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Complex Time for Chaoplex Systems: From Newton to Wiener

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Abstract

After introducing the context and prehistory, the paper shows the threefold rationale for proposing an extension of conventional time, able to be used in modelling living systems: failure of atemporal modelling in ecology; unsuitability of Newtonian time for transdisciplinary research; requirements of service-oriented software engineering (SOSE). The approach is boundedly rational: the start vector contains few premises (e.g., the extension must start from and be reducible to conventional time) and flexible criteria (e.g., the extension should be mathematically "convenient" and exploit its roots – mainly Euler and Laplace). On this groundwork, Wienerian time is defined as complex-valued extension of physical time, its components are evaluated, and first consequences for SOSE are inferred. After abridging the "Proof-of-Concept" appliance (research toolkit aimed at "What-if" scenarios for exploring homeostasis in benthic communities) the paper focuses on the different temporal dimensions (required by the *system* and by any *perturbation* triggering its evolution toward homeostasis) and on the temporal accessibility relations between the two Kripke worlds. Instead of premature conclusions, the paper ends with assumptions inferred from the "Proof-of-Concept" application and suggestions to exploit other roots too.

Keywords: Wienerian time; General System Theory (GST); Kripke world; homeostasis; service-oriented software engineering (SOSE).

1 Introduction. Context and Prehistory

Context: a) deadline for validating *nondeterministic software* aimed at post-industrial engineering (i.e., designed for *service-oriented* modelling) with generally accepted industrial engineering methods (i.e., designed for *product-oriented* modelling [7]); b) corollary: designing mechanisms aimed at transdisciplinary research for *preserving ecological systems*; [2]; c) current phase: the research toolkit is in testing with field data.

Prehistory (in anti-chronologic order): a) Understanding user dissatisfaction. b) Previous research in agent-oriented software engineering (robots, agents and service users require different time dimensions [7] [4] [3]). c) The decisive discussion about the (maybe essential but uncared for) role of time in agent self-awareness with Donald Perlis (in 2008). d) Early experience with "PDP-like" real-time programming (where *compile*, *task building* and *run* time where separated). e) Early experience with (stereophonic) amplifier stability (phase distortion is reflected very differently in complex space for electromagnetic or electroacoustic fields).

The paper shows the *rationale* for proposing an extension of time, able to be used in modelling living systems from three stances (ecology, transdisciplinary research, SOSE, in Section 2) and the *approach* (start vector and roots to look for, in Section 3). On this basis, *Wienerian time* is defined, its components are evaluated, and first consequences are inferred (Section 4). The research toolkit is abridged focusing on temporal dimensions and on temporal accessibility relations between Kripke worlds (Section 5). Instead of premature conclusions, the paper ends (Section 6) with *assumptions* inferred from the "Proof-of-Concept" application and *suggestions* to exploit other roots too.

2 Rationale. Failures and Requirements

The reasons are conceptually linked (even partially nested) but still distinct in practice.

2.1 Failure of Atemporal Modelling in Ecology

– Ecologic systems evolve in *irreversible time* (called *Bergsonian*, details in 4.1),

– Ecologic systems are *chaoplex*. Chaoplexity is both *cognitive* (main parameters, processes, and relations are unknown) and *structural* (there are very many species and environment features).

– The key relation between *diversity* and *stability* is chaoplex and is not yet suitably modelled (ecologic stability can refer to several attributes: resilience, persistence, etc.).

– Evolution of ecologic systems must be modelled as *processes*. Processes within a living system require *Bergsonian* time (at most simulated through closed *Newtonian* time).

– From a biologic perspective, *homeostasis* is *macrochronically* a state but *microchronically* (as *key way* to ensure *preservation*) it is outcome of a (negative *feedback*) *process* triggered by a *perturbation* in a *dynamic* environment.

– Predictive models predict *synchronically* (*biodiversity* seen as spatial *distribution*) but cannot predict *diachronically* (*stability* seen as *evolution*). Such models are useful for *diagnosis* not for *prognosis*. To *predict evolution* a statistically relevant amount of *temporal information* is required (perhaps requiring several temporal dimensions).

2.2 Unsuitability of Newtonian Time for Transdisciplinary Research

As living systems evolve in Bergsonian time, transdisciplinary rules (stemming from GST and cybernetics) must be respected (for the application in 5.1 they act nearly as premises):

– Living systems are *nondeterministic*, and *open* (statistical determinism is irrelevant).

– *GST* (as *transdisciplinary* bridge between user *requirements* and model *suitability*) should set up a *common denominator* for all time species involved.

– From a GST perspective, *homeostasis* (as key species of *stability*) is outcome of a (negative *feedback*) *process*, and it should be seen as *system attribute* because it is a state originating from complex systemic *processes*. This is vital in practice because as system *characteristic* it becomes controllable and able to counteract harmful perturbations (5.2).

– Uncertainty due to *contingent future* should be considered (at least to try to reduce major effects of unforeseen, arbitrary, and dangerous anthropogenic disturbance).

2.3 Requirements of Service-Oriented Software Engineering

Services are surely *processes*. Thus, *service-oriented* engineering is *based on processes*.

– Processes *cannot* be modelled neither *atemporally,* nor using *Newtonian time* since: a) services are *user-validated*; b) users assess services in *Bergsonian time.*

– Corollary: services should be modelled in a time species *compatible* with user time; hence, there should be temporal *accessibility* relations between the "Kripke model world" and "Kripke validation world".

– Uncertainty cannot be modelled using time series: presuming that future evolution will merely extrapolate the past, nothing will improve.

Conclusion*: an undemanding species of time (letting the hope that system evolution can be controlled) is required; to be *effectual* too, it should be *mathematically tractable.

3 Approach. Start Vector and Roots

The boundedly rational approach contains four (strict) premises and five (flexible) criteria

3.1 Premises

*P*1. The only mathematical representation of time is *conventional time* (any time moment $t_k \in \mathrm{R}$). Hence, any extension must start from and be reducible to *Newtonian time*.

$P2$. Immediate implication: the extended time must be physically compatible with usual Newtonian time t, i.e., there must be temporal accessibility relations between the two Kripke worlds (e.g., in the toolkit, between the "system world" and the "perturbation world", 5.2, 5.3).

$P3$. The extension must reflect (at least partially) *irreversibility*, as chief feature of Bergsonian time.

$P4$. To ease transdisciplinary research, GST must be kept as *Lingua Franca* (it was proposed in [7], and proved mandatory for cybernetic modelling of living systems).

3.2 Criteria

$C1$. To get acceptance among both software designers and researchers of living systems, the new time species should be built "on the shoulder of giants" (here: Euler, Fourier, and Laplace). To start with a sound foundation, this criterion is elaborated upon in 3.3.

$C2$. For the same aim, the new time species should be not just mathematically tractable but also "mathematically *convenient*" (in the meaning given by Poincaré).

$C3$. The new concept should be tested within a user-validated application via a substantial model, able to verify total conformance to the premises and as much as possible to the criteria.

$C4$. The application domain should be relevant to transdisciplinary research, living systems, chaoplex environments, cybernetic modelling, and SOSE.

$C5$. Irreversibility should be looked for in magnitudes related to time that model physical irreversible processes (e.g., biologic decay).

3.3 From Euler to Laplace, to Bergson, to Wiener and Back

The key ideas to avoid *tabula rasa* are in fact an informal chain of implications:

– The first area to search is *system stability* ($P4$), where deterioration processes can be expressed as function of Newtonian time (e.g., loss of energy).

– System stability is studied in the complex frequency plane $p = \sigma + j\omega$ switching from the time to the frequency domain and back through Laplace transforms ($C1$).

– Comparing the exponents in the Laplace transform (e^{pt}) and Fourier transform ($e^{j\omega t}$), their necessary adimensionality suggests a likeliness: if "classic" frequency ω is the inverse of "classic" time t, then complex frequency p could be the starting point for a new time species ($C1$).

– p is encouraging because its real part $\mathrm{Re}(p) = \sigma$ models irreversible deterioration ($P3$, $C5$). (For instance, σ in a damped sine wave can signify attenuation caused by thermodynamic losses in resistors or parasite resistances).

– Corollary: the complex magnitude $1/p$ is a good candidate for describing a new, "mathematically convenient" kind of time ($C2$).

4 Complex Time as Extension of Physical Time

The endeavour nature entails replacing the "State of the Art" investigation with proving notation legitimacy in the given conceptual interpretation.

4.1 Conceptual Interpretation and Notation Legitimacy

"From St Augustine to Stanford nobody knows what time is [...] Science (physics, maths, [...] computer science) offers divergent views about external time (e.g., clocks measure circular time while thermodynamics, cosmology or logic conceptualise linear time). [...] Science (neurosciences, psychology, cognitive science, linguistics, anthropology) offers divergent views about internal time (e.g., the debate about its "thickness" or the "melatonin problem")" [4].

Since time is "undefined, controversial, and highly subjective" [4], only the legitimacy of using the notations below for the time species directly involved is abridged here.

Wienerian time. Google search (June 11, 2013) shows only two instances of its use:

– "Methods within this approach go under several names in the geological literature, but in essence are all extrapolations of Wienerian time-series" [1].

– "Even time cannot be measured with absolute precision, since [...] all stochastic perturbations due to Noise, which would affect the vibrations of the clock, are impossible to account for (this is the problem of "Wienerian time") [http://planetbuddha.blogspot.ro/2011/06/ epistemology-of-stochastic.html], 2011.

Newtonian and *Bergsonian time.* Choosing this title for the first chapter of [12], Wiener highlights the weight of these two contrasting kinds of time focusing on the opposition *reversibility-irreversibility.* Irreversible time was first called "human time" by Bergson [5] and later "living matter time" by Vernadsky [11]. Recently, this time was even tighter linked to living-system complexity: "internal (or subjective) time (as well as subjective space) of a complex system is determined by the content of its memory [...]. They are produced by information processes occurring in a complex system" [9]. On the other hand, in the area of technical diagnostics the concepts are linked to duration: "Testing and reasoning are two main closely related diagnostic activities. Diagnostic testing is realized in Newtonian (short) time while diagnostic reasoning – in (long) Bergsonian time" [6].

Hence, nothing affects the legitimacy of using these concepts in formalising the new time species. However, as regards the symbols used, for historic and pragmatic reasons – mainly to comply with the premises $P1$ and $P2$ – the time corresponding to Newtonian time will be still labelled "t". Confusion is avoided using the "Old English Text MT" font.

4.2 Defining Wienerian Time, Evaluating and Interpreting its Components

Wienerian time $\mathfrak{w}$ is defined as complex-valued extension of physical time t. Its real part is noted $\mathrm{Re}(\mathfrak{w}) = \mathfrak{b}$ (from Bergson) and its imaginary part is noted $\mathrm{Im}(\mathfrak{w}) = \mathfrak{t}$ (any time species compatible with, Newtonian time $t = 1/\omega$, as measured by any ordinary clock).

Definition.
$\mathfrak{w} \stackrel{\text{def}}{=} 1/p$, *where* p *is the complex frequency (3.3).*
Evaluating and Interpreting $\mathrm{Re}(\mathfrak{w}) = \mathfrak{b}$ *and* $\mathrm{Im}(\mathfrak{w}) = \mathfrak{t}$.

$$\mathfrak{b} + j\mathfrak{t} = 1/p = 1/(\sigma + j\omega) = (\sigma - j\omega)/(\sigma^2 + \omega^2);$$

$$\mathfrak{b} = \sigma/(\sigma^2 + \omega^2.)$$

Thus, $\mathfrak{b}$ can stand for Bergsonian time since:

– $\mathfrak{b}$ exists *iff* σ – that symbolises *irreversibility* (e.g., thermodynamic losses, biologic decay) – exists; indeed, if $\sigma = 0$ (no decay), $\mathfrak{b} = 0$ while the Laplace and Fourier transform become equivalent (undamped oscillation, described by $e^{j\omega t}$).

– Moreover, since in physical reality, $\sigma \ll \omega$ (at least in all practical situation with technological importance, as for instance any kind of oscillations), its numerical value is proportional to the numerical value describing intensity of *irreversible* decay.

Likewise, $\mathfrak{t} = -\omega/(\sigma^2 + \omega^2)$. When the decay constant $\sigma = 0$, $\mathfrak{t} = -1/\omega = -t$.

Thus, the Euler formulae (with $e^{j\omega\mathfrak{t}}$ instead of $e^{j\omega t}$) remain unchanged for any $\mathfrak{t}$ compatible with Newtonian time, t. Hence, mathematically, $\mathfrak{t} = -t$ has no major consequence: the elliptic trigonometry formulae are interpreted "clockwise", while for hyperbolic trigonometry formulae, the abscissa axis is reversed. However, from a physical stance, changing the sign of t means inverting "the arrow of time" (in the meaning given by Eddington). As a result: a) the decay constant σ must not be negative to signify actual decay; b) the hyperbolic sine can suggest rather propensity to *system stability* than danger of its *explosion.*

4.3 Consequences for Service-Oriented Software Engineering

As condensing target (2.2, 2.3), *raison d'être* (2.1), essence (4.2), and first results (5.2, 5.3) of the endeavour, the title needs explaining the stance: a) *Software Engineering* is regarded as adult research subdomain of Computer Science (not just as innovative subdomain of *IT*). b) *Service-Oriented* refers to *Engineering* as a whole, key feature of *post-industrial* engineering (not to *Software Engineering*, that *was always* service-oriented); c) *Consequences* has three time horizons: *short* (no consequence whatsoever, since accepting $\boldsymbol{\mathfrak{w}}$ implies several paradigm shifts); *medium* (clearly positive, *iff* the application in 5.1 fulfils reliably the requirements in 3.3); *long* (based on future work, 6.2).

Since the paradigm break entailed by complex time is deep, medium-horizon consequences are shown by three threads embodying (in order of decreasing abstraction) the way down from time memeplex instance [4]: mathematics, transdisciplinary research, SOSE, computer science, software mechanisms for modelling processes in living systems, programming techniques [7].

– *Time is negligible (mainly, relatively to space).* In papers there are 50 times more references to "mathematical *object*" than to "mathematical *being*" ("mathematical *process*" means "calculation" [thefreedictionary.com/mathematical+process]); predictive models are atemporal; there are no quality standards for post-industrial engineering; there is yet only one standard for agents; there are no mechanisms for nondeterministic software; object-orientation is still prevailing (even in script languages!); exceptions are simulated.

– *Newtonian time suffices.* Despite not asserting this explicitly, the illusion is nurtured ignoring any kind of user-centredness. The problem was comprehensively dealt with in [7] focused on decision-making: "Since both *nature* (i.e., situations needing decisions) and *humans* (i.e., decision makers) are *analog* and *nondeterministic*, it is increasingly awkward to rely on *numeric* and *algorithmic* decision support". For control engineering reversible (circular) time suffices indeed (human-automata interaction is not within a (Dennett) "intentional stance").

However, in robotics – in spite of huge advances due to increasing the cycle duration – the idiosyncratic, unnatural robot behaviour is caused firstly by its fractured time, impeding appropriate interaction with humans communicating in irreversible time. Thus, reducing the gap between robots and agents would be a main consequence.

– *Bergsonian time is "long".* [6] made a big step towards the badly needed paradigm shift, realising that *testing reasoning* and *diagnostic reasoning* occur in distinct temporal dimensions. [6] considers that the first occurs in (short) Newtonian time, while the second occurs in (a longer) Bergsonian time; moreover, humans interact in Bergsonian time even in closed technological environments.

5 Times for Modelling Homeostasis with Hysteretic Delay

The implemented research toolkit is outlined in 5.1 from the stance of "Proof-of-Concept" application. Next, the "Concept" is detailed: there are distinct times (5.2) that must be compatible (5.3).

5.1 "What-if" Scenarios for Preserving Ecologic Systems

The toolkit is based on a non-algorithmic cybernetic (discrete time) model of processes towards homeostasis with hysteretic delay (Figure 1) of a benthic predator-prey species pair when the existing homeostatic state was disrupted by anthropogenic disturbance (modelled as Heaviside function), employing for system time $\mathsf{t} = \mathrm{Im}(\mathfrak{w})$. The interaction between A, β, Δt, and $\mathsf{t}_{\mathfrak{h}0} - \mathsf{t}_0$ is widely tested. In essence, $\mathfrak{w}$ should comply with two conditions: the *user* requires an *unchallenging model* (expressing the hope that system evolution can be – somehow – controlled); the *software engineer* requires a *mathematically tractable model* (to be *effectual* and to be *easily integrable* in existing applications). Validity is assessed from both a *conceptual* perspective (theoretical soundness was shown above) and from an *operational* one (working potential is shown here).

By serendipity, unavailability of temporal data proved helpful since it allowed mechanism validation with much greater generality (*system* time **t** is more different from *perturbation* time τ than firstly intended: a) **t** is discrete; b) τ can remain undefined.

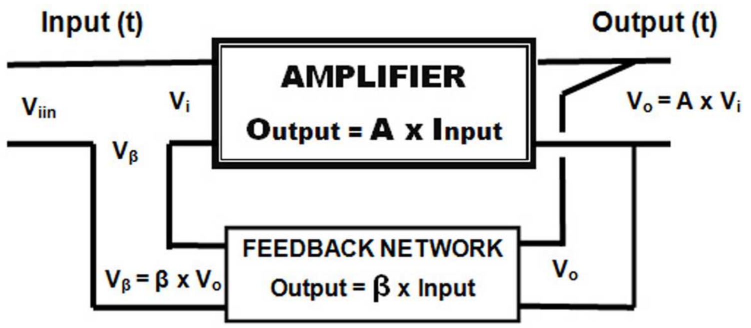
Although harder to assimilate cognitively, in electronics – due to the great speed of signal propagation – feedback mechanisms can mostly afford to sidestep an explicit temporal dimension (Figure 1a). Yet such circumvention is impossible when modelling processes in living systems. Homeostasis is no exception (details below, Figure 1b).

5.2 Perturbation and System Require Different Times

To ease modelling ecologic system stability through homomorphic projections, it is useful to rediscover Barkhausen's relation for general system (in)stability by means of Figure 1. The figure tries to "recapitulate transdisciplinary" the conceptual evolution from *technologic solution* (Figure 1a, adapted from [2], shows the quadripolar structure of a typical negative feedback loop in early electronic equipment) to *pivotal principle* of cybernetics (Figure 1b shows the block diagram for feedback in a cybernetic system reduced to essentials),

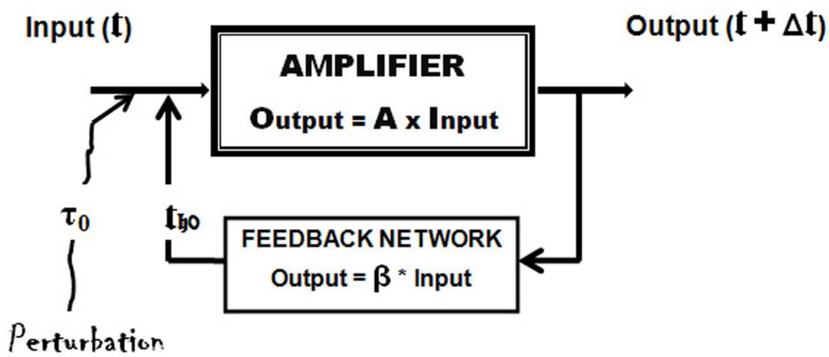
The strangeness or even illusoriness of a total instantaneity suggests a kind of time travelling. Indeed, it is straightforward to neglect the time needed to amplify the input signal (i.e., to consider that V_o is quasi-synchronous with V_i). However, it is cognitively hard to admit that a fraction of V_o is combined with its *own input* V_i and is even capable to influence the amplification process as a whole (i.e., to consider that "signal *cause*" and "signal *effect*" can be mixed up instantaneously). This perspective becomes totally inacceptable in ecology (where Δt represents usually the duration of a generation of a species).

Thus, ecologic modelling requires *microchronic* perspective. The simplest applicable time is *discrete time.* (For instance, here the input value "*before* feeding back" would be seen in the n^{-th} moment, while the value "*after* feeding back" would be seen in the $(n{+}1)^{-th}$ moment.). More generally, for any process, where time cannot be neglected, the feedback loop should reflect the two successive time moments: V_{ipr}, (pr,



A_{fb} = A/(1 - β*A) *iff* Δt -> 0 (macrochronic view).

Figure 1a. *Barkhausen*: β < 0 to reduce noise and distortions in early radio receivers



A (t_n) = V_o /(V_i(t_n) - β*A* V_i(t_{n-1})) *because* Δt >> 0 (microchronic view).

Figure 1b. *Wiener*: β < 0 to enable *stability* in cybernetic (mainly living) systems

Figure 1. Evolution from *atemporal solution* to *Wienerian time principle*

from *preceding* or *previous*, was the input value *before* being amplified) and V_{ic} (c, from *current*, is the value that enters the amplifier *now*). Referring to discrete time moments, $V_{ic} = V_i$ at t_n and $V_{ipr} = V_i$ at t_{n-1}.

Two elements in Figure 1b are fundamental from a biologic perspective:

– Δt. Homeostasis "is really a dynamic steady state, i.e., fluctuating regularly in time" [10]. Homeostatic state is arrived at after a time interval depending on the specific context.

– *Perturbation*. In biology as a whole current models solve "the homeostasis part of the problem but not the patterns of deviation from homeostasis (pathodynamics)" [10]. In GST language, this "deviation" is caused by any perturbation changing the system state. However, perturbation cannot be modelled as belonging to the system *genotype* because as *trigger* of homeostasis it is the key factor in system operation (it appears only *after system ontogenesis*). Moreover, perturbation cannot be seen neither as belonging to the system *phenotype* because it *must be input* magnitude until homeostasis is achieved.

***Conclusion*: perturbation must be seen evolving in a time dimension τ distinct from and compatible with the system time $\mathsf{t} = \mathrm{Im}(\mathfrak{w})$.**

5.3 The Two Kripke Worlds Require Temporal Accessibility Relations

Beside the structure of t as time points set, critical is also the hysteretic delay:

As entailed by assertions above (2.1, 5.2), *homeostatic states* result from *adaptation processes* triggered by *perturbations* in (dynamic) environments. Thus, the "What for" question (vital for the *model*) is answered: the process leading to a homeostatic state should be a fitting balance between efficiency and resource consumption.

Since (*undesired*) perturbations are processed similarly to (*desired*) input, negative feedback will reduce their effect "$1+|\beta|^*A$" times – that means, with a sufficiently great $|\beta|$ (almost) as much as needed. The price? *More energy* spent for amplification. (In electronics and robotics there is also *more risk* regarding system stability.) Paradoxically, in ecology price is irrelevant, since concern about stability is mostly the *raison d'être* for research.

Thus, the "How" question (vital for the *implementor*) is answered too: there must be temporal accessibility relations between the Kripke worlds carrying out homeostasis with hysteretic delay. The time dimensions require temporal correlation in (at least) two instants:

– $\tau_0 > \mathsf{t}_0$ (entailed by the *intrinsic exogenic* nature of any perturbation);

– $\tau_h = \mathsf{t}_{\mathfrak{h}0}$ (τ_h is the moment in Newtonian time when the system begins to counteract the perturbation, after the hysteretic delay; $\mathsf{t}_{\mathfrak{h}0}$ is the moment in system time when the β network is connected to the amplifier input; since there can be *only one* "big bang" moment $\mathsf{t}_0 = \mathsf{t}_{\mathfrak{h}0}$, when the system starts to react – delayed or not).

***Conclusion*: the Kripke worlds implementing homeostasis with hysteretic delay require correlation between the *perturbation* time τ and the *system* time $\mathsf{t} = \mathrm{Im}(\mathfrak{w})$.**

6 Instead of Conclusions

If $\mathfrak{w}$, as proposed above, is accepted by mathematicians and found useful by computer scientists (mainly for modelling living systems), the (far-reaching) consequences impair rushing to conclusions. Thus, instead of conclusions, some placeholders:

6.1 Assumptions Inferred from the "Proof-Of-Concept" Application

Although software engineering assessments cannot follow a single application of t, there are some counter-arguments to *advocatus diaboli* questions like "Why should we believe that t is something else than t written with another font?"

1. As it has been shown when modelling homeostasis with hysteretic delay, it is obvious that within *living systems* there are pro-

cesses that cannot be modelled atemporally; moreover, as advanced biologic research shows, t-based models are inappropriate. On the contrary, $\mathbf{t}$ proved to be convenient even in a chaoplex situation, requiring microchronic approach.

2. For *Computer Science* and IT it is a long needed conceptual clearing up and “operational synthesis” of the (dis)similarities between the time kinds used in robotics (closed, circular, expressed by t), process-oriented engineering (irreversible, describing decay, expressed by $\mathfrak{b}$) or conventional modelling (reversible, irrelevant, or lacking altogether).

3. At *transdisciplinary level* (with GST as *Lingua Franca*), emerge some clear benefits:

– It seems to be the first mathematically convenient extension to physical time.

– It unites in a simple mathematical object several aspects (mathematical, physical, or engineering) cut off until now, in distinct mathematical approaches (Euler, Fourier, Laplace, Heaviside).

– Wiener’s seminal distinction between (reversible) Newtonian and (irreversible) Bergsonian time, obtains a first coherent mathematical expression.

6.2 Unexploited Roots: From d’Alembert to Husserl, to von Mises

Likewise, instead of future work, some suggestions to exploit other roots too seem encouraged by the “Proof-of-Concept” application. Promising research directions could be:

– Speculating about $\mathrm{Im}(\mathfrak{w}) = \mathbf{t}$: when $\sigma = 0$, $\mathbf{t} = -t$, maybe replacing usual time t with $\mathbf{t}$ in the electromagnetic wave equation would restore symmetry not only in the major conceptual relationship between time and space in the d’Alembertian ($\phi = \Delta\phi - \partial^2\phi/\partial t^2$), but also in the Minkovski space as a whole.

– While irreversible *Bergsonian time* (i.e., a kind of $\mathfrak{b}$) is generally accepted as “human time”, there is ongoing debate regarding the presence of genetically conditioned mechanisms triggering circular times (i.e., kinds of $\mathbf{t}$), as circadian cycle (with the unsolved "melatonin problem") or "systolic rhythm", similar rather to *Newtonian time* ($t = 1/\omega$). Thus, maybe $\mathfrak{w}$ as model of time can help research *Husserlian* time, using the Dirac function $\delta(t)$ to express Sartrean time: present: $y-$axis ("*l'être*"); past/future: $x-$axis ("*le néant*") [4].

– $\mathfrak{w}$ may help to regard probability as *subjective* experience (replacing t in the von Mises limit) not just to get rid of "gambler's fallacy" but also to prove Gigerenzer right ("the inability to understand statistical information is not a mental deficiency of doctors or patients" [8]).

– Bodiless agents (lacking haptic proprioception) could get new chances to rival robots.

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References

[1] G. Baecher. *Probability Theory in Geological Exploration.* Research Memorandum, IIASA, [http://pm.umd.edufiles/public/water_library/1975/Probability%20Theory%20in%20Geological%20Exploration_1975_.pdf], 1975.

[2] B.E. Bărbat, I. Presură, T. Tănăsescu. *Audio-Frequency Amplifiers.* Ed. Tehnică, Bucureşti, 367 pp., 1972. (In Romanian.)

[3] B.E. Bărbat. *Natural Time for Artificial Agents.* Exploratory Workshop on NL-Computation (Invited paper.) ICCCC 2008. Abstracts of ICCCC Papers: ICCCC 2008 (I. Dziţac, et al. Eds.), Workshop Keynote Lectures, 27, Agora University Editing House, 2008.

[4] B.E. Bărbat. *NEWTON, HUSSERL, WIENER: A Temporal Golden Braid.* (Invited paper at ICCCC 2010). Abstracts of IC-

CCC Papers, International Conference on Computers, Communications & Control, 12, Agora University Editing House, Oradea, 2010.

[5] H. Bergson. *Time and free will: an essay on the immediate data of consciousness.* Mineola, N.Y.: Dover Publications, 2001.

[6] H. Borowczyk, P. Lindstedt, J. Manerowski. *Newtonian and Bergsonian time in technical diagnostics.* Journal of KONES Powertrain and Transport, **19**2, pp.61–66, 2012.

[7] R.D. Fabian. *Bounded Rationality in Agent Orientation - "Just-In-Time" Visual Pattern Recognition.* PhD Thesis, "Lucian Blaga" University of Sibiu [http://bcu.ulbsibiu.ro/digitale/doctorate/Ralf_Fabian_Phd_Thesis.pdf], 2011.

[8] G. Gigerenzer, A. Edwards. *Simple tools for understanding risks: from innumeracy to insight.* British Medical Journal, 327, pp.741–744, 2003.

[9] P.O. Luksha. *Memory as producer of subjective time and space in complex systems.* [http://www.mdpi.org/fis2005/], 2005.

[10] D.C. Trost, et al. *A model for liver homeostasis using modified mean-reverting Ornstein–Uhlenbeck process.* Computational and Mathematical Methods in Medicine, **11**, 1, pp.27–47, 2010.

[11] V.I. Vernadsky. *The Biosphere*, complete annotated edition.- Copernicus / Springer-Verlag, New York, 1998.

[12] N. Wiener. *Cybernetics. or Control and Communication in the Animal and Machine.* MIT Press, Cambridge, 1948.

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