rough description of their meaning. Such imprecise descriptions might then also be exploited in modular contexts.

An informal specification of a system is a description of this system that is somewhat vague, i.e., what it means or what the words in this description exactly mean may be unclear or even it may seem absurd or impossible to achieve. The symbiotic nature of a system parts means that, if even only one of these parts is eliminated, not only the system collapses but also all the other symbiotic parts collapse as well. Deductive-like problem-solving systems are systems that are defined exactly by their corresponding axiomatic system. We now will provide more precise descriptions of these notions.

A. *Informal Specification*

Let us consider the sentence: "Knife without a blade, for which the handle is missing." In a usual context, we may agree with the claim that this sentence is absurd [9]. However, we can consider another context in which this sentence represents an informal specification of an object to be constructed. Indeed, a surgeon may express a desire for a perfect cutting tool exactly by this sentence. The absence of a blade expresses his desire to cut with an unbelievable (for a knife) precision. The absence of a handle expresses his desire for a guarantee that this perfect 'knife' is out of reach for an incompetent person. Considering thus the words 'knife', 'blade' and 'handle' not as words with their usual 'material' meaning, but as underspecified words with the desired relevant 'characteristics' meaning, we obtain that a laser is a convenient solution for the surgeon's wish. An informal specification thus expresses a goal that may seem unachievable though, in fact, it implicitly contains a strong intention to reach this goal as much as possible. Of course, it is accepted *in advance* that some reasonable trade-offs may arise in order to reach this goal.

In the framework of CSE, an ***informal specification*** of a system is thus a description of this system by a *sentence* in which occur terms that are not yet exactly defined; they are *underspecified*. When considered out of a particular context, such a description, i.e., informal specification, may even seem absurd (as we have seen above for the 'knife-without-blade-…' specification) or the goal specified by it may seem impossible to reach (as might be argued, for instance, for a goal expressed by P2-paradigm). The meaning of these terms, in which a particular given informal specification is expressed, will evolve during the system construction. In other words, depending on some constraints and opportunities that will arise during the construction of the system, the meaning of the terms used in the starting specification will evolve and will make a part of the solution. The initial ambiguity of terms occurring in a given informal specification is eliminated by the provided solution. The evolution of these terms will also bring an exact specification of the context to be considered. Thus, in order to work with an informal specification, we must agree (and be aware) that the definitions and the exact context (or interpretation) are not given from the start, as it is usual for contemporary exact sciences. Therefore, in order to consider research working with informal specifications as a justified part even of contemporary exact sciences, this paper presents some arguments that have to be taken into account. The notion of 'epistemic justification' described in the next sub-section helps us in this task.

B. *Epistemic Justification*

As [23], p. 22, states, "justification is at issue only where something is untoward; there is *prima facie* violation of a norm or expectation that constrains action."

There are two facets of such a violation when working with informal specifications and underspecified contexts (frameworks, interpretations) in contemporary exact sciences.

The first facet concerns the necessity to consider 'fruitful' as well as 'luminous' experiments. As Bacon states in [2], fruitful experiences are concerned with the research starting from already rigorously defined 'building blocks' (definitions, tools, strategies, frameworks). However, luminous experiences express the fact that, in order to reach a goal, all the building blocks have to be created, usually from scratch. From a technological point of view, it means that fruitful experiences aim at improving on an existing technology (this is called 'innovation' in modern vocabulary), while luminous experiences aim at inventing a new technology (Bacon calls this 'progress' – a term that modern science tries to forget, as can be illustrated by the contemporary mutilated perception of creativity denying the possibility of creation from scratch [8]).

The second facet concerns the necessity to understand and accept a somewhat unusual kind of verbal expression (communication) when working with informal specifications and underspecified contexts. In other words, if we want to persuade an audience about a reasonable and realizable character of a goal that seems absurd or impossible to achieve (as it may seem for a system creation via P2-paradigm), we need to better specify a particular interpretation context (or, referential context) in which this goal has to be understood. In other words, we need to dissolve the rigidity of usual expectations (relying exclusively on a limiting 'logical exact reasoning') of the audience that constrains and impedes upon action oriented towards 'rigorous creativity'. In other words, as we have done for the above 'knife-without-blade-…' specification, we need to be convincingly 'talkative' in order to dissolve

 ISBN: 978-1-61208-838-9

such rigidity. This 'talkative' character is typical of the argumentation in which one relies on 'recusation' instead of 'refutation'. To our best knowledge, such a kind of argumentation took place already in Francis Bacon's work [3] [1]. As stated on the fourth cover page of [3], refutation supposes a common ground on which the discussion starts. In contrast to this, recusation starts from scratch by building a new unusual ground in which the discussion will start and take place. In other words, in refutation, we are concerned with the same 'measure' (roughly speaking, a measure is here a system of measurement, i.e., an exact specification of the context and the tools to be used) and we are refuting a usual 'order' (roughly speaking, an order is here a way how we use these tools) by specifying some weaknesses or incoherencies of this order. We then introduce small improvements of (or in) this order or we suggest a completely new order in the same measure. Inversely, in recusation, we do not rely on an already known and agreed upon existing measure, but we introduce a new measure with a relevant order. In a standard 'logical' measure, there is no possible order which would allow us to consider some absurd goals as realistic goals. Therefore, the recusation here consists in specifying a new 'rigorous creation' measure in which these goals become realistic. Of course, we need to be concerned with the reliability of this new measure (see [23], p. 33-36). A method (or a measure) is reliable provided it is used in 'normal conditions'. 'Normal conditions' are those for which the method (or measure) was designed for. This means that the condition of intentionality is heavily present [23], p. 33. It is known (see [20], for instance) that intentionality cannot be present in formal logical reasoning in other way than as the 'intention of a formal manipulation'. This is the first point where our 'recusation' of the 'impossibility' of P2-goal (i.e., of creating a system built via the P2-paradigm) starts. Namely, our *intention* is to *create* a measure (i.e., a referential rigorous context) in which creating P2-systems is realistic. (Our intention is not a formal manipulation.) It is known that when people do not share the same intention there is little or no possibility to reach a common agreement (see the first paragraph of [10]). Since we are in a scientific context, we have a slight advantage that lies in dissimulating the notion of intention by employing the notion of hypothesis instead. In other words, we may ask our audience to 'study' with us our hypothesis of a possibility to consider our P2-goal as a realistic goal. Nevertheless, there exists a serious problem. Namely, in this particular case, the 'study' of our hypothesis is nothing but a construction of a referential rigorous context (i.e., a measure) in which creating a P2-system can be considered as a realistic goal. This 'study' requires from each one of the audience to employ the same effort, the same 'tools' and to have a strong 'intention' to create a solution for this goal. As we know, scientists do not usually share this vision of 'study of a hypothesis'. This is why, in agreement with [23] and [27], we call our justification 'epistemic' in order to express explicitly the requirement to rely on the same intention, the same tools and the same effort.

Epistemic justification is usually concerned with truth-conduciveness [23]. In other words, in the traditional sense, epistemic justification is concerned with the *verdict* 'true'. Note that, here, we are not concerned with 'verdicts'. We are concerned with the question:

How we can create a reasonable system that solves all the problems in the same way. (2)

We are not questioning whether this is possible. We simply have a strong intention to create such a system. In other words, we expect to have to make a few reasonable trade-offs in our process and we are decided to provide all the effort and ingeniosity necessary to create a system that solves all the problems in the same way. Since we are preoccupied here with 'How?' (see (2)), the verdict 'true' is of no interest during the creation process. However, in order to find an answer to (2), we are concerned with the 'inspiration-conduciveness' of a particular experiments-formation in the process of a particular system that solves all the problems in the same way. The notions of symbiosis and of deductive-like problem-solving systems presented just below will allow us to refer to this topic in Section III.

C. Symbiosis

In the process of a search for an answer for (2), we need to be aware of a particular interdependence, called here symbiosis, of the parts of some existing systems developed by humankind. By ***symbiosis***, we understand a composition of several parts that is vitally separation-sensitive and, by *vital separation-sensitivity* of a composition, we mean that eliminating one of its parts has three possible consequences. It may be a complete destruction or a non-recoverable mutilation or uselessness of the remaining parts. This implies that the divide and conquer strategy, as well as analysis and synthesis, are inappropriate tools when creating and observing symbiotic systems. Symbiosis is therefore different from synergy, since synergy is a mutually profitable composition of elements that are not destroyed nor mutilated by separation.

A well-known picture (available on the Internet) may be used for an intuitive understanding of what we mean by 'destruction' in our definition of symbiosis. It is the 'Young Girl-Old Woman Illusion' (YGOWI) as given, for instance, in [29]. The symbiotic parts, however, do not necessarily need to coincide in the final symbiotic object as it is in YGOWI. From a systemic point of view, symbiosis of a system is embodied by the *vitally separation-sensitive interdependence* of all the notions and the parts of this system. This shows up by a 'circular' character of the definitions in the following sense: Consider two notions n_1 and n_2 describing two symbiotic parts of a system S. Then, the definitions of these notions look schematically like

$\mathrm{Def}(n_1)$ = description_in_terms_of(…,n_2, …) (3)

and

$\mathrm{Def}(n_2)$ = description_in_terms_of(…,n_1, …). (4)

For instance, if we want to give the instructions to draw the YGOWI to a painter that has never seen such a kind of illusion, we must describe the 'young girl' of this illusion by referring also to the 'old woman' in the picture, and *vice versa*. We shall introduce the symbol ♦ to denote a symbiotic composition. Then, we shall represent symbiotic systems with the help of a particular systemic representation. For instance, for YGOWI we have the symbiotic representation

YGOWI = Young_Girl ♦ Old_Woman, (5)

where

Old_Woman = Old_Woman ♦ Young_Girl (6)

and

Young_Girl = Young_Girl ♦ Old_Woman. (7)

This concrete representation illustrates that symbiotic descriptions are usually considered as fallacious.

Note that mathematical recursion is a particular case of circular definitions that are accepted. However, (5) illustrates that, in general, (3) and (4) are not an instance of recursion. This means, that symbiotic descriptions are not fallacious, they only represent a complexity for which the usual analysis (such as modular thinking) is inappropriate.

A non-trivial example of a symbiotic system the parts of which are programs can be found in Section VI. of [18].

The next section presents Deductive Systems as scientific objects where symbiosis is present. We will show that while a *manipulation* (or use) of a particular deductive system does not require the awareness of the presence of symbiosis, the *creation* of a deductive system does require symbiosis.

D. Deductive-like Problem Solving Systems

Since deductive systems are a natural illustration of systems that 'think of everything' in the same way, or rather that try to capture by a compact finite formulation all true statements of a particular domain (thus 'thinking of everything true' in a particular unified way), explaining what we mean by a deductive system is important. By ***Deductive Systems*** (DS), we understand a particular kind of axiomatic systems in the sense that these systems formalize, in a compact finite way, the knowledge about a Real-World Situation (RWS) with the aim to handle this knowledge in an efficient uniform way. In our work, the notion of DS is always related to a particular RWS (i.e., an intended interpretation). DS are therefore different from the usual formal systems for abstract considerations.

Peano's Axiomatic Definition (PAD) of NAT and Euclid's Geometry (EG) are the best-known examples of DS. As it can be illustrated by the evolution of PAD and EG, a formalization of an RWS leading to a DS consists in a 'selection' of essential primitive notions and axioms representing the essential relationships among these notions.

Primitive notions are the notions that are *not* defined with a help of *previously* defined notions. Before a full formalization of an RWS, the meaning of these notions is informally specified by a *large experience* in RWS which shows that they are useful and essential for considering RWS. For instance, if we consider NAT, a large experience shows that the primitive notions in a formalization of NAT are not only 0 and Suc, but NAT as well. In particular, we cannot (or do not know how to) provide a clear description of what we mean by natural numbers by referring to other already defined notions. Indeed, when defining NAT, we need to refer simultaneously to 0, Suc and NAT themselves. Similarly, we cannot specify what means 0, for instance, without referring to Suc and NAT. In other words, (3) and (4) adapted here for these three primitive notions have to be considered (as will be described by formula (8) just below). This illustrates that the primitive notions of a DS are, *a priori*, symbiotic.

Thus, ***axioms*** of a DS express the statements about the relationships among the primitive notions. The essential particularity of these relationships is that, together, they provide a definition of all primitive notions. In other words, a particular primitive notion is not defined by a particular axiom: all axioms are symbiotically necessary in order to provide a clear description (and thus a definition) of the meaning of a particular primitive notion.

We said above that primitive notions of a DS are not defined with a help of previously defined notions. However, all primitive notions, say p_1, …, p_n, are defined simultaneously, each depending on all the other primitive notions, by simultaneous considering all axioms of the system. Thus, (3) and (4) can be written in the form

$$\mathrm{Def}(p_i) = \mathrm{AXIOMS}(p_1,\ldots,p_i,\ldots,p_n), \qquad (8)$$

where 'AXIOMS' denotes all DS-axioms considered simultaneously. This also means that all primitive notions are of the same, essential, importance. Therefore, no primitive notion plays a secondary (or auxiliary) role.

Note that, to the best of our knowledge, the symbiotic character of the primitive notions and the axioms of a DS has never been mentioned before in the literature.

Since the primitive notions of PAD and EG are symbiotic, their axioms could not be determined via (P1). The axiomatic constructions of both these systems were determined via (P2), since in both cases the aim was to obtain one global system describing the respective RWS. In general, a DS can be represented as a result of an attempt to proceed with a particular P2-paradigm, namely

$$\exists\ \mathrm{DS}\ \forall\ \mathrm{Truth}\ \mathrm{covers}(\mathrm{DS},\mathrm{Truth}). \qquad (9)$$

Here, 'covers' means that a 'Truth' is either an axiom of DS or it can be deduced from axioms of DS.

We shall now informally describe what we mean by a deductive-like P2-symbiotic system.

By a ***deductive-like problem-solving system*** we mean a system such that its primitive notions are specified informally and the essential relationships among them, expressed by a finite number of axioms, provide their exact definition.

In our work, we consider deductive-like problem-solving systems S that have the property**:**

$$S(S) = S. \qquad (10)$$

Formula (10) is known as the *Ouroboros equation* [26]. For a human-created system S, (10) can be seen as the final form of a particular evolutive process, that we shall call here Ouroboros process, represented by

$$\lim_{n\to\infty} S_{n+1}(S_n) = S, \qquad (11)$$

where S_0 is an initially given informal specification for S. In this process, S creates itself (from its own informal specification). This is why, we characterize a problem-solving system that verifies the Ouroboros equation as a *Generator of assets* (usually, a solution to a problem is an asset) *that is an asset* (since S is a solution to a problem as well) *that self-generates* (i.e., it provides a solution to its own creation). Another way to express this is by saying that such a generator of assets is a symbiotic part of its own creation.

Therefore, it is important to understand that, from a practical point of view, to go from S_0 to S_1 is the most complex task, since this step already must

- anticipate (and thus allow) the whole evolution (11),
- have a solid and efficient strategy for specifying the primitive notions of S_1 and their symbiosis expressed by the resulting axioms,
- incarnate all methodological fundamentals related to the creation of P2-deductive-like problem-solving systems.

In our future work, we will show that the Ouroboros process is a particular form of pulsation (presented in [18]).

Metamorphic Thinking guarantees that these three conditions are satisfied in CSE. More precisely, CSE is created so that these conditions do hold. Note that (11) can be also seen as a process of reaching a consensus in multi-agent systems [35]. This thus relates to the process of *creating* a pluridisciplinary fundamentals theory enabling *symbiotic* collaborations (see Section VI. of [18]) that are able to reach such a consensus for their aimed project. CSE aims exactly to become such a pluridisciplinary fundamentals theory.

III. Metamorphic Thinking

The role (and the name) of MT is best understood in the context of the three remaining CSE parts, namely Symbiotic Thinking (ST), Resonance Thinking (RT) and Pulsative Thinking (PT). With respect to the symbiosis of primitive notions and axioms of deductive systems, ST means that we focus on the creation of primitive notions and axioms that are symbiotic procedures. Resonance Thinking means that during such a creation we focus on experientially induced inspirations that are oriented towards the P2-paradigm. PT means that we handle incompleteness of our real-world perception relying on the evolving creation pulsation model of deductive systems. In other words, these parts express the three essential characteristics of building a deductive system. In contrast to this, MT expresses the fact that the formulation of CSE is heavily determined by the explicit emergence of CSE in the process of the creation of a particular Program Synthesis system [12]. In other words, the experiences in creating this PS-system and the 'crystallizing' process of the CSE final structure have been symbiotically intertwined.

The information presented in this paper completes a first tour of an informal presentation of ST (presented in [19]), RT (presented in [18]) and PT (presented in [17]). The symbiotic structure of CSE requires such an unusual presentation (according to modern scientific standards).

This paper focuses on the epistemic justification of relevant inspiration conduciveness of CSE experiments. This justification consists in taking into account, simultaneously

- the specifically oriented presentation of fundamental notions presented above in Section II,
- our previous descriptions of ST, RT and PT mentioned just above.

This means that a self-containing exhaustive presentation of MT is out of reach of a short paper, since it requires a global exhaustive description of CSE. More exactly, a global exhaustive description of CSE is a 'definition' of MT. This is illustrated already by the YGOWI example illustrated above, where we have seen that, in order to define Young Girl, we have to consider simultaneously the whole context, i.e., (5), the 'definition' of Old Woman, i.e., (6) and the 'definition' of Young Woman, i.e., (7). More formally this is described above by (8). Therefore, our future work aims at

- providing such a global presentation of CSE,
- illustrating the advantages of CSE parts (i.e., ST, RT, PT and MT) in a PS context, and
- presenting Ouroboros process as a particular form of pulsation.

Note that an Ouroboros process has already been explicitly illustrated in [13] while creating the CSE-like method called Créativité Formelle (Formal Creativity).

IV. Related Work / Applications / Challenges

Since the main particularity of CSE is focusing on 'creating from scratch', there seems to be no other approach aiming at the same task. Moreover,

- focus on epistemically justified creation instead of skilfull observation,
- focus on P2 instead of P1,
- autopoiesis, and
- considering symbiosis

are the main differences of CSE in comparison with several approaches such as [4] [5] [6] [7] [21] [22] [24] - [26] [28].

We have previously given more detailed descriptions of differences and sometimes even suggested a possible cross-fertilization of other scientific disciplines and works with our approach as follows. In [18], we show how CSE and Michie's Ultra-Strong Learning [34] further elaborated in the works like [32] [33] might be fruitfully cross-influenced. In [18] [19] we illustrate how some unconscious cognitive processes, as the so-called Conceptual Blending [30], can be compared to a conceptually similar, but a conscious particular creative process as described by CSE. We illustrate also how research on cognitive processes of the human brain might follow the Ouroboros process. In [18] we compare CSE with some works on General Systems Theory and on Multidisciplinary Design. As the need for CSE became evident in PS, in [31] we compare some classical research works in PS with our application of CSE to this field.

However, we may consider CSE (through Ouroboros process) as an inspiration for creating 'perfect security' systems that do not break but evolve with each attack to a stronger version. A similarity of this idea can be seen also with mutations of Covid virus the main intention of which might be seen as 'living eternally'.

The main challenge of CSE is to underline the impossibility of replacing symbiotic collaborations by the usual synergic ones. Moreover, it is necessary to underline the need for accepting a non-standard, but epistemically justified way of doing and evaluating the research in the field of CSE creation. A non-trivial example of consequences of an attempt to replace a symbiotic collaboration by a synergic one can be found in Section VI. of [18]. See also the note at the end of Section II.D above.

V. CONCLUSION

This paper provides the last missing part in a presentation of a whole set of all the symbiotic parts of Cartesian Systemic Emergence constituting the foundation of a particular kind of scientific creativity necessary for developing Symbiotic Recursive Pulsative Systems. Moreover, this paper implicitly provided the basic principles for achieving a project aiming at implementing this particular scientific creativity.

CSE brings a progress to modern science at least on three points:

- ✓ it justifies P2-creation of SRPS,
- ✓ it shows that P2-creation requires its own particular kind of presentation, collaboration and evaluation, and
- ✓ it shows the inadequate character of the present intellectual property law still unable to protect this atypical kind of long-term research [13].

We hope that this first informal global (even though not exhaustive) presentation of CSE will stimulate the scientific community to explore more actively the potential of CSE in several, possibly new and on purpose created domains, namely whenever dealing with security constraints in any kind of innovative thinking.

REFERENCES

[1] F. Bacon, The wisdom of Ancients (La sagesse des anciens), Vrin, 1997.

[2] F. Bacon, Novum Organum, P.U.F, 1986.

[3] F. Bacon, Rrecusation of philosophical doctrines (Récusation des doctrines philosophiques), P.U.F, 1987.

[4] L. von Bertalanffy, General Systems Theory, George Braziller, 1969.

[5] J. L. Blizzard and L. Klotz: A framework for sustainable whole systems design, Design Studies 33(5), 2012, pp. 456–479.

[6] F. Charnley and M. Lemon: Exploring the process of whole system design, Design Studies 32(2), 2011, pp. 156-179.

[7] J. A. Crowder, Multidisciplinary Systems Engineering: Architecting the Design Process, Springer, 2018.

[8] M. Csikszentmihaly, Creativity - Flow and the psychology of Discovery and invention, Harper Perennial, 1996.

[9] O. De Rudder, Aperto libro ou le latin retrouvé, Larousse, 1989.

[10] R. Descartes, Discourse on the Method, in R. Descartes, translated by J. Cottingham, R.Stoothoff and D. Murdoch: Philosophical Writings of Descartes, vol. 1, Cambridge University Press, 2006, pp. 111-151.

[11] M. Franova, Deductive Systems, a work presented at the national competition (SVOC) of research work of Czechoslovakian university students in section: Epistemology, logic and philosophy, Bratislava, 1980.

[12] M. Franova, An Implementation of Program Synthesis from Formal Specifications, in Y. Kodratoff, (ed.), Proceedings of the 8th European Conference on Artificial Intelligence, August 1-5, Pitman, London, United Kingdom, 1988, pp. 559-564.

[13] M. Franova, Créativité Formelle: Méthode et Pratique - Conception des systèmes "informatiques" complexes et Brevet Épistémologique, Publibook, 2008.

[14] M. Franova, Cartesian versus Newtonian Paradigms for Recursive Program Synthesis, International Journal on Advances in Systems and Measurements, vol. 7, no 3&4, 2014, pp. 209-222.

[15] M. Franova and Y. Kodratoff, Cartesian Systemic Emergence - Tackling Underspecified Notions in Incomplete Domains, in O. Chernavskaya and K. Miwa (eds.), Proc. of COGNITIVE 2018: The Tenth International Conference on Advanced Cognitive Technologies and Applications, ISBN: 978-1-61208-609-5, 2018, pp. 1-6.

[16] M. Franova, Trace of computation for ack(3,2), https://sites.google.com/site/martafranovacnrs/trace-of-computation-for-ack-3-2 (Retrieved: 03/2021).

[17] M. Franova and Y. Kodratoff, Cartesian Systemic Pulsation – A Model for Evolutive Improvement of Incomplete Symbiotic Recursive Systems, International Journal On Advances in Intelligent Systems, vol 11, no 1&2, 2018, pp. 35-45.

[18] M. Franova and Y. Kodratoff, Cartesian Systemic Emergence and its Resonance Thinking Facet: Why and How?, International Journal On Advances in Systems and Measurements, IARIA, 2020, International Journal on Advances in Systems and Measurements, issn 1942-261x, Volume 13 (Number 1 & 2), pp.11-25.

[19] M. Franova and Y. Kodratoff, Symbiotic Thinking … for Cognitive Modeling as Well, in C. Sennersten and O. Dini (eds). : COGNITIVE 2020, The Twelfth International Conference on Advanced Cognitive Technologies and Applications ; ISSN: 2308-4197, ISBN: 978-1-61208-780-1, IARIA, ThinkMind, October 2020, pp. 7-12.

[20] J. Y. Girard, Le champ du signe ou la faillite du réductionnisme, in T. Marchaisse, (dir.): Le théorème de Gödel, Seuil, 1989, pp. 145-171.

[21] H. Kopetz, Simplicity Is Complex: Foundations of Cyber-physical System Design, Springer, 2019.

[22] J. L. Le Moigne, La théorie du système général, théorie de la modélisation, P.U.F, 1984.

[23] J. Leplin, A theory of epistemic justification, Springer, 2009.

[24] M. S. Levin, Modular system design and evaluation, Springer, 2015.

[25] A. Reichel, Snakes all the Way Down: Varela's Calculus for Self-Reference and the Praxis of Paradise, Behavioral Science 28(6), November 2011, pp. 646 - 662.

[26] J. Soto-Andrade, S. Jaramilo, C. Gutiérrez and J.C. Leletier, Ouroboros avatars: A mathematical exploration of Self-reference and Metabolic Closure, in T. Lenaerts, M. Giacobini and al. (eds.), Advances in Artificial Life ECAL 2011: Procs. of the 11th Europ. Conf. on the Synthesis and Simulation of Living Systems, The MIT press, 2011, pp. 763-770.

[27] R. Swinburne, Epistemic justification, Oxford University Press, 2003.

[28] C. S. Wasson, System Engineering Analysis, Design, and Development: Concepts, Principles, and Practices, Wiley-Blackwell, 2015.

[29] E. W. Weisstein, Young Girl-Old Woman Illusion, From MathWorld - A Wolfram Web Resource. (Retrieved: 03/2021) http://mathworld.wolfram.com/YoungGirl-OldWomanIllusion.html.

[30] G. Fauconnier and M. Turner, The Way We Think: Conceptual Blending And The Mind's Hidden Complexities, Basic Books, 2003.

[31] M. Franova, Cartesian versus Newtonian Paradigms for Recursive Program Synthesis, International Journal on Advances in Systems and Measurements, vol. 7, no 3&4, 2014, pp. 209-222.

[32] S. Muggleton, D. Lin, and A. Tamaddoni-Nezhad: Meta-interpretive learning of higher-order dyadic datalog: predicate invention revisited, Machine Learning 100; 2015, pp. 49-73.

[33] S. Muggleton, U. Schmid, C. Zeller, A. Tamaddoni-Nezhad, and T. Besold, Ultra-Strong Machine Learning: comprehensibility of programs learned with ILP, Machine Learning 107, 2018, pp. 1119-1140.

[34] D. Michie, Machine learning in the next five years, Proceedings of the third European working session on learning, Pitman, 1988, pp. 107-122.

[35] Y. Shang, A combinatorial necessary and sufficient condition for cluster consensus, Neurocomputing Volume 216, 5 December 2016, pp. 611-616.