SYMMETRY FOR INTELLIGENT ANALOG SIMULATION

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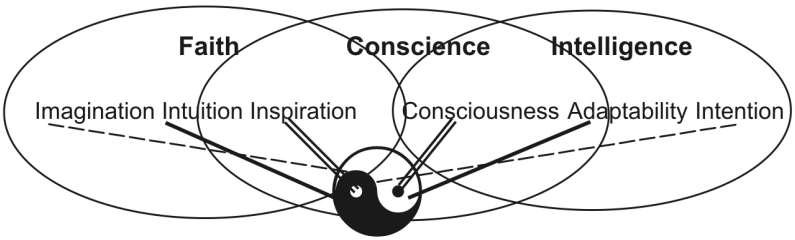
ABSTRACT. *Intelligence* = Consciousness × Adaptability × Intention and *Faith* = Intuition × Inspiration × Imagination, are the complementary parts of the human mind. *Conscience* = Consciousness × Inspiration is the link between. Simulation is the relation between function and structure. Coexistent interdependent hierarchical types of different kind structure the universe of models for complex systems.



The symmetry between construction and understanding is an essential step to the symmetry between intuition and reason – extended adaptability for natural operations, and further, between faith and intelligence. Conscience simulation demands to transcend from

computability to simulability. A way to begin is hierarchical simulation. Coexistent interdependent hierarchies structure the universe of models for complex systems, e.g., hardware – software ones. The power of abstraction is the real measure for the human mind. Turning the abstraction into comprehensive construction could be the aim of humanity, the unique God for different cultures of free humans.

1. Hierarchical approach

An operating system serves the autonomous programs, both for the function of the hard and for development of the soft. The society has to assure health and education for every human, and encourage search and research for any conscient human. *Way*, *Truth*, *Life* will coordinate the evolution as long as we have arts, science, and engineering. Both intelligent simulation and the simulation of intelligence demand transcending the present limits of computability toward simulability, by an intensive effort on extensive research to integrate essential mathematical and physical knowledge guided by philosophical goals. [9] Arts and science are equally noble, even if one appears rather spiritual and the other rather material. Their alliance is vital and demonstrates the non-solvability of the nowadays spirit-matter dichotomy, and of all resulted secondary dichotomies, actually functionally generated by the space-time dichotomy necessary to the human evolution. The human has to enlarge, not to tear, the bands of the reason, and to apply them to the society. Reason has to transform into the consciously recognized limits of the Intelligence in front of the Faith that offers to the human the way to evolve beyond any limits.

We need consciousness to return intelligently to faith; faith bases on inspired imagination-controlled intuition

A reasonable society is hierarchical. Its essential architecture contains three tree-like structures for the same set of humans**,** therefore, interdependent: arts, science, and engineering-technology. The social hierarchies reflect only a temporary order, generated by

humans, to help them concentrate on the spiritual evolution, without neglecting the material problems. The hierarchical social structure can assure an optimal organization of humans among humans. The interdependence of the three social classes is assured functional, not only structural. Without giving up anything essentially human: culture, social or natural togetherness, different approaches, humans have a lot in common: philosophic desire, comprehension of the own hierarchy in the context of the other two, free life based on understanding the necessities, constructive fear of the unknown, and especially the love for creation. Except the three cultural ways, that permanently *divide et impera et intellige*, there is no other. [8]

People of one choice exist, in all senses of the word. They either comprehend all the alternative ways and their convergence, or, in the context of natural love for philosophy and interest for the other selectable directions, put more passion in one direction.

Of the first category are temporary elected, in different convergent hierarchical modes, the social leaders, of the second, the institutional directors. Both kinds of leaders are more philosophical than their cohabitants, even if the ones master the strategic perspective given by an attained peak, while the others have the joy of the courage to climb into profoundness. The elected artists permanently reconfigure a system of laws, to be beautiful by intelligibility, true by consistence, and good by human understanding. The elected physicists, pure or of different correlated scientific domains all collaborating with mathematics and engineering, govern by research strategies with Gods fear. The elected engineers critically construct and criticize constructively. [7]

For any social role, the elected concentrate, respectively, on faith (mathematicians), conscience (physicists), and intelligence (engineers). There always exists a human, called No. 1 or the Philosopher, depending on the stability of the times, cloudy or clear Sky. He will always lead directly the elected or the philosophers, who will know to educate and learn optimally the humans of all ages, including themselves. We have to start. Otherwise, it is no hurry.

Intellige is to link, to understand, to be aware. In Latin: *intellego* = to understand, to feel, to master, to gather in mind. Artificial has a derogatory sense; however, the root of the word is art. Arts remind of liberty, as arts for arts. Artificial is at first sight the complement of natural. Our ideas transfer us to places that are neither natural nor artificial. Maybe artificial means something natural created by the human being and nature is an extension of our body. However, we feel to be superior to nature, as to our body: we think. [4]

Why are only humans creating arts, why do they need to know more, and why do they construct other and other natural things they have not found in the nature? We learned the arts have to discover the beauty, that science looks for the truth, and that engineering invents things to help us, caring for the good. *Goethe* wrote on Frankfurter Theater: *Das schöne wahre Gute* because the three wonderful scopes have to be always together. He stretched the good that is important to all natural beings, whereby for beautiful or true cares only the human being.

Arts and science demand a distinct power for both development as understanding, and possibly for usefulness. Engineering is to be ingenious, not only to design engines. [3] The abstraction power distinguishes us among the natural beings.

Any human choice to surpass the Nature by arts, to know it better by science, or to enrich it by it by ingenious construction, is as noble and legitimate, because to follow any selected way demands intelligence. Artificial intelligence has an initial sense of enriching natural domains by natural extensions. Reason is an extension of the Nature. The natural language whispers: as the rational numbers are a straight extension of the natural ones, if we neglect the integers, however, you remain in a countable world as the Nature initially is. [5]

We should not be ashamed if someone that we only understand by proper preparation is at least as powerful as the Nature; let's remember the beautiful mother language. *Cer* (sky) suggests the infinite, and we desire to see it and to link its begin to

its end, or better the never begin to the never end, and we find the *cerc* (circle). The language whispers to us again: π is not rational, it is more than this, and it is as if we listen to a symphony by *Beethoven*. We understand that the Reality of our Existence is more than the Nature of our Being; therefore, we should know them better, because only Nature can open us the way to Reality. We wonder whether any of the alternative ways demands the same intelligence kind, and if not, which of them should we first research (*cerceta*) in order to simulate it.

Arts are free, and even when they return to Reason, as mathematics, they bring results, that could before just be seen by Intuition, to send by Inspiration and Imagination to Intelligence. Physics reaches and gets conscious of Reasons limits, both by the quantum theory and by the too complex phenomena, e.g., society and human. It looks like there is no difference for the intelligence that is useful to one of the ways. An example, that confirms that they simply represent different approaches to understand and develop the (presently natural) Reality, is *architecture*, which we cite in each of them. To conclude: Intelligence is more than Reason, to make us feel as beings superior to Nature, what also means that we have to respect Nature more: *Spiritus sanus in mens sana in corpore sano*. Therefore, there is something else in the Intelligence, which allows us to consider ourselves humans, human groups, peoples, beings on the Earth, or conscious beings in the physical Universe. We also feel that there is something essential beyond the physical – the metaphysical (*Plato*).

More, there is something exterior to the human intelligence, without that we could not fight the Time to evolve. We have to feel complete, even if we need education and permanent work in communication with the other humans, of the past, the present, and the future.

We need Conscience to link Faith to Intelligence

You see now why we neglected the integers when we showed that the rationales are countable, i.e., they are as much as the

naturals. This way, we divided the problem into two others that we do not forget to reintegrate after we have solved them – *divide et impera et intellige*.

We count the positive rationales x/y along the secondary diagonals in an odd quadrant of the coordinate system (x0y). Then we repeat this counting for the negative ones in an even quadrant. Finally, we count them together by jumping between quadrants for every current number. We come to the idea how to count the IQ s without using *divide et impera et intellige* that we have to keep in mind for harder problems, as Life, Truth, and Way.

We have to remember the abstractions that assisted us to go further. We said complete human to someone complete in a context, what implicitly supposes the power to go beyond the context.

This is the story of the integers (*integer* = perfect, complete): they have a beautiful complete theory, however, do not forget to build the rational numbers to feel as close as needed to any real number. Nevertheless, they realize this is not enough, rewarded by the conscience of the continuous reality – infinitely more powerful than the discrete/ countable one.

To IR, we get by the perfect circle that is beyond the power of reason. Another way to the same scope is by the boring perfection of the square, when computing its diagonal ($\sqrt{2}$). Again and not fortuitous this alternative is due to *Pythagoras*, the godfather of π. The beautiful natural induction tells us that the equilateral triangle and the square are but the pioneers of the regular polygon sequence that converges to the circle.

Encouraged, we turn an equilateral Δ or a square about itself, obtaining the area of the circumscribed circle when the number of sides $n \to \infty$, from the areas of the n-sided polygons. However... we wanted to approach π by a sequence of rational numbers, but the example is not good.

Again, we hear like a sweet wind from the sea: *Alle guten Dinge sind drei* and intuitively sense that we have to know how mathematics masters the infinite. For long time, we knew nothing of sets, but we knew too well to play the role of a calculator. We

must not forget what intuition said to intelligence, by Imagination: we just had imagined a sequence of *algebraic irrationals* converging to the *transcendent* number π. We scare to be further taught rather what a discrete computer, instead of what an intelligent human, has to know.

For example, we plan to realize artificial intelligence, to have a friend that is conscious of the problems to solve together. For the moment, there is no artificial intelligence. However, we learn to be conscious of the computer limit to process only rationales. This means it uses a sequence $(x_n)_{n\in IQ}$ that converges to $\sqrt[n]{a}$ (*Newton*), what reminds us of the density of IQ in IR.

Perhaps not practice has to push us into evolution, but Gods fear, i.e., the scientific desire, on any reached level of knowledge, for the next one. Conscience attaches us to science and unfastens us of the false eternity, arrogated by some level of the evolution to freedom. To be free we have to understand all the necessities in the Reality, metaphoric: to escape God of any fear. Intelligent systems need a cosimulation of the parts that belong to different domains, e.g., hardware+software, in the context of a unified representation for simulation parts. Unified simulation of the hardware-software systems is imposed by the incompatibility or the lack of optimality that results of the initial partition of the system.

The design-verification cycle is not efficiently processed for a fixed partition. This disadvantage is eliminated when the simulation methodologies are unified, e.g., by categorial strategies. [1] This implies planning and learning, i.e., the possibility for interlevel communication in the knowledge hierarchy.

An intelligent simulator learns by recursive generation + validation, possibly interactive, of models. The objective of human-machine dialog is to advance toward simulated intelligence by knowledge communication in a common language between human and his mental/ physical extensions.

We pleaded that abstraction is the handiest tool for the human among other beings. Let us use it to simulate the present situation. Neglecting the conscience, let us see what remains.

What should I do? What you want. What do I want? What you like.

What do I like? What you should do.

This is a cyclic definition only at first sight, because it is most probably that what he should do has changed while crossing the cycle by what he wants or likes. We sketch a minimal intelligent system: it has to be adaptable, self- and context-aware, communicating with the exterior by signals/ actions.

<=preprocessing ← senses
Conscious processor = (knowledge acquisition + behavior rules) +
(intention formulation) + (action authorization) + (action command)
=>control → effective organs

However, we try it to be fashionable. Consequently, we also abstract from the fact that a discrete processing is not capable of self-consciousness. To avoid any discussions we abstain from any hypothesis on the class of the processor, discrete or continuous. What is the Conscience: it is the link, in our mind, between what we are conscious of and what we are not. Presently, only the extended to Reason adaptability, and the unjustified Intention, are conscious. Presently, we talk about electronic computers, but the nowadays trend is to copy from the living Nature, i.e., to emulate advantages of the living beings to achieve unconsciously complex duties. Vanguard domains are biotechnology and computational intelligence. Neither intelligence nor life is well understood, remember *Goethe*'s *Zauberlehrling*; more important is that emulation is less human than simulation, remember *Mozart*'s *Zauberflöte*; they should always develop in parallel, permanently exchanging experience, remember *Thomas Mann's Zauberberg*. We can imagine an intelligent machine that looks like a human (robot <= labor, in Slavonic). It accumulates knowledge and behavior rules by preprocessing the senses, and it can change the interior defining rules (reconfigurable) corresponding to the behavioral (professional, ethical) knowledge that is considered most important, e.g., most

recent or most decent. Therefore, it can consciously filter the actions that determine a new state of the context, what also means new knowledge to accumulate and to be conscious of (adaptability).

It means, the dialog with the external environment determines the intentions. If the system had conscience, the external dialog would be more complex and interesting. Consciousness only makes the adaptability more efficient, what, among others, transforms the human into the most powerful animal. Why do we compare the system without conscience with an animal, not to a human? It is true that we could compare it to an animal, if we had attributed intuition to it. However, what for should we do this, when the human just adapted to a consumption society? The built artificial objects and the socially useful natural objects send him the necessary messages to adapt consciously at the rising efficiency of the society. He neglects both the warnings from the superfluous Conscience and the unnecessary Intuition. If sometimes the two beasts shout too loudly, it is just unpleasant. To be useful Intuition should be linked by Conscience to Intelligence, and intelligently bridled by Imagination. More, Intuition should also know to bridle by Intention the Adaptability. Whether he is human or animal, the human is anyway a machine, a social machine.

His use is to contribute at the eternity, on an arbitrary level of evolution, of a materialistic consumption society. The evolution is for the human among humans, assisted by a reasonably organized society that develops by the human, for the human towards the Human. We said arbitrary level, however, if the educated and encouraged consumption were not strictly materialistic, the human himself would escape from the vicious circle together with the others. More, the present level is artificial in the human evolution. The essential limit of discrete computability, inherited by the computational intelligence, is the necessity of self-reference to integrate the knowledge of the levels to that of the metalevels for modeling the conscience. A hierarchical type representing reflexive abstraction can model the conscious knowledge and the knowing

consciousness, if it categorically collaborates with a simulation hierarchical type.

We have to search and research for the aspects of the Reality, and of the human mind that reflects it, even if they are neither constructively nor intuitively expressible. The desire to stop the human evolution on arbitrary stages has no real argument. The evolution is forced to halt on an inhuman level, a consumption society transforming the society into a beehive without interest for conscience and faith, what most probably was realized by destabilization of all revolutionary forms.

We need intelligent Faith to develop to freedom as humans among humans

2. Looking for hierarchical ways

Intelligence simulation designates the project to understand and technologically implement hardware-software a conscious adaptable knowledge generation/ processing. We changed the standard name of AI, to emphasize the need to understand the simulation; everything we know on simulation approaches us of the intelligent simulation of intelligence.

Formalization requires computer-oriented knowledge representation, and inference compatible to computable reasoning. The present work hypothesis considers the human as the only model for behavioral/ structural intelligence, different from a syntactical machine.The system that results of intelligence simulation should be able to explain itself without referring to its internal representation, i.e., to be conscious, and to have a causative behavior. This behavior is due to its internal structure and independent of the exterior interpretation, i.e., it is adaptable. By dialog, it can be aware of an intention, and by all this, it is intelligent.

Intelligence simulation is researched functionally and structurally; however, the present trend is the intelligence emulation (computational intelligence). It is more efficient, especially for adaptive learning, i.e., it does not care for conscience. The

hierarchical simulation, assisted by mathematics to get theoretical and formal, can lead to comprehension of the results. The approach has to be concentrated on the knowledge hierarchies, to simulate metaknowledge, for the system's adaptability, and for searching the way to simulate the Conscience.

The basic hierarchy types (classes, symbols, modules) correspond to (syntax, semantics, pragmatics) of the hierarchical language that has to express the intelligent simulation. Intelligent simulation results from the integration of the simulation hierarchy with its knowledge counterpart that represents a reflexive abstraction converging to self-consciousness of the intended adaptable simulation.

The recursively controlled sequential soft/ hard process has to be replaced by a reactive controlled continuous soft/ hard process. Most probably only the sequential reasoning distinguishes two limits of the computability, i.e., speed and possibility, in the essentially unique problem: Conscience. We deserve an example.

Symmetry on (simulation, knowledge) enables intelligent simulation

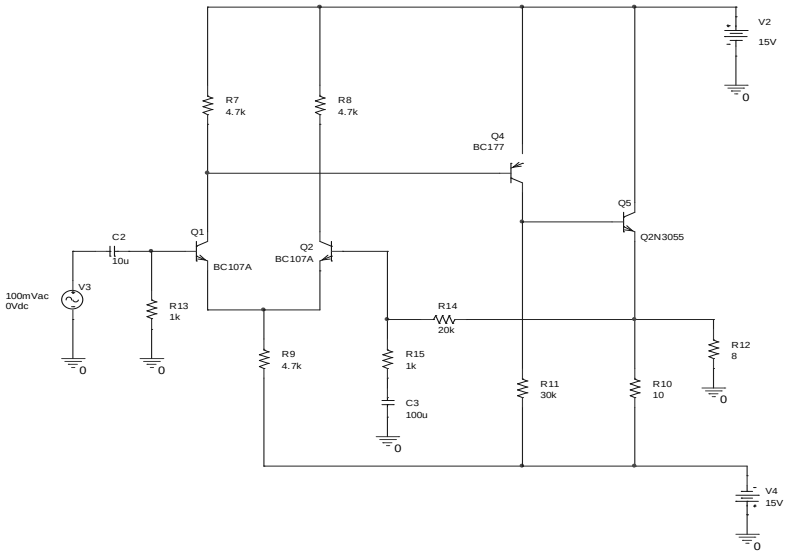
3. Transfer function singularities

Twenty years ago, one of the authors together with a friend – now professor at *Carnegie-Mellon* University – presented a related work that compared two methods to determine the poles and zeros of a transfer function, based on state-equations, respectively on node-equations. Complexity of the set-up actions of the first was balanced by weak convergence of the second. This is a typical case to try heuristics together with expert systems. Ten years ago, both authors together with other members of a Romanian–German team, presented a knowledge-based object-oriented analog simulation system. Note: The *Newton-Raphson* method has been used in circuit simulation for forty years, and the interest for its optimization has not decreased. The graphical or numerical results of a circuit simulator are the primary information that has to be

sampled with a variable rate appropriate to the simulator output variation. Knowing the dominant singularities is decisive for simulation, as they reflect the stability of the circuit [2], or can represent primary information in formal simulation, e.g., root locus method.

The transfer function of a linear (linearly approximated around a static operation point) circuit is a ratio between real coefficient polynomials with complex roots, functionally describing the frequency behavior. A pattern-matching search decides which rule applies, and at the end, the transfer function results as a two polynomials ratio. The search is bottom-up while determining the singularities, and top-down to find recursively the dominant ones.

The function of the program is threefold: *classification* – to recognize the type of singularity from the transfer function or *Nyquist* diagram; *control* – for stability; *anticipation* – to link the results to possible alternatives for improved behavior. It is object-oriented, and written in Java. The main classes are *Element*, *Rule*, *Match*, and *Act*. The input is a circuit simulator. AC result (numerical or graphic), the output a rational function representing



the approximate transfer function that describes the essential behavior. For the integrated audio amplifier below, the system finds the transfer function too "noisy", and proposes to "clean" it, by insertion of RC series group in parallel to R_{14}; further it verifies whether the capacitance can be integrated.

4. Reflexive Abstraction and Knowledge Hierarchies

The integration between discrete and analog is again needed, for a most soft adaptability and for conscience simulation as continuous recurrence, i.e., analog reaction. A continuous model for hierarchy levels, keeping the discrete hierarchy attributes, could better model the conscience. This means metaknowledge is modeled hierarchically in order to manage self-reference.

Different useful interpretations of the knowledge hierarchies are: real time of the bottom levels, corresponding to primary knowledge/ behaviour/ methods, is managed at upper levels, representing concrete types/ strategies/ models, and abstracted on highest levels to abstract types/ theories/ techniques.

Knowledge bases on morphism mapping the state-space of the object-system onto the internal representation of the simulator. An intelligent simulator learns generating and validating models of the object-system; representation for design and analysis should be common; the algebraic structures on which the different hierarchy types are based on is extended to topological structures; the different simulation entities are symbolic, having attributes as: type, domain, function.

A topology on the space of symbolic objects permits grouping items with common properties in classes. A dynamically object-oriented internal representation results, that can be adapted to the different hierarchy types.

Topological concepts, as neighbourhood, or concepts integrating mathematical structures, as closure, can be applied in verification/ optimisation. The simulation framework represents entities and relations of the simulated system, as well as general

knowledge about the simulated universe. Knowledge-based architecture bases on separation of representation from reasoning

An intelligent system is capable of reflexive abstraction, being controlled by problem specification and solving strategies. Strategies are derived from a higher level of knowledge, representing approach principles, which are structured by an even higher level containing abstract types. Applying this, both at environment and simulation component level, ensures flexibility of the framework realisation, by defining it precisely only in the neighbourhood of solved cases.

For representation, this principle offers the advantage of open modelling. The user describes model templates, following a general accepted paradigm that ensures syntactic correctness; the meaning is specified by user-defined semantic functions that control the simulation. For example, a module in an unfinished design can be characterised by constraints regarding its interaction to other modules; the constraints system is a model, open to be interpreted, thus implemented, differently, adapting to criteria in a non-monotonic logic. All simplifying hierarchies contribute to the reaction, while knowledge hierarchy stores, analyses, locally integrates, informs the awareness realising parts and globally integrates.

Interlevel relations in a knowledge hierarchy can be interpreted as planning and learning. Explanation is essential for knowledge-based systems. It can be expressed as proof in a deductive system, whose axioms are the equations constraining component models and input signals, theorems are simulation results, and inference rules represent logic and domain-specific calculus. Constructive logic permits extraction of the system behaviour/ structure from the proof.

5. Mathematical steps beyond Reason

The way to freedom is by understanding necessity. We have to recall to our conscience, to reintegrate our mind, and to remember that society has to assist humans to live among humans, not to consider them its slaves.

1. Structuralism of the spatial-temporal team of mathematicians Bourbaki succeeded in showing the common traits of different domains, emphasizing the structure that abstracts from the definition set; algebraic structure supposes computation over set elements – algebraic operations; topological structure associates to set elements sets of subsets – neighborhoods; order structure compares set elements.

2. Hilbert spaces ground the behavioral model for quantum physics, i.e., the part that is independent of any concrete intervention (in the world of abstractions). The link to the complementary part of the model, representing the interface to the physical world, can not be expressed algorithmically, suggesting the model is not correct in the Reality.

3. Banach algebra introduce, additional to the topological vector spaces, a commutative multiplication that, by an adequate transformation, results in a commutative functional composition, eliminating one of the most important constraints in a classical sequential model.

4. Inductive limits direct the convergence of hierarchical types, enabling the compatibility of partial simulations and contributing to the correctness by construction of the design.

5. Self-adjoint operators and eigenvalues/-vectors assist the knowledge concentration/ stability.

6. Reflexive topological vector spaces contain the necessary ingredients for the representation of the Conscience, by reflecting the adaptability in the variability of the space dimensions.

7. Fixed points help to formalize the simulation goal.

8. Unseparable spaces can instrument the understanding of inspiration and intuition.

9. An analog computability and an integrated mathematical-physical-comprehensible modeling the Intellige of the three approaches are promising ways.

10. Simulability is computability to the power of continuum: metaphorical thinking, unrestricted mathematics, analog electronics. Mathematical measurability is a way to formalize it.

11. The types of hierarchy link comprehension to the construction: their syntax relies on classes, the meaning on symbols, and their use on modules.

12. The knowledge hierarchy type offers a way to model consciousness. The theory of categories offers well-suited formalism for types. Constructive type theory permits formal specification-verification generating an object that satisfies the specification.

13. We have to consider/ remember that reality is infinitely more than nature. Recurrence is confined to discrete worlds, while abstraction is not. The difference suggests searching for understanding based on mathematical structures that order algebra into topology.

14. Especially, hierarchical reflexive: ideas about ideas and how to get to ideas, representations on representations, objects to synthesize/ analyze/ modify objects, and how to build/ understand representations, concern the evolutionary intelligence.

15. Our approach for singularities determination permits the most important aspect for the analog engineer: to know and to use the dominant singularities.

16. The integration between discrete and analog is needed, for a most soft adaptability and for conscience simulation as analog reaction.

17. Types associated to categories open the way toward including in the concept the inner and exterior knowledge: hierarchy types are expressed as equivalent categories; hierarchic types are expressed as isomorphic categories. Simplifying hierarchy types are linked together by covariant functors; conscience hierarchy type is linked to the simplifying hierarchy types by countervariant functors.

18. Mathematics contains structures that suggest to be used for self-referent models. The richest domain in this sense is functional analysis, which integrates algebra, topology, and order.

19. Constructive mathematics constrains the concept of mathematical function to that of algorithmically computable function, concentrating on the complexity of the algorithm that

computes the function. Extending the computation, whose name is linked to discrete, to simulation at the power of continuum results in simultaneous surpassing of the two computation limits: convergence and its speed.

6. Analog systems – solution of the future

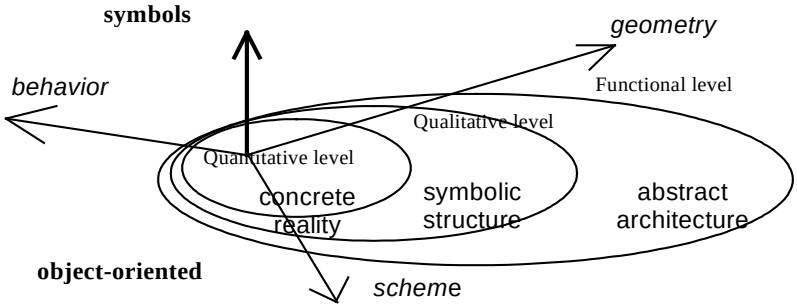
Methodology (paradigms, styles, techniques, models, methods), development/ unfolding medium and assistance/ execution instruments for system simulation, e.g., microelectronic, refer to the (Gajski)Y diagram: radially appear representation domains (behavioral, schematical, geometrical), while concentrically – abstraction levels of the considered simulation hierarchies (functional-symbolic, structural-symbolic, physical-symbolic). We vertically extend the Y diagram to add the symbolization degree. To tend to intelligent simulation, simulation hierarchies for solving or building, that assure the adaptability, are to be accompanied by the knowledge hierarchy type, for a better approximation of the consciousness necessary to intelligence. On Y diagram, simulation operations are:

– deplacements along the axes correspond to top-down – implementation or bottom-up – interpretation

– passing between representations: (behavior → structure) – synthesis/ (structure → behavior) – analysis.

Design is a sequence of implementations and syntheses, while verification one of interpretations and analysis; they have to be integrated on/ between any level/s of the construction. Like this representation is a fundamental criterion to partition the (integrated electronic) systems universe.

Other ways for this used in simulation are: abstraction level – digital/ analog, realization – MOS/ bipolar; these are not proper partitions over the systems universe: digital systems/ MOS technologies accept simpler models, in different representations, corresponding to simpler more abstract mathematical structures that enjoy more efficient operational results than the analog systems, respectively, built in bipolar technologies. We conclude that simulation methodology for the latter generalizes some of the firsts.



Intelligence needs analog thinking (metaphors). Analog simulation could indicate both surpassing the noncomputable and the simulation of conscience. [6] Analog simulation needs to be formalized on superior abstraction levels. Analog simulation has to process in the same formalism, initially in the same framework, with the digital one, although using different strategies, methodologies, or instruments:

- Relevant hierarchy types and corresponding abstraction levels have to be object of standardization from the analog design community together with the computer-aided design (CAD) community, after uncoordinated research period.
- Extreme representation domains: functional and geometrical are fixed; the intermediary domain(s) – one or more schematic domains – is determined by decomposing the simulation process in *technology* free/ dependent parts, and developing a schematic-based simulation *theory*, to enable the designer intuition to participate at the simulation.

Particularities of analog simulation:

- Description: various specifications, and no standard AHDL – analog Hardware Description Language; behavior is rarely functionally specified; precision of information is not easy to determine.
- Complexity: few components intensively used; simulation is much more complex than for digitals.
- Hierarchy: only structural hierarchies are exploited; abstraction levels are vaguely defined.

System	Digital Signal Processor
Functional module	A/D, D/A
Architectural module	Operational Amplifier
Electronic module	Differential Amplifier
Device	Transistor

• Approach: various system solutions correspond to the competence and performance requirements; topologies are conservative (chosen of a restricted collection of schemes), especially for inferior abstraction levels; however, parameter sizing/ properties determination of a system require more flexibility and precision than what a *bottom-up* approach assures, i.e., semi-custom/ module generator.

• Technology: strongly reflected on simulation, however, most basic topologies (lower levels) are common to the usual technologies.

• Optimization: applies only on the lower abstraction levels of blocks, or/and of the whole system, i.e., hierarchical optimization is not developed.

7. Conclusions

The hierarchical principle has to be applied to the object of knowledge as to the knowledge structure itself: it mediates the link of paradigm to environment. Reconfiguration continues the ideas of hardware-software cosimulation, intending to extend the software flexibility to hardware, as parallel software tries to get closer to hardware performance. The experimented ways to reconfigurable design are Field-Programmable Gate Arrays for circuits and reconfigurable networks for systems. We want to reach this goal integrating hierarchical intelligent simulation to nanotechnological implementation. Reconfigurable computing architectures complement the existing alternatives of spatial custom hardware and temporal processors, combining increased performance and density over processors, with flexibility in application. We follow the paradigm of intelligent simulation functionally modeling self-aware adaptable behavior to simulate intelligence.

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Appendix: Theory of categories
Category: K = (|K|, Morph (K), °), whereby:
1. |K| = class of objects: A, B,...
2. Morph(K)=$\forall(A,B)\in|K|^2$ associated morphisms K(A,B)={f, g,..$\in$ A$\rightarrow$ B}; morphisms are relatively different: $\forall(A,B)\neq(A',B')$ K(A,B)$\cap$K(A',B')=$\varnothing$
3. (composition of morphisms):
- associative: h°(g°f)=(h°g)°f$\in$ A $\rightarrow$D, $\forall$f$\in$ A$\rightarrow$B, g$\in$ B$\rightarrow$C, h$\in$ C$\rightarrow$D
- identity $\forall$object: $\forall$A$\in$|K| $\exists$id$_A\in$ A$\rightarrow$A $\quad\forall$f$\in$ B$\rightarrow$A id$_A$°f=f
$\forall$g$\in$ A$\rightarrow$C g°id$_A$= g.

Initial object: I$\in$ K $\forall$A$\in$|K| $\exists$! f $\in$ I$\rightarrow$A (unique, to isomorphism).
Final object: F$\in$ K $\forall$A$\in$|K| $\exists$! f $\in$ A$\rightarrow$F (unique, to isomorphism).
Isomorphism: f$\in$ K(A,B) $\exists$!g$\in$ K(B,A), g°f = id$_A$, f°g = id$_B$ (g = f^{-1}) $\Leftrightarrow$ *isomorphic* categories.
Monomorphism: f$\in$ K(A,B) $\forall$ g, h$\in$ K(C,A) f°g=f°h$\Rightarrow$g=h (reducible to end).
Epimorphism: f$\in$ K(A,B) $\forall$ g, h$\in$ K(B,C) g°f=h°f $\Rightarrow$g=h (reducible to begin).
Functor: F $\in$ K $\rightarrow$ L is defined by a function on the objects:
F $\in$ |K| $\rightarrow$ |L| $\forall$(A,B)$\in$|K|^2, F $\in$ K(A,B) $\rightarrow$ L(F(A),F(B))
a) F(id$_A$) = id$_{F(A)}$ $\forall$A$\in$|K|
covariant b) F(g°h)=F(g)°F(h) $\forall$ g,h$\in$ Morph(K) so that g°h is defined;

countervariant b')$F(g\circ h)=F(h)\circ F(g)\ \forall\ g,h\in Morph(K)$ so that $g\circ h$ is defined.
Natural transformation/ functorial morphism: $\eta\in F\Rightarrow G$ ($F,G\in K\to L$ functors)
assigns $\forall A\in|K|$ a morphism $\eta_A\in F(A)\to G(A)$ in L $\forall f\in A\to B$ in K:

$$\eta_B\circ F(f) = G(f)\circ\eta_A.$$

Functorial isomorphism $\Leftrightarrow$ *equivalent* categories:
$\eta\in F\Rightarrow G, \theta\in G\Rightarrow F\ \eta\circ\theta = id_G,\ \theta\circ\eta = id_F$.