Ralf D. Fabian

Bounded Rationality in Agent Orientation - "Just-In-Time" Visual Pattern Recognition

PhD Thesis in Computer Science and Information Technology

Advisor: Boldur E. Bărbat, PhD
Evaluators: Acad. F.Gh. Filip, PhD, Romanian Academy
D. Dumitrescu, PhD, "Babeş-Bolyai" University
I. Moisil, PhD, "Lucian Blaga" University

Dedicated to the Ninetieth Anniversary of Lotfi A. Zadeh

**"Lucian Blaga" University of Sibiu,
"Hermann Oberth" Faculty of Engineering
Sibiu, 2011**

*Când munca s-a sfârşit şi toate verigile au
fost prinse în lanţul de neînfrânt, am văzut
că eu eram cel prins în propriul meu lanţ*
RABINDRANATH TAGORE "Gitanjali"

Table of Contents

FIRST CHAPTER
Introduction. (Bounded) Paradigmatic Shifts

SECOND CHAPTER
Bounded Rationality Vs. Chaoplexity: Best Is Not Always Better

THIRD CHAPTER
Bounded Rationality in Humans and Agents. State of the Art

FOURTH CHAPTER
The Meteoric Rise of "Bounded Rationality". Its New Role

FIFTH CHAPTER
Transdisciplinary Communication Needs a *Lingua Franca*: GST

SIXTH CHAPTER

Non-Algorithmic Mechanisms for Word-Based Modelling

SEVENTH CHAPTER

Boundedly Rational Experimental model(s) for EU2020 Targets

EIGHTH CHAPTER

Implementing the Experimental Model for Visual Patterns

NINTH CHAPTER

Evaluating the Good, the Bad, and the Future Contingent

FIRST CHAPTER

Introduction. (Bounded) Paradigmatic Shifts

The paradigmatic shifts are far-reaching – albeit inexorably bounded, to pay respects to the main thesis concept – in the very *topic* (1.1), are mirrored in the *thesis* texture (1.2) and permeated (even) the *author* (1.3).

1.1. About the Topic

In the context of paradigmatic shifts "bounded" means "unfinished". It entails a challenging *thematic context* (1.1.1) and a stimulating *historical context* (1.1.2).

1.1.1 Thematic Context

Beyond the intrinsic hurdles involved by various paradigmatic shifts, there are deep divergences between computer scientists depending on their professional background – better said perspective – even when they agree as regards facts. A key instance relates to the very thesis kernel:

All stakeholders implicated agree that in a post-industrial (service-based society) most untrivial applications have to deal with decision making in dynamic situations and agree also that "dynamic" implies "uncertain". Unfortunately, abridging an issue dealt with in 4.3.2, "uncertain" means practically (mainly, subconsciously) quite different things for:

- *Mathematicians*: uncertain = *unknowable*. If it can be obtained through computation and/or deduction it cannot be uncertain. Time does not matter – mathematics is atemporal.

- *Software developers* (mainly for automatic control): uncertain = *undependable* (either untrustworthy or variable or unknown).

- *End users* (real-world decision makers): uncertain = *undecidable* (first of all for future contingents).Decisions must be made "*Just-in-Time*" as defined by Toyota [158] for its inventory system, (According to the BBC, until the 2011 tsunami Toyota was never out of stock.) There simply *is no time* neither to wait for further information to appear nor to optimise using incomplete information.

Moreover, accepting the idea that decision making under time pressure is intrinsically nondeterministic is mentally uncomfortable. Its corollary regarding the non-algorithmic nature of decision support software is even more.

Though, no CSIT thesis in the domain of engineering sciences could avoid devising new software and illustrating it convincingly in an experimental model – no matter the label put on it. Asserting that *it must be non-algorithmic* is an unavoidable risk.

1.1.2. Historical Context

Within the EU2020 strategy *continuing education* is a key pillar for *sustainable development*. In this context the Sibiu University (LBUS) started a transdisciplinary research project aiming at continuing education in engineering affordable for a medium-sized East European university. The undertaking was launched focusing on a paradox: "Our present object of work (*teaching*) is neither present nor object, since it aims at a future, quite far away, process (*learning*). Why should the teacher focus on solving (*predictable*) problems, when the learner should focus on managing (*unpredictable*) situations?" [63]. Thus, the research is focused on:

- *heutagogy* (for *learning* as nondeterministic *process*);
- *educational chaoplexity* (for *teaching* as post-industrial *service*);
- *bounded rationality* (advanced from cognitive *limitation* to IT *mechanism*, to cardinal educational *guiding principle*).

The research was intended to be carried out through a PhD theses cluster including: a) this thesis; b) "Non-deterministic e-Teaching in Uncertain, Dynamic Environments. Experimental Model Based on Memetic Engineering" (scheduled for November 2012, [26]) and c) "Holistic Heutagogy for e-Maieutics-Based Lifelong Learning" (in a stage too unsatisfactory to be relevant and now practically abandoned).Since the four technical reports ceased to exist, being dissolved in the thesis, they will not be referred to explicitly.(However, to keep a trace of the chronological evolution, their presentation slides are still available [43], [44], [45], [42]. Likewise for [26], the only technical report so far for the second thesis mentioned.)

The last update of this thesis took place on October 26[-th], 2011.

1.2. About the Fabric

The thesis fabric refers to explaining *abbreviations* (1.2.1), setting up a fine-tuned *terminology* (1.2.2), and outlining the *contents organization* (1.2.3).

1.2.1. Abbreviations

Abbreviations are not always present (e.g., for the sake of expressiveness they are sacrificed in titles or in key sentences). The list below is an excerpt from [14].

AI:	Artificial Intelligence
AO:	Agent-Orientation
AOSE:	Agent-Oriented Software Engineering
API:	Application Programming Interface
BASYS:	Balanced Automation Systems
BR:	Bounded Rationality
CAS:	Computer-Aided Semiosis
COST:	European Cooperation in Science and Technology
CSIT:	Computer Science and Information Technologies

CSITAO: *CSIT* focused on *Agent-Orientation*
CTED: Continuing Education
CWA: Closed World Assumption
CWW: Computing With Words
DSS: Decision Support System
EDCHY: Educational Chaoplexity
GST: General System Theory
GUI: Graphical User Interface
ICT: Information and Communication Technologies
IDE: Integrated Development Environment
JIT: "Just-in-Time"
LB: Left Brain
LBUS: "Lucian Blaga" University of Sibiu
MEng: Memetic Engineering
ODUE: Open Uncertain Dynamic Environments
OS: Operating System
PrPidsDM: Premises for Post-industrial Decision Making
RB: Right Brain
SOSE: SOSE1 + SOSE2 ("S" stands for both "Service" and "Semiotic")
SOSE1:   Service-Oriented Software Engineering
SOSE2:   Semiotic-Oriented Software Engineering
UI: User Interface

1.2.2. Terminology

For any exploratory research terminology is crucial. Above all, this first thesis within the EU2020 research cluster – and most likely the first authentically agent-oriented thesis in Romania – needed some major conceptual clearing up. Thus, to serve, clarify, simplify, co-alesce, and explain all CSITAO research, a *Carnap-like glossary* [14] was initiated.

For this thesis such an undertaking is *sine qua non* at various echelons as shown by the following examples (5.3.1, 5.4.4, 7.2.1):

- Fundamental concepts as "*algorithm*" or "*programming language*" must be redefined in line with post-industrial society requirements. First of all, in spite of being defined in a FIPA standard [126] the very "*agent*" is deeply misunderstood even in PhD theses.

- New concepts are expressed even in English using debatable terms: "*chaoplex*" should suggest rather "*complex*" than "*chaotic*".

1.2.3. Contents Organization

After this introductory chapter, the first attack on optimisation is launched ("Best Is Not Always Better") in Chapter 2, including the problem definition and the approach. The State of the Art in Chapter 3 brings in also the main conceptual neighbourhood (e.g., Semiotics, Memetics). On this groundwork, the next two chapters present the thesis kernel, namely the main paradigmatic shifts defended: the new role of bounded rationality in the post-in-

dustrial era, focusing on the evolution "From Kelvin to Zadeh" (Chapter 4) and choosing GST as "Lingua Franca" for transdisciplinary communication, focusing on bounded rationality as twofold feedback (Chapter 5).The new paradigms are illustrated in Chapter 6 by two non-algorithmic mechanisms for word-based modelling: a multifunctional bar for decision input and a non-algorithmic service-oriented decision-making framework. Both mechanisms are integrated in experimental models: a conceptual model of post-modern educational chaoplexity (Chapter 7) and an implemented model for visual patterns (Chapter 8). The overall evaluation in Chapter 9 summarises the original contributions in four categories: conceptual pillars, apparatus, approaches and effects of serendipity; likewise, the problems emerged during the research – and still open – are grouped in line with the expected role the author can play in their future investigation. To keep relevance, enhance argument, and ease reading the comprehensive bibliography is split into two parts in line with the role played when referred to: recent (2007-2011) factual references (used mainly for the State of the Art) and all kind of other sources of ideas.

1.3. About the Author

To impair artificialness I will use here the first person, I try to explain the *motivation* (before starting the endeavour, 1.3.1), the *paradigmatic arguments* (during the research, 1.3.2) and to pay the sweet debt of *thankfulness* (1.3.3).

1.3.1. Motivation

Besides the usual incentives to start a PhD. in "Cybernetics and Economic Statistics", after losing my doctoral adviser, the motivation to start PhD. in Engineering Science is obvious analysing the directions of my papers quoted in 2.3.

The first doubts about the universal effectiveness of conventional mathematics in IT applications were raised during my first doctoral studies (in 2002-2008) by two circumstances: a) the loose relationship between formal languages and real-world problems (e.g., the futility of compiler theory in modelling economic applications); b) the meagre practical results of applying traditional optimisation methods in any kind of modelling (e.g., the feebleness of popular algorithms in multicriterial optimisation). Thus, I was conceptually ready to accept the Simonian ideas about BR, first of all as regards the usefulness of approximation in anthropocentric interfaces (in agent-oriented context the problem was dealt with in [40]).

A key role played my evolving standpoint on cognitive science and its relationship to IT: as application developer trained in object-oriented programming I ignored it until my first research in artificial intelligence; then, being involved in agent-orientation I accepted cognitive science only as application field of CSIT – namely as modelling cognition based on sequential deterministic computation. Now, I accept the conceptual basis of Figure 1.1 but I still have (diminishing) doubts about the developing abilities of nondeterministic software for the time being.

On this groundwork my intentions are to keep walking on this way (first of all I intend to develop an Ada-like exception handler, 6.1.3), being engaged as much as possible in future work – above all as outlined in 9.3.1.

1.3.2. Paradigmatic Arguments

In essence the divergence could be reduced hereto the well-known clash in AI – widespread nowadays in IT as a whole – between *objects* and *agents*, as explained in [35] and shown in Figure 1.1.
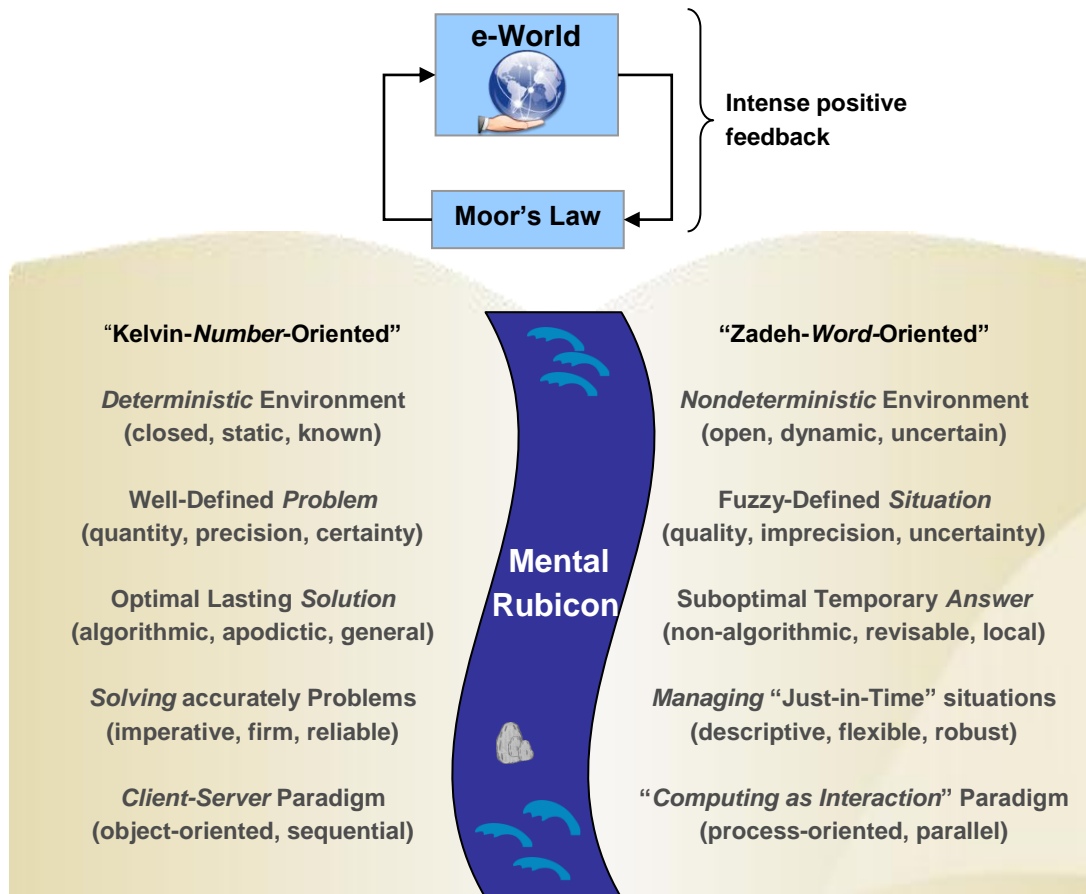
Figure 1.1. Crossing the Mental Rubicon (inspired from [35]).

Now the conceptual Rubicon is considerably narrowed in line with the diachronic perspective about *cognitive science* as detailed in 3.2.2.1. In short, the compromise defining the thematic context can be summed up as follows: the thesis is conceived as agent-oriented but the "service-providing software entity" reflected in the experimental model could be labelled as "*agent*" iff it is treated by the operating system as thread. Though, because of reasons given in 6.1.3, it was mandatory to accept the unpleasant implication that, in the absence of a genuine interface agent, the human service provider takes over a part of the tasks commonly carried out by interface agents.

1.3.3. Thanks

Looking back on all I have experienced throughout these years of my PhD study, I get deep feelings of gratefulness and surprise. There were certainly many people who shaped me as the person I am now, to whom I'd like to address my words of gratitude.

Besides God and my parents, I have to pay tribute to the myriad contributions of my advisors, collaborators, and many others that I won't be able to mention here. Thank you all for being there and guiding me.

I have great pleasure in expressing my sincere thanks to my esteemed advisor Boldur Bărbat. His ideas and tremendous support have had a major influence on this thesis. He spent a lot of time helping me, along with other people of our research group. I am grateful

for the incredible amount of energy he spent around the clock teaching me what research means – it did not matter how late at night or early in the morning it was.

My deep gratitude goes to the thesis evaluators; I thank Acad. Florin Gh. Filip for his thorough review and information regarding automatic systems, decision making and anthropocentrism; Dan Dumitrescu for his attention given to the results of the thesis guiding me on reformulating the original contributions, and Ioana Moisil for always providing a right way out of any complex situation.

A very special thesis committee guided me through all these years. Dana Simian, Ioana Moisil and Daniel Volovici, to each of them I owe a great debt of gratitude for their patience, inspiration and friendship being my advisers.

I would like to thank all the members of the Computer Science and Automation Department for their kindness, time and generous support. My deep gratitude goes to Daniel Volovici, Mihu Z. Ioan, Ioana Moisil, Macarie Breazu for all the helpful comments and suggestions. A special thanks goes to Lucian Vințan, for his advices and constructive questions.

I prize the enormous amount of help from my Rector Constantin Oprean. He cared to assist me to continue my PhD study at this university, after losing my initial PhD adviser and also lessened the financial burden of the new endeavour. Moreover, I am proud for several papers published together.

I'd like to thank Claudiu Kifor for logistic and financial support within the significant lack of funding during the two years of my PhD study.

Furthermore, I'd like to thank the dean of the Faculty of Science, Dumitru Batâr for accepting and supporting our countless meetings and working sessions.

My gratitude goes to all the members of the Department of Informatics, led by Dana Simian. A special thank you goes to Cristina Brumar for the many interesting and fruitful discussions along with her great support in almost every hazardous situation.

When it comes to managing urgent, "Just-in-Time" situations, there can be simply no way around one person - and I can hardly remember an unmanageable situation for her - thank you Mariana Gliga. And last but not least - thank you Daniel Hunyadi for keeping me out of trouble and always being there when help was needed.

It was a real pleasure and honour to work with all these people and to benefit from their knowledge.

I wouldn´t want to finish without expressing my sincere appreciation for my parents Andreas and Karla, who were the most basic source of my life's energy. I have amazing parents, unique in many ways and the stereotype of perfect parents in many others. Their involvement was unconditioned all the years; they have given up many things favouring me, cherishing with me every moment of my life, and supported me whenever I needed it, regardless of all my strange moods (especially during the last month) they were exposed to. Thank you for all your love and encouragement.

SECOND CHAPTER

Bounded Rationality Vs Chaoplexity: Best Is Not Always Better

Man muss noch Chaos in sich haben um einen
tanzenden Stern gebären zu können
NIETZSCHE "Also sprach Zarathustra"

Since there is no *tabula rasa* in PhD research, before defining itself as *problem* (objectives, starting point, road map, 2.2), the thesis presents its evolution as *topic* (2.1). Then, the key syntagms in the *title* are scrutinised (2.3) and the *approach* is outlined (2.4).

2.1. EVOLUTION OF THE TOPIC AT LBUS

Work carried out before the PhD started is abridged as *prehistory* (2.1.1) and is followed by the two year *thesis period* (2.1.2). The *author's pre-thesis work* (2.1.3) ends the sub-chapter.

2.1.1. Prehistory (2001-2009)

A compromise between the "no *tabula rasa*" principle (2.2.3) and the need to decree a point in time where prehistory begins is rather easy for exploratory research in CSITAO: at most a decennium. A "boundedly rational" deviation for this thesis is the century start year.

Research at the Faculty of Engineering (2001-2005) and at the Faculty of Sciences (2005-2009) represents the main strands (in parentheses are only the sources of main ideas quoted in this thesis.

2.1.2. Historical Period (2009-2011)

The starting point of the EU2020 theses cluster is, "the broad outline of a strategy to journey "from Sibiu to Lisbon via Bologna", where a Rector joined the educated guess of a manager with the "educated vision" of a doctoral advisor: "education in the Knowledge Society would focus rather on *skills* than on *knowledge*"[65]." [63]

The problem of service-oriented approach to quality management was addressed very recently from a clear-cut engineering perspective as regards service architecture and from an agent-oriented stance as regards application structure in [68].

Transdisciplinary links in agent-orientation are dealt with in [67] where the impact of time-related concepts is underlined: a) designing *services* instead of *products*, involves *parallelism*, hence a powerful temporal dimension; b) to interact capably, client/learner and server/teacher must be somehow "contemporaneous" (this the huge challenge of continuing education). Later, BR was filtered in [40] "through the Sieve of the Lisbon Objectives".

Recently, occasioned by two papers prepared for a Conference on Psychology, Counselling and Guidance [62], [61], the intrinsic thesis transdisciplinary vein become not just more manifest but influenced significantly the overall approach.

2.1.3. Author's Pre-Thesis Work

When I started my first PhD study (1.3.1) both the thesis topic and my conventional mathematical-IT background generated paper based on – or at least referring to – concepts difficult to defend as regards there applicative role in economics as: pattern matching and tree grammars [114], abstract state machines [116], algorithm for string replacement [113], fuzzy grammar, intermediate code [135], total fuzzy grammars [117], fuzzy extension on context-free grammars [39], syntactic pattern classification [37].

There were also some papers with valuable ideas for this thesis related to graphical user interfaces [115] and study program design [38]. The first paper directly related to the thesis objectives – representing also my first step toward a new paradigm – was [13] and one year later the second step with [54] and [73]. A less relevant step but in the right direction, namely transdisciplinary bridges, was [41].

2.2. DEFINING THE PROBLEM

Any important journey is predefined by its *objectives* (2.2.1), *starting point* (2.1.2), and *road map* (2.1.3).

2.2.1. Objectives

After each objective is a short comment, mainly a mini-rationale for its current formulation:

1. *Revisiting thoroughly the concept of bounded rationality, in view of its roles in a post-industrial (service-based) society*.

Since the major new role of BR as "educational mechanism" is hard to confine in the classical conceptual framework, two expansions are necessary: a) *Choosing a Lingua Franca for holistic approaches able to promote transdisciplinarity (above all as regards psychologists).* b) *Expressing bounded rationality in terms of General System Theory.*

2. *On this groundwork, substantiating the ambivalence of bounded rationality (cognitive limitation and IT guiding principle) within the agent-orientation paradigm, in applications destined to perform in dynamic and uncertain environment).*

Since no cooperation with psychologists could be started, three expansions were necessary to achieve the objective: a) *Investigating preterminologic BR (mainly the anthropogenetic divergence between optimization and simplicity).* b) *Exploring the role of BR as "psychological stabiliser" (through negative feedback).* c) *Extending the analyse to (largely preterminologic) synergy as (boundedly rational) resource amplifier.*

3. *Instantiating this approach for continuing education, via a framework able to manage educational chaoplexity based on bounded rationality as common denominator of, mechanism for, and connection between the two facets of continuing education: e-teaching and e-learning.*

Because the educational instance (within the EU2020 theses cluster) had to be advanced due to the much stronger link to cognitive psychology (involved by the expansions of the first two objectives), the initial framework was detailed with three subobjectives closer to the related thesis [26] than to this one but included (temporarily) here for the sake of consistency: a) *Investigating post-modern "educational chaoplexity"*. b) *Exploring e-teaching as boundedly rational system*. c) *Boosting e-teaching via extrapolating lasting topics and behaviours*.

4. *Validating the approach by carrying out an experimental model of a nontrivial service to be provided (from a holistic perspective, within a user-centred application) by an agent-oriented interface in uncertain and changing environments. To ensure the qualitative validation soundness, the application field chosen is "Visual pattern recognition".*

Besides the prudence entailed by the lack of confidence in the easy accessible APIs [146] (commented upon in 1.3.2) the main selection criteria were: a) any service quality assessment in continuing education is still rather moot; b) there are several widespread benchmark programs for convincing comparisons; c) both holistic approach and "Just-in-Time" response are quintessential; d) it opens a valuable gateway towards validating the fifth objective too.

5. *Exploring the paradigmatic shift towards building Computer Science rather on semiotics than on mathematics.*

The first results achieved in approaching BR transdisciplinary, allow trying to recycle – at least partially – the unfinished research in Computer-Aided Semiosis as well as the various attempts to devise facets of bodiless agents. However, the high engineering research risk involved, confines the enquiry to the aspects able to be reflected in the experimental model.

2.2.2. Start Vector. (Premises and Working Assumptions)

Neither premises nor working assumptions are negotiable (details in 2.4.1). This thesis is based on six premises (*Pr*) and six (ad hoc) working[1] assumptions (*Wa*):

Pr1: In post-industrial (service-oriented) engineering failure is ruled out for vital services (because some of them are "vital" in the very sense of the word) [65].

Pr2: Post-industrial (service-oriented) nontrivial applications are intended for intense interaction in open, heterogeneous, dynamic and uncertain environments (OHDUE).

Pr3: All established results of GST and its related sciences (mainly cybernetics and synergetics), as mentioned in Chapter 5, are accepted as premise.

Pr4: Both *decision making* and *learning* are cognition-based, nondeterministic, *processes* that operate in dynamic and uncertain environments; hence, they cannot be modelled *deterministically* and cannot be described adequately by *algorithms*.

Pr5: Agents are *processes* devised as *interactants* not *objects* devised as tools [59], [35].

---

[11] Here, "working" has the same pragmatic connotation as in the syntagm "working definition" [8].

Pr6: Precision is costly [87].

Wa1: The very concept of bounded rationality involves suboptimality in nontrivial applications [13].

Wa2: In line with *Pr1*, decision-making support applications based on conventional algorithmic software are either *unaffordable* (with scarce resources) or *ineffective* (as regards end-user expectations) [64].

Wa3: Analog input is *natural* (the human mind is visually oriented), *general* (for any usual linguistic variable), *effective* (fast, robust, ergonomic) and very *easy to implement* [16].

Wa4: Cognition is (regarded as) holistic and boundedly rational.

Wa5: Precision is useless [35], [64]. To pay tribute to Zadeh's work [64] this assumption is called "*Rationale 3*".

Wa6: Precision could be harmful when decision is urgent ("Just-in-Time" decision making) [35], [64]. For the same reason, this assumption is called "*Rationale 4*".

2.2.3. Road Map Based on Idoneity. (Criteria)

In exploratory research – above all in CSITAO – listing a set of clear-cut criteria is neither necessary, nor sufficient. However, it is mandatory to set up also a second road map: a "Plan B", based on agent-oriented software engineering (AOSE) tenets. Indeed, since CSIT remains a branch of engineering and since exploratory research in AO is more risky than in other areas, every CSITAO PhD work should have a standby solution (see also *Pr1*). Some examples for this thesis:

- *No Tabula Rasa*. Beginning from scratch is avoided by reshaping previous work (favoured by the free choice of thesis topics).

- It seems rather obvious that – without daring to assert "the end of reductionism" – cognition can be studied only macroscopically, i.e., holistic, within cybernetic intentional systems (5.2). Though, since it is not CSITAO this claim stems from[2], it cannot be regarded here just as working *hypothesis*, not as *assumption*.) Anyhow, on this groundwork it can be argued that: a) a service must be evaluated *in corpore*, by the end user in a subjective manner and against some tacit – even changing – expectations. That implies at least two key approach features: *successive prototyping* and *qualitative validation* (see 2.4).

- Of course, *static* knowledge should be replaced by *dynamic* knowledge. However, how can *tacit* knowledge be *voiced* in (temporally distant) e-teaching?

- What means "unaffordable (with scarce resources)"? A less fuzzy formulation than that in *Wa2* could be: "affordable for a medium-sized East European university in difficult times" or "in the near future".

In short, flexibility means withdrawing in idoneic manner from the first to the second road map. This thesis was forced to do it in the experimental model: the mechanisms (6.2,

---

[2] Even its origins are debatable: cognitive science, cognitive psychology, GST, Eastern tradition, philosophy?

6.3) were *conceived* for "Plan A" (continuing education) but *developed* for "Plan B" (visual pattern recognition, 8.1.1-8.1.3).

2.3. EXPLAINING THE TITLE

On the groundwork of the apodictic 2.1 and the revisable 2.2, the four syntagms in the title can be explained - and their subliminal messages suggested.

2.3.1. Bounded Rationality

The term "*Bounded Rationality*" is used as defined, explained and endorsed in [155], [156], [157], [153], [128], [129], [127]). In real-world applications, it is illusory to hope for well-defined (if possible, monocriterial) problems, complete information, accurate data, acceptable time restrictions, low risk, conventional business, etc. and for being able to give optimal solutions through scores of exact data (if possible, output offline and sequentially). On the contrary, most problems are multicriterial, online, and distributed, supplied with incomplete, fuzzy, and/or uncertain information – arriving in parallel, in huge amounts and in unpredictable moments –, in the context of critical response time, high risk, virtual enterprises, etc. Thus, the challenge is to *manage situations*, since there is no time to *solve* (accurately) *problems*. The solution must arrive "Just-in-Time" and be acceptable suboptimal" [13].

2.3.2. Agent Orientation

The term "*Agent-Orientation*" is used as defined and explained in detail in [93] and endorsed by the definition of "agent" in a FIPA standard [126]. In the context of BR, anthropocentric systems, *Pr5* and *Wa4*, much more relevant than individual (weak or strong) agent features are: a) the agent metaphor (making decision in behalf of humans, agents are non-deterministic *par excellence*); b) affordability implies bodiless interface agents for any kind of services as well as toy problems; c) despite its relative simplicity, an interface agents must be modelled as *process* and implemented as *thread* (i.e., as atomic, sequential, a-synchronous, and dynamic entity); d) for this thesis the interface agents for the experimental model could not be reliable if programmed neither in mark-up languages, nor with existing APIs. Thus, "the unpleasant implication" (1.3.2) of acting somehow as its own interface agent will be the less bad solution for this thesis. That is the minor significance of "agent-orientation". Though, the major meaning in the title is: in the effort to assimilate a paradigmatic shift it is often necessary to dare to assert– not only in a PhD thesis – that *architecture* always prevails over *structure*. Thus, since the thesis architectonic is clearly agent-oriented, albeit no piece of code is labelled as agent, the syntagm should be in the title.

2.3.3. "Just-In-Time"

From the two-echelon perspective of the thesis its role in the title is: a) for this thesis it is agent-oriented mechanism (3.4.2);b) for the thesis as keystone of the EU2020 research cluster, it is paramount because, as response time (3.4.1), it states the feature of nonde-

terministic dialog, basic for the shift from *product* to *service*. For this very shift, from a slightly different perspective, "Just-In-Time" has also a new third role: c) it is regarded as main current connotation of "real time" (3.4.3).The new role is crucial for the thesis setting due to three reasons regarding learning based on bounded rationality because:

-it is inherently associated with the role as response time, vital in any teacher-learner interaction (not only in "socratic duologue", 7.1.3);

-it is illustrated in the implementation of the two non-algorithmic mechanisms (6.2, 6.3) as well as in their integration into the experimental model (8.4.1, 8.4.2).

-it concerns not just this thesis but the whole research cluster related to EU2020 where it achieves another vital – albeit paradoxical – connotation: continuing education involves a "JIT synchronization" between e-teacher and e-learner [26].

2.3.4. Visual Pattern Recognition

It was always in the title but changed its *raison d'être* each year. Abridging its history is telling for illustrating that: a) despite being *terra incognita* exploratory research needs very flexible intellectual road maps; b) paradigm changes are sometimes mentally painful:

- *2009*. It appeared as a compromise between the fear of lacking a credible experimental model for daring new ideas (author's stance) and the chance to prove holistic cognition avoiding the programming difficulties involved by the temporal dimension of interface agents for service-oriented applications (advisor's stance).

- *2010*. The EU2020 theses cluster offered the challenging test-bench domain of continuing education but no chance whatsoever to prove the engineering soundness of an experimental model. Taking advantage of previous LBUS incremental research in this area [143] it seemed worth to pay the price of lessening the link between the target application domain and a recently investigated domain full of verified algorithmic benchmarks.

- *2011*. The successful – and as unexpected as serendipity entails – development of two mechanisms, proved to be easy to implement after having the courage (or very odd idea?) to simulate the nondeterministic behaviour of a complex interface agent by the decisional (macroscopic[3]) free will of its owner (6.1, 8.2, 8.3). Thus, the toy problem domain was not necessary anymore but is still useful for its engineering relevance. Moreover, improving image transmission becomes obsolete (8.4.1); hence, related benchmarks too.

2.4. APPROACH

After setting up the approach framework (2.4.1), the three fundamental approach dimensions are scrutinised: *anthropocentrism* (2.4.2) is required by any service-oriented project, *transdisciplinarity* (2.4.3) is required by any (meta)model of continuing education while *microcontinuity* (2.4.4) is *sine qua non* for any experimental model.

---

[3] To avoid fruitless philosophic arguments, the term is used as shorthand for the generally acceptable syntagm: "macroscopically perceptible".

2.4.1. Applying the Start Vector. Adapting the Criteria

The approach is based on the nonnegotiable *start vector* (2.2.2) and on the adaptable *criteria* (2.2.3). All fight conformity, i.e., express intellectual adherence to the service-society paradigms but the criteria admit implicitly that a variable time is needed to assimilate them in behaviour. Thus, the adapted approach criteria are the following:

- *Bounded rationality versus "Just-in-Time"*. "*Just-in-Time*" is required to respect reasonable time limits while *bounded rationality* is the most affordable means to meet the theses deadlines within rational limits of accepted risks. (In fact, they are both "fortunate limitations" and so interlinked in human reasoning that they could be stated vice versa too: "Just in rationality" and "Bounded time".

- *No object-orientation.* Any approach to develop "object-oriented agents" is not just irrelevant but confusing and counterproductive.

- *What Dennett stances are suitable* [93], [96] (details in 4.2)? A black-box approach is required by the emphasis on *ergonomicity*, emblematic for any engineering endeavour ("easy to understand, easy to use"). On the other hand, a key feature of engineering is its *process* nature (that holds from management to development, to the very object of work). Thus, agents are more suitable, being the only software type explicitly conceived as *processes* (though, they are not mandatory)" [65]". Of course, when agents are complex (2.4.2), the intentional stance is most appropriate (when the environment is chaoplex, such a stance is mandatory *because* of BR!).

- *Simulating the e-maieut.* The target of [5] was "to introduce the concept of *eMaieutics* [...] and to illustrate it in experimental models, where *maieutics* is action-oriented (i.e., promoting rather dynamic than static knowledge) and highly personalised, while "*e-*" is carried out through virtual entities interacting with the learner as interface agents" [5]. "According to this definition, *maieutics* is not affected by replacing the virtual entity by a living one.

2.4.2. Anthropocentrism

As a constant concern of CSITAO research it was promoted by LBUS as key word of EU scientific cooperation in 2005. Its significance was recently emphasised again in [7].

For the EU2020 cluster anthropocentric approach is the backbone of any credible application. If teaching is not a human-centred service, what is it all about? (Indeed, narrow-minded expressions intended for robots like "machine-learning" or "learning algorithms" sound unacceptably outworn in continuing education. More details in [26].)

There are three facets of anthropocentrism that revolutionise IT application development. Each of them could be sufficient as *raison d'être* for this thesis:

- *Holistic approach.* If some undemanding and very predictable services could be canned – and handed over to machines or primitive robots – no service whatsoever could be assessed (or not even adequately provided) if conceived as decomposable, i.e., reduced artificially to "components".

- *Architecture vs. Structure.* Almost as corollary of the above, architectonic aspects are far more pertinent than structural details.

- *Agent-orientation*. Corollary of anthropocentric development: "unable to manage the system complexity involved by current IT applications, humans must transfer most of this complexity to the system" [10] (elaborated upon in 5.2.2, 6.1.2).

In short, CSIT becomes CSITAO to signal the need to regain in the *post-industrial* era the *control over technology* (almost) *lost by humans* in the *industrial* era.

2.4.3. Transdisciplinarity

Although being found frequently in exploratory research, a transdisciplinary perspective is not mandatory as such. The need for transdisciplinarity was increased – at least in the case of this kind of research – through the inability of IT people (CSITAO researchers included) to convince social scientists that they need each other. Indeed, the failures were caused mainly by the inexorable dilettantism entailed by monodisciplinary (IT) approaches to real-world problems.

Hence, for a CSITAO PhD research *anthropocentrism* (here seen more than just an *approach*, namely seen as *target*) and *transdisciplinarity* (as *means* to achieve it) are *sine qua non* requirements entailed by the very nature of services. The prefix "trans" insinuates – if not an opposition to "cross", "multi" etc. – that modern complex service providers have to cooperate seamlessly. (That holds even more for agent developers. Hence, both the transdisciplinary orientation of the third chapter and the fifth chapter as major extension of the thesis scope were necessary.)

2.4.4. Microcontinuity. Successive Prototyping

A CSITAO application should be "designed iterating a design-implementation-evaluation cycle, saving re-implementation time since the first design is based on empirical knowledge of user behaviour. Anyhow, the design of truly anthropocentric systems has to be carried out by interdisciplinary teams" [96]. For instance to communicate successfully "agents should manifest stepwise human-like behaviour. Here micro-continuity can help since not the *anthropomorphic feature* itself has to be replicated, but its *appearance*" [10]. If a complex agent-based interface is not fitting, at least multimodal communication should be provided.

To conclude, there are two hallmarks of the approach shift: a) intense focus on transdisciplinarity; b) more daring communication modalities in the experimental model.

THIRD CHAPTER

Bounded Rationality in Humans and Agents. State of the Art

If you cannot get answers keep putting questions

After adapting the *"State of the Art" guidelines* [14] to this thesis (3.1) and enhancing the investigation about *transdisciplinary bridges* (3.2) the scrutiny is focused on the *basic concept* (3.3) and on the *basic paradigm* (3.4) respectively.

3.1. ADAPTING THE "STATE OF THE ART"

"*Adapting*" has here two meanings: a) the *synchronic* connotation refers to *fine-tuning the guidelines* in line with the thesis targets (3.1.1); b) the *diachronic* connotation refers to updating the first technical report (first version: November 2010) and integrating it seamlessly into the thesis. That means refreshing both *sieve* (3.1.2) and *magnifier* (3.1.3). All the quotations are from [14]. (In parentheses are the immediate consequences upon this thesis.)

3.1.1. Fine-Tuning the Guidelines

Beside the three familiar roles – found in almost all theses – the "State of the Art" report has here two new roles: the fourth is related to the latest condition of Computer Science whereas the fifth is a kind of self-experiment motivated by the research objectives of this thesis as well as by the need to be integrated in the EU2020 research cluster.

3.1.2. The Sieve. Thesis Non-Objectives

"To separate the wheat from the chaff, it is vital to assert what the thesis is not about" [14].

   - *Incremental research*. That is the paramount restraint since the fourth objective "may lure to exaggerated circumspection in approaching" the targets. (Here the novelty of the thesis objectives makes this risk negligible.)

   - *Industrial society*. "Nothing should refer to a product-based society or to whatever of its Zeitgeist components. The research is rooted in and dedicated to the post-industrial (service-based) society. (Any reference to conceive of agents as something else than service-providers is avoided as going against the trends in CSIT.)" [14] (It results unmistakable from the objectives.)

   - *Conventional CSIT paradigms*. "It is a cardinal restraint since in Europe – and in Romania even more – the agent is still considered to be rather a program than a process". [14]. (Idem. Moreover, it is a leitmotif of the thesis architectonic.)

   - *Pattern recognition*. As explained in detail in 2.3.4 this most natural field where BR reveals itself, was chosen as test field because there are several widespread benchmark programs enabling indisputable validation of the research results. Thus, this subfield is re-

garded to be outside the thesis scope. Only some prevailing algorithms and their corresponding benchmarks are referred to.

- *Computer vision.* From the thesis perspective it is considered just a popular means to attain artificial pattern recognition. (Idem. Even more.)

- *Principles of subfields the thesis is strongly related to.* Despite its osmotic interference with other fields (e.g., cognitive science, psychology, biology, epistemology, logic, GST) the thesis is *trans* – not *multi*-disciplinary. Elements of other disciplines are not purposely looked for since CSIT is just a means to illustrate them. However, being unable to start a genuine cooperation with social scientists [62], [61], this restraint was not obeyed to the fullest extent, entailing the major risk of dilettantism.

3.1.3. The Magnifier. Keeping Roots in the Real-World

For CSITAO the magnifier is essential for keeping roots in real-world situations and should be employed – this time successively – for fine-tuning the research from the perspective of the following key elements (the order is relevant but not mandatory): *Locality in time (Moore's Law)* and *Locality in space (ODUE)*.

3.2. TRANSDISCIPLINARY BRIDGES

Applying self-recursion to a kind of higher-order metaphor it could be speculated that such bridges are meant to simulate the accessibility relations between two possible Kripke worlds: "Despite the fact that the e-World is already "real" and the real world becomes increasingly "electronic", the conceptual gap between them is yet vast. To shrink it, we need trans-disciplinary approaches, able to integrate biased perspectives. The starting point is an analysis of the basic concepts (including main myths and metaphors)" [98]. Today they are seen as *memes* (3.2.1). Of course, the chapter core is 3.2.2, linking *cognition mechanisms* to BR. On this groundwork, two essential facets of "BR in action" can be investigated: *Semiotics* in 3.2.3 and *Memetics* in 3.2.4 as distinct bridges, namely from primarily architectural perspectives. (Finally, the bridges will be united in 5.4 to boost *transdisciplinary synergy*.)

3.2.1. From Myths, Through Metaphors to Memes

Metaphors are semantic transferences between two domains ([137] quoted in [98]. In short [8], metaphors are deeply rooted in myths (psychologists are aware about the mytho-magical thought tendency in the right brain hemisphere); mainly in IT, myths are valuable sources of metaphors (for instance, "avatar" could be considered an effective catachrestic metaphor). "Caveat: when myths become prejudices they impair paradigm shifts (e.g., Mayan Calendar: end of time at December 21, 2012 = end of world)" [8].

3.2.2. Cognitive Psychology, the Protecting Pillar

To catch the trend, the nuanced evolution of Thagard's perspective (from 2005 to 2010) – having the weight of a *Stanford Encyclopedia of Philosophy* – is highlighted below.

3.2.2.1. Cognition. Where Does It Stems From?

In nuce, if the "intentio lectoris" construal of Thagard's position is correct, it could be inferred also from the titles of his determining works on this topic, beginning with "*Mind: Introduction to Cognitive Science*" (this was the main source of both information about and critique of cognitive science that governed the research perspective in the prehistory of CSITAO, since its publishing in 2005, through its reflection in *The Stanford Encyclopedia of Philosophy*); "*Philosophy of Psychology and Cognitive Science*" (2007), "*Why cognitive science needs philosophy and vice versa*" (2009)*;* "*The Brain and the Meaning of Life*" (2010) [83] (this has for the EU2020 cluster the role played in the past by the 2005 work).

RB		**LB**

Corpus callosus: communication channel

Holism	**Reductionism**
Emergence, chaoplexity, intentional stance, excitation, parallelism, creativity, positive feedback	**Additivity, hierarchy, functional stance, inhibition, sequentiality, stability, negative feedback**
- *Information the verb*: dynamic knowledge, uncertainty, reactivity, AI logics, revisable inference (induction), multithreading, *agent*-orientation.	**- *Information the noun*: static knowledge, determinism, planning, bivalent logic, monotonic inference (deduction), algorithms, *object*-orientation.**
- *Bodiless agent* (time-perception-based).	**- *Robot* (proprioception-based)**

Figure 3.1. Boundedly rational and reductionist image about holism.

3.2.2.2. Holism vs. Reductionism in CSIT

The ironical caption of Figure 3.1 shows that the holistic approach was yet hardly able to go beyond a half of a brain. Definitely, it is not enough! The oversimplification is – at least partially – caused by the reductionist approach still prevalent in cognitive science: cogni-

tion can be modelled only computationally and computational approach is confined to the left-brain (LB). What about the right-brain (RB)?

Figure 3.1 is inspired from earlier CSITAO research (mainly [35], [12], [8]), represents now the stance of thesis EU2020 research – and implicitly the approach framework for this thesis. Thus, many concepts it refers to will be elaborated upon in the next chapters.

Somehow as corollary, we feel that our way of thinking – no matter of cognitive psychology – is a stable pillar and protects us against the terrifying speed of environment changes – first of all those made by humans. Now it is possible to express a transdisciplinary research proposing BR as "cognitive engine", using scientific terminology (Chapter 5).

3.2.3. Semiotics, From ⌐UNES to Emoticons in Communication

Semiotics entered CSITAO research through several ways because a service-based society requires at the same time, parallelism, temporal dimension and intense communication between service provider and user. Previous work is abridged in 3.2.3.1 and a constant concern of CSITAO – outside the strict scope of this thesis – in 3.2.3.2.

3.2.3.1. Computing with Words, Sounds, or Gestures

"Most mathematicians – and some computer scientists too – overlook the major paradigm shift in IT: from "client-server" to "computing as interaction" in open, dynamic, and uncertain environments. This shift is due mainly to Moore's law and to its consequences: Internet, broadband technology, agent technology, Google, and so on [35] [...]. As a result: a) cardinal concepts (approximation, uncertainty, granularity, etc.) are either ignored or misunderstood; b) the requirement that IT solutions must come "Just-in-Time" (JIT), implying bounded rationality (BR) as fact of life is disregarded. Regrettably, the "Weltanschauung"-gap is widening both horizontally ("humanists" and "technologists" become less transdisciplinary) and vertically ("Kelvin-number-oriented" and "Zadeh-word-oriented" computer scientists are pushing artificial intelligence in opposite courses of action)" [8]. In the prehistory of this thesis, some reusable results were achieved in the following agent-oriented domains (unfortunately, the related PhD theses were abandoned):

- *Computer-Aided Semiosis* (CAS). In [15] "an affordable manner to "invent new Computer-Aided *x*" application domains is proposed. To substantiate the approach, the domain must be immediately useful, challenging, easy to implement and "as humanist as possible": Computer-Aided Semiosis. [...T]he message receiver understands the meaning of the message through the process of semiosis, i.e., thus the receiver "fills the message with significance" [112]; hence it is vital for any communication and is strongly dependent on the cultures involved" [111]. Likewise, "the new kind of "less data-oriented computing" (Zadeh's "computing with words") can be extrapolated to "computing with gestures" [15].

3.2.3.2. Nonverbal communication

The research legacy of primeval nontextual communication abridged above is put into effect in the thesis and reflected in the experimental model based on the guidelines shown in Figure 3.2 (inspired from [8] where semiotics was for the first time referred to as foundation for devising bodiless agents with Husserlian time).
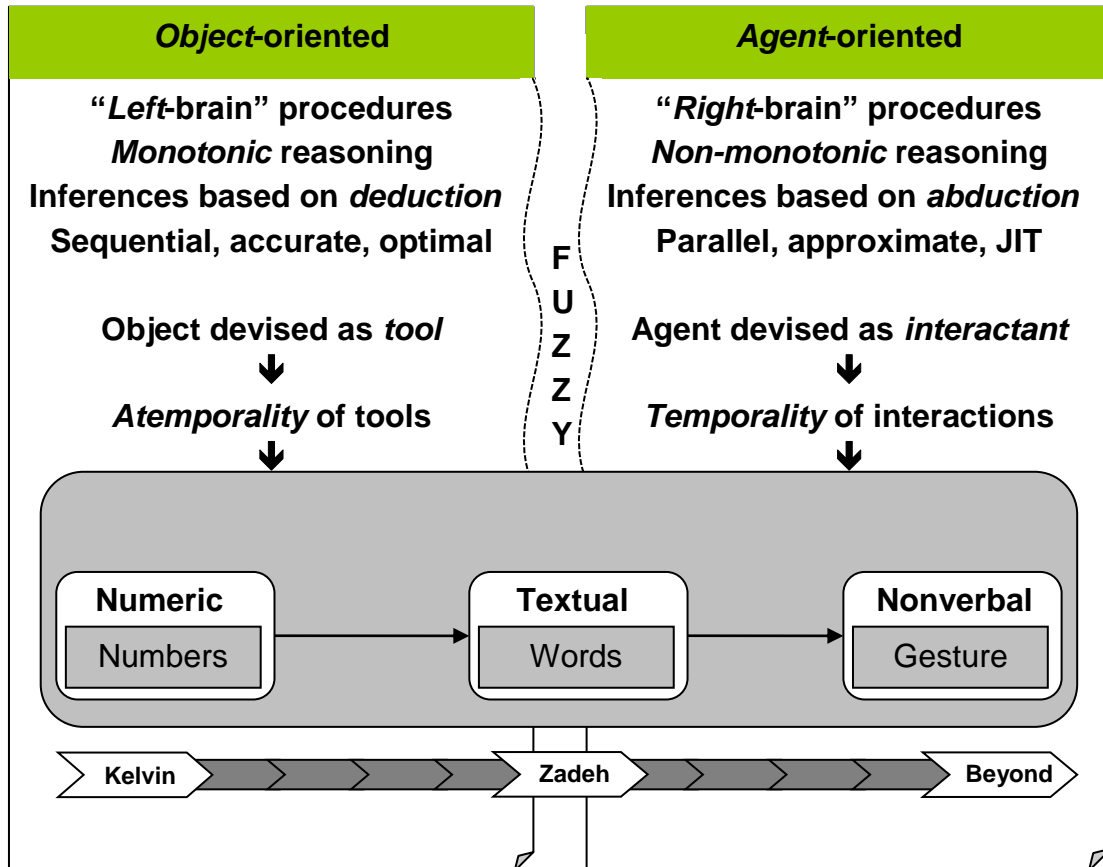
Figure 3.2. Multiple paradigmatic shift in the theoretical foundation of semiotic-based bodiless agents.

As regards the strange title of 3.2.3, it hides some subliminal messages:

a) Semiotics has a tremendous preterminologic history (when hardcopies were yet carved in stones).

b) Semiotics has also a tremendous comeback (when hardcopies tend to become useless).

c) The portmanteau word "emoticon" is telling: the very blend shows that conventional text was unable to convey anthropocentric messages (icons are much simpler and stronger even for primeval emotions).

d) The runes were chosen as starting point for the semiotic journey – albeit their "second century newness" in comparison to much older writings – because they were (and to some extent still are) much more then letters or even instances of skaldic poetry: runes were transcribed metaphorically as "kenningar" [102] (a very rich concept, from the Old Norse verb kenna "know, recognise; perceive, feel; show; teach; etc."

[.wikipedia.org/wiki/Kenning#Etymology], creating an educational riddle – perhaps one of the first European applications of BR in continuing education. Thus, the rune ᚱ ("Reid", "ride") was the answer of a riddle contrasting the rider's luck to the horse's effort. Moreover, some runes got memetic character – unfortunately the rune "Sol" written twice conveyed a very toxic memeplex.

3.2.4. Memetics. An Engineering Perspective

Including memetics here among transdisciplinary targets is arguable because: a) it is yet in a syncretic stage; b) memetic engineering – its technological arm – all the more; c) neither BR nor "Just-in-Time" need to go further than metaphors; d) perhaps not even reorienting CSIT towards semiotics should need it. Nevertheless, there are at least three reasons – corresponding to three levels – to consider it in this thesis (the intermediate "EU2020 level" is dealt with in [26]): Scientific Status (CSITAO Level), Memetic Engineering as Antidote to Vicious Memes (Thesis Level)

3.3. *BASIC CONCEPT*: BOUNDED RATIONALITY IN SERVICE-ORIENTED SYSTEMS

Starting from the (implicit) keywords the first search expression was "Bounded Rationality" + Agents + Complexity + Optimization". However, because relevance depends not just on quantity but on diversity too, the restriction was relaxed to "Bounded Rationality" + Agents + Optimization", giving over 86,000 results – any scope extension being irrelevant. Passing from the sieve to the magnifier, the focus was on authors of seminal papers (beside Simon, for instance Gigerenzer, Selten, Sugimori), newness (except sources of ideas, from 2007) and impact (e.g., more than hundred citations). As a result, *bounded rationality instead of optimization* (3.3.1) deals with the concepts themselves. Only optimization is ignored because of "Instead"; its connotations are the ordinary ones as set up by its very etymology, definitions (in mathematics or operational research) and its use (first of all in IT). Then, *bounded rationality* is explored as *necessary condition* (3.3.2), i.e., as confining anthropocentric research effectiveness to acceptable *cognitive complexity* (vital for continuing education strategies involved in the EU2020 program). At the end *bounded rationality* is explored as *sufficient condition* (3.3.3), i.e., as efficient mechanism to reduce *structural complexity* in the experimental model.

3.4. *BASIC PARADIGM*: "JUST-IN-TIME" SERVICE OR FAILED SERVICE

The first search expression was "Bounded Rationality" + "Just-In-Time", giving over 10,000 results. Since concept evolution was not a target anymore, the search could be focused successively on Google Scholar (since 2007) with 360 results. Since five results were from LBUS, to avoid the risk of "endogamic closure", the scope was not narrowed further. Thus, "Just-In-Time" is explored as *response time* (3.4.1), as *agent-oriented mechanism* (3.4.2), i.e., as key mechanism to simplify the experimental model, and as *post-industrial variant of "real time"* (3.4.3).

3.4.1. "Just-In-Time" As Response Time

Ironically, the concept of "Just-in-Time" was born under a constellation of paradoxes, most of them seeming to be suicidal for the very concept.

From the two-echelon perspective mentioned in 2.3.3, the eleven paradoxes will be put in two (fuzzy confined) groups: the first is related to the general *shift from product to service* (2.3.3), and the second is focused on the evolution of the concept not only in relation to bounded rationality but focused on the strange *requirements of continuing education*. Thus, the order is a partial one in each group and shifting from the first to the second is a continuous move rather than an abrupt conversion:

a) Sugimori and the other inventors of the "kanban system" [158] intended to optimize the Toyota production system, while JIT was the seed of accepting that optimization is obsolete in real-world problems.

b) JIT production as "inventory-management strategy developed by the American automotive industry" realised that stating the problem in line with its original idea ("According to Ohno, inventory is waste that costs the company money" [50]) monocriterial optimization problem would be absurd. Indeed, at "Toyota's production of over 15,000 cars a day" [71], a nil inventory was unthinkable.

c) It was defined as multicriterial optimization problem: JIT is about "providing the right material, in the right amount, at the right time, and in the right place" [50]. "On-time delivery is also a great source of reputation for quality and benefits from parallel movements such as Just-In-Time and so on. [...] On account of their much vaunted just-in-time inventory system, the company maintained only three days of stock, while a new factory would take six months to build" [71]. Only soon after it became obvious that any attempt to avoid bounded rationality – sticking to optimization as business mechanism – is prone to fail.

d) Moreover, the "kanban system" was dedicated to the epitome of the industrial era – the car industry – spawning even the term "Toyotism" [109] to replace the ancient "Fordism" – but was the kernel of the post-industrial era. In fact, JIT was service oriented from its very beginning as "information tag" letting know that a new product can be produced (JIT). The evidence is given by the etymology of the Japanese word "kanban": "Kanban is a visual signal that's used to trigger an action. Roughly translated, it means "card you can see" [http://whatis.techtarget.com/definition/kanban.html].

e) Much more wide-ranging, even as Zeitgeist component JIT is somehow self-contradictory. For instance, Virilio's "logic of speed" (that shapes his dromology), is powerfully expressed nowadays through broad-band technology *because* of the context created by Moore's law. However, the three day Toyota inventory represented a rather *festina lente* strategy, *because* it is multicriterial and boundedly rational. [7]

f) The next paradox is very telling since it has also linguistic roots: a "Just-in-Time service" sounds more and more pleonastic. Bizarrely enough, it replaces another anachronic expression: "Real time programming". The subliminal message is twofold: time is inexorably linked to the nature of (nontrivial) services; software should be based on processes not on programs (at least to be able to implement agent reactivity – no service

provider could survive without reacting "Just-in-Time" to client requirements in ODUE [89], [142], [165]).

g) Despite the obvious fact that JIT delivery is decisive for any quality assessment of service providing, the value of a service is still elusive and highly subjective. Hence, a service-oriented approach to quality management is both unavoidable and challenging [68].

h) What is more, the field of learning – where "Just-in-Time" service is a *sine qua non* constraint – is a highly relevant example of how challenging could be any attempt to define this concept. Even more, when continuing education enters the arena, *teaching* and *learning* become mixed in a postmodern phenomenologic autopoietic adventure that impairs severely any objective assessment. [69].

i) The paradox is aggravated in engineering education where the switch from *static* to *dynamic knowledge* (i.e., to *skills*) is both urgent and hard to outline [66].

j) Focusing on CSIT, a new time-related paradox emerges: atemporal, conventional mathematics-based education becomes unbearable – simply because atemporal services are out of the question in real-world settings. "More *Time* Is Needed" [67] in both hypostases as resource (preemptive in structure, non-preemptive in architecture).

k) Finally, the apex of all aporetic situations comes out in lifelong learning: the temporal hiatus between (present) e-teacher and (future) e-learner. [64], [5].

In short, if a State-of-the-Art section can be presented as a sequence of eleven paradoxes, this very fact is a relevant "kanban substantiation" that a major paradigm shift is needed "Just-in-Time" – here JIT is almost synonymous with "badly".

3.4.2. "Just-In-Time" As Agent-Oriented Mechanism

Here the magnifier is again implementation-oriented exploring JIT as lever to exploit BR in mechanisms (6.2, 6.3).

A most specific context for JIT is in [51]: "serendipity in robbery target selection". "Conventional wisdom also holds that 'bounded rationality' is especially problematic in high-velocity, uncertain environments imbued with desperation (such as street culture)" [51].

3.4.3. "Just-In-Time" As Post-Industrial Variant of "Real Time"

Here the magnifier is teaching-oriented, i.e., "Just-in-Time" being seen as cardinal architectonic feature. From a slightly different perspective "Just-In-Time" is seen as main current connotation of "real time", reflecting the shift from product to service, crucial for the thesis setting (2.3.3, 3.4.1). Thus, research regarding learning based on BR is investigated too because of some very down-to-earth consequences – for the whole research cluster related to EU2020 – of the paradox constellation revealed below: a) it cannot be dissociated from "Just-In-Time" as response time; b) it could be considered only after the implementation of the experimental model; c) it concerns not just this thesis but equally also other two EU2020 theses (3.1.1) where it achieves another vital – and still paradoxical – connotation: continuing education involves a "JIT synchronization" between (*present*) e-*teacher* and (*future*) e-*learner*.

3.5. EXPERIMENTAL MODEL DOMAIN

The implicit search keywords for this section, "bounded rationality" + "visual pattern recognition", revealed 13.000 results, containing rather coincidental occurrences than significant information. (Hence, the architectonic novelty of the experimental model domain is clearly determined.)Thus, the few valid information applicable after filtering refer to *compression* and *benchmarks* (3.5.1). However, to add a "RB-touch" to a very compressed "LB story" the chapter ends with some old news about *Lena as "Information Age Madonna"* (3.5.2).

3.5.1. Compression and Benchmarks

By narrowing the search to "just in time" "tailored transmission" the result was the expected one: until now "image transmission" and JIT had no conceptual relationship.

In the field of visual information, transmission and storage are closely tied together, because of the need for compression. The purpose of image compression is to represent images with less data in order to save storage costs (in the XX-th century) or transmission time (always) [http://en.wikipedia.org/wiki/Image_compression]. Relevant technical updates are in [145], [86], [84]. Roughly, these techniques are split into *lossless* or *lossy* versions. Both – even if lossy compression is usually based on techniques for removing details that humans typically don't notice – still transfers the image as a whole, unaware of *semantic content* or *user-tailored* "JIT" transmission.

In the field of the model, conventional benchmarks are test images widely used in digital image compression/transmission and generally in image processing and computer vision. The most famous one is presented below.

3.5.2. Lena as "Information Age Madonna"

Some of the standard test images that have reached cult status over time are known as Lena, Pepper, Baboon (aka. Mandrill), Barbara, Zelda, Airplane, Photographer, Lighthouse, Boat. These images are still present in recent research and keep on their status of benchmark [86], [84], [55].

Thus, because of the wide popularity of the Lena picture, it is – if not mandatory – at least very wise to choose Lena as benchmark.

FOURTH CHAPTER

The Meteoric Rise of "Bounded Rationality". Its New Role

The logic of reality triumphs over the logic of theory
WELLS "A short history of the world"

The baroque title insinuates a long preterminologic existence as an "incognito voyage" and hence encourages a chronological approach, investigating the evolution of the very concept of BR from hindrance to excuse, to mechanism, to strategy, in line with the holistic approach the EU2020 theses are based on. Thus, "meteoric rise" should not be disambiguated since it suggests – besides an impressive evolution – Haeckel's recapitulation theory (see 7.4.3). Accordingly, the conceptual rise is split into *three eras*: *Pre-Simonian* (4.1, characterized by preterminological syncretism), *Terminological* (4.2, focused on the possibility of proper human decision making) and *Post-Industrial* (4.3, focused on fighting chaoplexity).

4.1. PRE-SIMONIAN ERA. BEST VERSUS SIMPLE

"Don't plan anything in detail" is not an advice from a guru of Economics, but a constituent of a Viking law (i.e., "Be brave and aggressive" [http://www.facebook.com/group.php? gid= 147344168610982]) revealing three facts: a) BR has a long-standing and significant pre-Simonian use; b) it was organically related to another unborn concept: "Just-in-Time" (even for ancient people time was to valuable an asset to be spent on optimizing); c) it was not a purpose for itself, but an ingredient of a holistic endeavour. On the other hand, during its half a century long terminological life (namely, *after* the Simonian description) the concept underwent various transformations, acquiring several new connotations – some basic ones due to psychologists, as illustrated in the "State of the Art" above, including the ambivalence of BR in education and the holistic approach underlined. Therefore, the pre-terminological life of BR shows its intrinsic anthropogenetic/psychological nature, unavoidable because of the vital need to manage situations "Just-in-Time".

4.1.1. Why Is "Best" Antagonistic to "Simple"?

The deep psychological divergence between "best" and "simple" – illustrating the ambivalence of BR – is noticeable in the way the Aesthetic canons were dealt with in the classic period of visual arts: they were both normative (it is simple to obey a given rule, believing that it is "perfect") AND flexible (when the Zeitgeist changed, it became simpler to feel free to be creative, forgetting about cumbersome rules). Though, there are just apparently two opposite meanings of canon. Indeed, the only problem is to find out what is easier in a given moment? Sticking to the "old best" but learning all its details or getting rid of it and inventing a "new best" (positive feedback reacting to changes in the environment)?

Hence "simple" was paramount, whereas "best" became arguable (in 5.2 such incongruities are lessened). The trouble started when mathematics rose from an essential intellectual and pragmatic endeavour based on palatable concepts expressed via common words (e.g., integers or fractions) to a scientific-esoteric religion where words are too simple to express real-world concepts, whereas "best" is disconnected from "good" (hence, "better" is confusing) being defined dogmatically, based on numbers: stiff, atemporal, Manichaean – hence bewildering.

4.1.2. Some Lessons from the Prehistory of Optimization

Quotations from a comprehensive Dido problem history conveys three – subliminal but cardinal messages: a) It is an old mathematical and philosophic memeplex (although the Greeks knew that the solution is a circle, the first rigorous proof was given only in the 19th century, long after seminal work of great mathematicians such as Euclid, Al-Kindi, Leibnitz and Newton). b) It highlights the pervasive propension towards "optimising optimisation". c) Likewise, it suggests another longlasting propension: the Kelvinian obsession with precise measurements as axis for scientific advancement [35], [12], [64] (see also 3.4).

4.1.3. Simple Is Looked For

The archetypal instance of this heuristic rule is Occam's Razor, "*Lex parsimoniae*". Other instances: Dennett's "intentional stance", thumbnail rules, educated guess, toy-problem modelling. (They are not elaborated upon here, because they are used as main tools in [26].)

4.2. TERMINOLOGICAL ERA. IS PROPER DECISION MAKING ACHIEVABLE?

The question defines the era. What is much more, Simon *invented* the era by *defining* the term. Trying an answer, BR is looked for in *decision making* itself (4.2.1) as well as in its target application domain, *behavioural economics* (4.2.2). On this groundwork BR is examined within its relationship to *approximation* (4.2.3), to *uncertainty* (4.2.4) and to *a post-industrial theory of value?* (4.2.5). Though, as shown in 2.3 the thesis' main two conceptual pillars coexisted in this era for decades. Therefore, an investigation about their relationship should be expected as "4.2.6. Bounded Rationality and "Just-in-Time"". From a subjective, "*intentio auctoris*" stance, its unfeasibility explains what this thesis is all about.

4.2.1. Bounded Rationality and Decision Making

"The research program of bounded rationality is built on three premises: (a) humans are cognitively constrained; (b) these constraints impact decision making; and (c) difficult problems reveal the constraints and highlight their significance. Thus, strategies may be optimal in easy domains (e.g., tic-tac-toe) but suboptimal in hard ones (e.g., chess)." [101].

"It is said that Herbert Simon would have described himself as follows: "*I am a mono-*

maniac. What I am a monomaniac about is decision making". [...BR] was a conceptual weapon against the "optimization" school which dominated the decision paradigm. Thus "bounded rationality" was a refutation of all the classic hypotheses of optimal choice: perfect knowledge of alternatives and consequences, perfect preferences between consequences and so on. But if Simon was critical to maximization theories, he persistently understood the concept of rationality through one specific operationalization: an empirically grounded theory of human problem solving. [...] Simon also proposed to build such theory of decision making and problem solving on a « satisficing » principle. This principle introduces subjectivity, "rules of thumb", heuristics or ad hoc moves as basic decision making processes. *For sure, there can be no universal "satisficing" principle or it would appear as a new form of "optimization""* [132].

4.2.2. Bounded Rationality and Behavioural Economics

Unfortunately, in (behavioural) economics BR is still considered just as a hindrance, not as a means to manage situations "Just-in-Time". Thus, Santos [77] talks about "problems caused by incomplete information, bounded rationality and weak willpower".

"From his early papers on administrative behaviour to his last investigations on thought and learning, Simon kept a same goal: to explain complex and mysterious human behaviour by simple and constrained, yet informed decision rules. [...] But beyond this critical aim, Simon attempted to build an empirically grounded theory of human problem solving" [132]. (Since the axis of the EU2020 research is education, the emphasis is on the key role of obtaining results "Just-in-Time" for both participants – teacher and learner – rather than on explaining why decision making – first of all in economic problems – is far from being easy to defend.)

4.2.3. Bounded Rationality and Approximation

Instead of optimization, the main mathematical mechanism able to save time in boundedly rational contexts is *approximation*. From the thesis perspective it was investigated in [13]: "approximation theory has still a major role to play in artificial intelligence but mainly aiming to achieve synergy via blending it with bounded rationality (based on the "Just-in-Time" paradigm), not as instrument for uncertain knowledge processing, because of its atemporality (mainly its incapacity to deal with future events)".

4.2.4. Bounded Rationality and Uncertainty

Here uncertainty is seen as the epistemic facet of nondeterminism [93]: for decision making it doesn't matter whether information is incomplete because the effects of an event are yet ignored or whether the event still not happened (future contingents).

Ignoring the fact that bounded rationality is "a form of behaviour associated with uncertainty where individuals do not examine every possible option open to them" [www.pest-management.co.uk/lib/glossary/glossary_b.shtml], the mathematical tools still recommended for modelling processes taking place in OHDUE (approximation theory included), are ill-applied when they try to deal with uncertainty" [13].

"Human intelligence [...] is modelled by an adaptive toolbox that contains building blocks for heuristics to direct search for information, to stop search, and to make a decision. Smart search rules describe how people find the few relevant pieces of information, in memory or in the outside world. Stopping rules describe a primary function of cognition, to ignore or discard irrelevant information. Decision rules translate the information searched in memory or in the outside world into behaviour, such as what profession to choose or what products to buy. The adaptive toolbox embodies an ecological, not logical, view of rational behaviour. The building blocks can be recombined to form new heuristics, which are rational to the degree that they are adapted to the structure of environments in which they are employed" [152]. (In line with the above, in this thesis, the first – very bounded – agent-oriented software will be considered applying heuristics similar to those used by a tired person when looking for the misplaced eyeglasses.)

4.2.5. Bounded Rationality and a Post-Industrial Theory of Value?

This section was added very late (October 2011) because the quotes that follow show that: a) existing theories of value are deficient; b) the reasons are known and commonly accepted (from increasing complexity and speed of change, to incomplete information and poor modelling); c) despite being written a few years after Kahneman received the Nobel Prize (3.3.1, 4.2.1 [141]), they don't refer to BR (just, "random acts of impulse" may suggest it vaguely); d) post-industrial society or service-oriented economy are not referred to either.

Lacking the very need of a theory of value in line with the new paradigms – in economics, management, IT and so on – substantiates the question mark in the section title.

4.3. THE POST-INDUSTRIAL ERA? FIGHTING CHAOPLEXITY

Why the question mark? Because: a) Post-industrial era is not yet conceptually established. b) Cognitive chaoplexity neither. c). There is a double (biased) perspective: for the EU2020 research the focus should be on the aim, whereas for this thesis the focus is on BR as means. d). Even considering only "conventional complexity" the problem is fuzzily related to the second and third objectives. (Hence, most quotations stem from previous CSITAO research.) Anyhow, as suggested above (4.2.3, 4.2.4) there are two kinds chaoplexity to be fought: *unavoidable* (because of *cognitive* boundaries, 4.3.1) and *avoidable* (via further investigation, 4.3.2).

4.3.1. Unavoidable (Cognitive) Complexity

"Present-day IT environments [...] move fast from limited, homogeneous, changing slowly, deterministic (even if partly approximated or even unknown) towards open, heterogeneous, dynamic, and uncertain environments (OHDUE). That means [...] intrinsically non-deterministic – as most environmental and almost all human stimuli generators. Among the context-related reasons: globalization, modern enterprise paradigms [...], intense (mainly positive) feedback. The main IT-related reason is Moore's law and its most vigorous consequences" [13].

In medical settings "The inability to understand statistical information is not a mental deficiency of doctors or patients but is largely due to the poor presentation of the information [...]. For each confusing representation there is at least one alternative[…]." [127].

4.3.2. Avoidable (Black Box) Complexity

The problem of boosting ergonomics in decision making via BR was dealt with in [16]: Uncertainty as epistemic concept, together with its species and degrees, was investigated starting from the 28 definitions found on the Web. Besides the [...] diversity of those definitions, ranging from "doubt" to "statistically defined discrepancy", the very meaning of uncertainty "depends on the professional background and on the task to carry out ([...] mostly on the time available to complete it)" [16]. To impair redundancy with 1.1.1, in short "*uncertain*" means practically for mathematicians, *unknowable*, for software developers, *undependable*, and for end users (decision-makers), *undecidable*. "In this context could be found a common denominator for a general definition of uncertainty – at least, acceptable to the three categories mentioned above? Uncertainty, in its widest sense, comprises any unsure link in the chain of steps necessary to fulfil a task" [16].

On the other hand, from the 28 definitions "only a few are interesting, since they are anthropocentric, mirroring the common user (mainly decision-maker) stance: a) "doubt" […]; b) "the fundamental inability to make a deterministic prognosis" […]; c) "lack of knowledge of future events"."[17].

Unfortunately, AO mechanisms "have – beside lacking validation *in vivo* (some of them not even *in ovo*) – a double vulnerability: they are either incremental as regards the "Kelvin way of thinking" or too loosely linked to new paradigms. Thus, what is their relevance? To break the vicious circle – since there is no "methodology for paradigm shift" – to leave behind the 3rd Order Ignorance [90], software should be considered "not a product, but rather a medium for the storage of knowledge. […] The other knowledge storage media being, in historical order: DNA, brains, hardware, and books. […] Software development is not a product-producing activity, it is a knowledge-acquiring activity" [90] quoted in [35].

FIFTH CHAPTER

Transdisciplinary Communication Needs a Lingua Franca: *GST*

The limits of my language signify the limits of my world
WITTGENSTEIN "Tractatus Logico-Philosophicus"

As shown in 2.2.1, this chapter is due to the double expansion of the first thesis objective (necessary to replace the conventional conceptual framework unsuitable to articulate the role of BR as *educational mechanism*): a) *Choosing a Lingua Franca* involves a *rationale* – as well as a *method* – of its own (5.1). b) *Expressing bounded rationality in terms of General System Theory* is carried out in three steps: In line with the even stronger emphasis on *holistic approaches* (as regards both BR and continuing education) the *Lingua Franca* is employed to elaborate on the relationship between *cognition* and (cybernetic, automatic, intentional) *systems* (5.2) and subsequently on the key – albeit ambivalent – role of *bounded rationality as feedback* (5.3). Shifting now the transdisciplinary focus from *psychology* to *semiotics*, synergetics – as a branch of General System Theory – is used to defend the fifth thesis objective, suggesting that when CSIT will eventually return to its (analog) sources in *search for synergy* it should head rather to *Lao Tzu* than to *Aristotle* (5.4).

5.1. RATIONALE AND METHOD

It is self-explaining that transdisciplinary research needs a Carnap-like glossary (1.2.2). Of course, it is better when such a "mini-ontology" is contained in an established theory usable as *Lingua Franca*. However, why this language should be *GST* needs a motivation. The reasons are presented according to increasing specificity: the need for *GST as metascience* (5.1.1), followed by the reasons clustered under the relationship between *semantic web and general culture* (5.1.2).

5.1.1. Post-Industrial (Holistic) Approaches Require GST as Metascience

Trying to adapt engineering education (EE) to the needs of a service-oriented society, [65] suggests "a way of easing paradigmatic shifts by instilling into syllabi metascience basics".

On this basis this thesis (and [26] even more) can expand the enquiry to *cognitive psychology* as a whole, formulating the needs of agent-orientation in terms of GST, not of Computer Science. Thus, it impairs parochial interpretations and becomes closer to an expected psychological perspective. Indeed, von Bertalanffy was biologist and was Fechner's student.

5.1.2. Semantic Web and General Culture

Other four reasons can be clustered under this "umbrella-title": *Semantic Web and semiotic endogamy; General culture requires GST*; *A fortiori, CSIT requires GST*; *GST is sine qua non for heutagogic metalearning*.

As regards the method of teaching GST, in line with the heutagogic exercise mentioned, it was direct, focused on the thesis objectives, as illustrated below.

5.2. HOLISTIC COGNITION IN GST TERMINOLOGY

An "acting premise" of the research within the whole EU2020 thesis cluster – shown explicitly or implied by the quotations regarding *cognitive science* and *cognitive psychology* is *Wa4*, now without any *caveat* parenthesis. As a result, here only the relationship between *cognition* and *educational systems* seen as *cybernetic* (5.2.1) and *intentional* (5.2.3) was a matter of interest and hence initially dealt with. However, to be more convincing as regards the paradigmatic shift towards *accepting two kinds of decision making* in a service-oriented society, the key features of *automatic* systems (5.2.2) were added. Likewise, the relationship between BR and the *Dennett Stances* (5.2.4) is worth deeper investigation.

5.2.1. Cybernetic Systems

To keep in line with the requirements of both transdisciplinarity and BR, the two parts of the syntagm "Cybernetic System" will be explained "as simple as possible but not simpler" – to cite Einstein's deference to yet syncretic BR.

Within the EU2020 cluster, the simplest instance of an educational system is represented by the classical pair: a teacher and a learner. (In the seventh chapter they will be prefixed with "*e-*".)

- *Cybernetic*. A system is called "cybernetic" if it is able to tune its input via "feeding back" information from its output. In the case of the simple system (referred to by default in this thesis), that means that *the teacher can tune* its teaching according to a *performance metrics* applied when *examining the learner's results* (4.3).

5.2.2. Automatic Systems

It is neither conceivable nor legitimate to change whatsoever regarding the connotations of any concept, or paradigm, or method applied in Control Engineering. Here it is about *divergent* paradigms. Hence it is (mostly?) about *language*.

It is obvious what "Automatic control" means but when "control" is used separately in its usual – and originary, primary – meaning (in GST terms, related rather to *negative feedback* and to *redundancy* than to initiative or *dominance* or *authority*) communication is impaired. (Indeed, Ctesibius' clepsydra is referred to even nowadays as precursor of Control Engineering although it *measures* time without being able to *control* it!)

Some debatable examples of unclear but important questions: "Does a robot have *initiative* when it is *in control*?" "Does *autonomous behaviour* imply *initiative* or *control*?" "Does it imply *both* or *none* of them?"

This thesis claims that in complex situations, human decision makers need a paradigm shift based on BR *because* they must make decisions "Just-in-Time". Some aspects of this "paradigm-shift-problem" are illustrated in Figure 5.1.
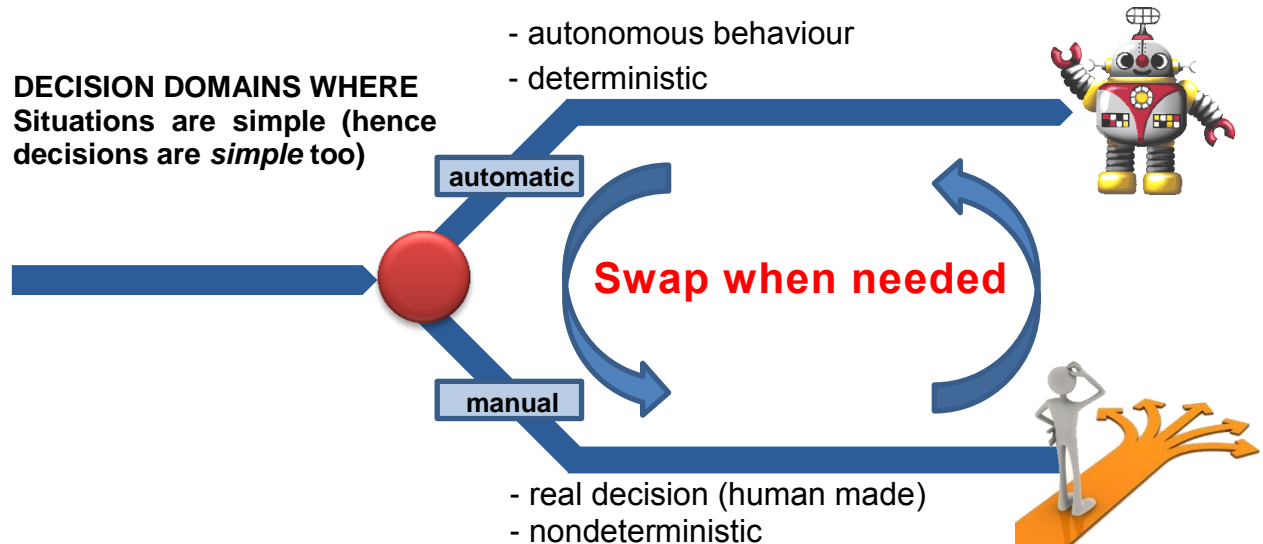
Figure 5.1. From simple to chaoplex … but "Just-in-Time"

As underlined in 2.4.2, a main principle of "anthropocentric design" states that the interface complexity should be the burden of the system, not of the user. As a result: anthropocentric systems "must work more and more in an autonomous way. There are three main sources autonomous behaviour stems from: living beings, automata, and software" [10].

5.2.3. Intentional Systems

As regards *intentionality* simplicity is impossible, since for living entities the feature is trivial, while for (bodiless) agents asserting it gets close to blasphemy.

In short – and somehow oversimplified – intentional systems are the "anthropocentric subset" of the set of systems with autonomous behaviour. (And they should stay so.)

5.2.4. Bounded Rationality and Dennett Stances

Obviously, the *tool is deterministic*, whereas the *person is* – at least, macroscopically – *nondeterministic*. As regards the functional stance, it shows the quintessential link between BR and "Just-in-Time": "Extending Kowalski's phrases from search to uncertainty, approximation, as a "don't care"-like uncertainty, can speed up remarkably data processing in key IT subdomains (e.g., image compressing) but is inherently unsuitable for "don't know"-like uncertainty, even in deterministic contexts (playing chess is a manifest example: certainty about the best move is given up to speed – better said, to inexorable time restrictions)" [64].

For the sake of communication effectiveness in continuing education two (chained) implications are cardinal for e-teaching:

- To be easily understood any nontrivial IT application must be empathized as an "intentional system" by both learner and teacher.

- The language should be "convenient" (in the meaning of Poincaré), namely anthropomorphous (besides Dennett, this is also defended convincingly by McCarthy, Shoham, Anderson; details and references are given in [9]).

TOOL	MACHINE	PERSON
Mechanistic stance	*Functional stance*	*Intentional*
(structure)	(utility)	(empathy)
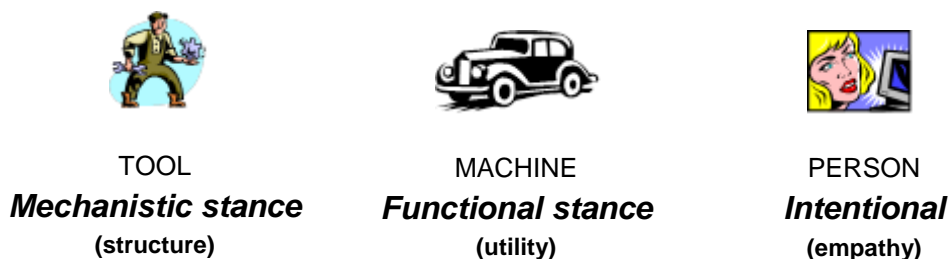
Figure 5.2. The Dennett Stances [93], [96]

5.3. STABILITY VS. CREATIVITY: BOUNDED RATIONALITY AS TWOFOLD FEEDBACK

To become a truly Lingua Franca, any language – no matter how formalized – has to tackle its ambiguities. Here, this means to insert all polysemantic keywords into the Carnap-like glossary [14]. As shown in 1.2.2, the antonym pair "*positive/negative*" is inescapable and deserves a careful explanation of its various connotations in both *natural language* (5.3.1) as well as in *scientific context* (5.3.2). Next, based on clarified concepts, the twofold role of bounded rationality is investigated: *preserving stability* (5.3.3) and *boosting creativity* (5.3.4).

From a CSITAO anthropocentric standpoint, filtered through the EU2020 objectives, and *in nuce*, feedback shows two hypostases: a) universal natural systemic *process* and b) versatile technologic *mechanism*:

- The *process* consists in taking a system's output magnitude, processing it according to some architectural objectives, and feeding it back into the system together with the initial input.

- The *mechanism* consists in the rules allowing to carry out the feedback subsystem in order to achieve the system objectives.

In short, almost always in nature (e.g., homeostasis in living beings) and very often in technology (e.g., reducing noise and message distortion in communication systems) the target looked for is *preservation* (e.g., in living systems to prevent decay), or *stability* (e.g., in artificial systems to prevent deterioration). This basic kind of feedback is called – for obvious historical and physical reasons - *negative feedback*.

For continuing education negative feedback is *sine qua non*, above all for the teaching process because it is *corrective*, and promotes *stationariness*, *stability*, and *reversibility*.

In short, it can be argued that: a) long-term quasi-stability is preserved through BR acting as negative feedback (5.3.3); b) short interludes of creativity can be boosted through BR acting as positive feedback (5.3.4).

5.4. IN SEARCH OF SYNERGY FROM HUMANS TO ANTS. (BACK TO PHILOSOPHY?)

After looking at synergy and analysing *where does it stems from* (5.4.1), its long prehistory and its fuzzy history *from Aristotle to Haken* are regarded through the thesis lenses (5.4.2), bringing to light the prospects offered. Then, reminding the fifth thesis objective, the way towards boosting the role of *semiotics* is suggested by heading at Eastern tradition (5.4.3). On this groundwork, the abstraction is reduced in 4.4.4, abridging from a CSITAO perspective the preliminary work necessary to apply BR in *modelling* in Chapters 6 and 8.

Of course, the target of the EU2020 theses cluster involves mainly Aristotelian connotations for synergy. On the other hand, the PhD domain requires also a rigorous approach to modelling, no matter how human-oriented the domain could be. Thus, despite being anthropocentric *par excellence*, continuing education requires that any credible model – based or not on BR – should consider GST as "brainstorm repository". Corollary: since Synergetics is a well-established science, Haken's principles [131], [130] should be considered too.

Why is Lao Tzu *better* than Aristotle? Because the essence – first of all the (mathematical) logic consequences – of his ideas are much more appropriate to (a Zadehian approach to) manage a service-based society. The problem is dealt with pragmatically in 5.4.4, based on the key disagreement about the possibility to achieve synergy otherwise than exploiting massive, fine-grain parallelism (first source of synergy, 5.4.1): "the Synergy of Complements is an inclusive principle: it does accept opposition, turning it to advantage. Unfortunately one cannot say this of the principle of the Exclusivity of Opposites" [139]. This is the essence of the second mechanism (6.3).

In short, to achieve *inexpensive* synergy, holistic approaches require *symbols* to express and exploit BR via the fertile and abundant ambiguity involved by *semiotics*.

The consequences on CSIT – and first of all on modelling – are paramount: a) any model of an anthropocentric system should be based on symbols; b) a fortiori, any model of an educational system; c) more a fortiori, any model dedicated to continuing education; d) even more a fortiori, any model aiming at synergistic effects; e) most a fortiori, any model involving BR. That involves a dramatic and multifaceted paradigmatic shift.

In short, to achieve synergy, modelling requires innovative (i.e., *nondeterministic*, *non-categorical*, *agent-oriented*) software no matter the (quintessential?) role of sigmoid.

SIXTH CHAPTER

Non-Algorithmic Mechanisms for Word-Based Modelling

*Bounded rationality is best perceived
when facing unbounded irrationality*

Despite its rank, this chapter is chronologically the last, written after failing to suggest a believable interpretation of the relationship between post-industrial decision making and BR. Thus, thoroughly reassessing the results so far, it seemed necessary to restate the start vector (2.2.2, 2.2.3, 2.4.1) focusing now on *post-industrial modelling* outlined from an explicitly decision oriented stance (6.1). Likewise, two innovative mechanisms – albeit in simple and old programming clothes, according to the approach (2.4) – were separated from the experimental model they belong to and reshaped as *non-algorithmic decision support* instruments (6.2, 6.3).

6.1. CONCEPTUAL OUTLINE OF POST-INDUSTRIAL MODELLING

To avoid any ambiguity, the *requirements for DSS* (6.1.1) and *for AO* respectively (6.1.2) are grouped separately despite their architectonic and structural interference. *Resource limitations* (mandatory for modelling in engineering) are examined (6.1.3).

6.1.1. Requirements for Post-Industrial Decision Support Systems

For the sake of transdisciplinarity it seems wise to keep for the time being the term "*decision making*" for humans and "*autonomous behaviour*" for all entities it "stems from: living beings, automata, and software" [10] (5.2.2, Figure 5.1).

According to the start vector (2.2.2) interpreted in the light of the connotations assumed (5.2.2 and above), this thesis asserts:

- All achievements of decision making (including all DSS developed according to [122], [46], [120], [123], [124], [119], [103], [104]) are considered as both necessary and valid in the post-industrial society.

- The challenges of continuing education appear practically also in most (non-trivial) decision-making. However, the paradigm changes implied request reasserting them explicitly here as *premises for post-industrial decision making* (*PrPidsDM*) despite redundancy with the start vector (2.2.2).

- *PrPidsDM1*. In a post-industrial (service-based) society chaoplexity is pervasive (not just *educational*, but *situational* in any dynamic and uncertain environment)

- *PrPidsDM2*. Any decision to be effective must be made "Just-in-Time".

- *PrPidsDM3*. Decision making *is* autonomous behaviour *par excellence*.

- *PrPidsDM4.* 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.

- *PrPidsDM5.* Any model of anthropocentric decision support should be based on symbols *accessible through the interface*.

- *PrPidsDM6.* Conventional (optimization-based) methods become unsuitable for decision support simply because (quasi-)timeless services are out of the question in real-world settings.

In other words: a) there are real-world situations where conventional-DSS-based decision making is *ineffective* or even *unacceptable* (when late decisions are harmful, *Pr1*, *Pr2*, *Pr4,Wa2, Wa6*); b) decision making in line with "BR+JIT" could be vital when switching from *automatic* to *manual* control is not suitably managed in risky situations (6.3.1, 7.2.3, 7.2.4).

As regards the prevalent mentality mentioned in 4.3.1 about therapeutic decision-making as exclusively human attribute, it is now accepted (and even common practice) that *low-level decisions* – including most of those made during intensive therapy – can be "delegated to other entities able to manifest autonomous behaviour" (the speech marks reflect the effort to avoid pointless arguments).

On the contrary, *high-level decisions* (mainly under time and/or risk pressure) should remain – at least for the time being – a last human privilege in withstanding alienation through technology (no tool or machine should be allowed to take initiative in vital matters).

Nevertheless, there is a major hindrance, due to a yet prevalent mentality: since (high-level) decision-making is an exclusively *human* attribute, non-algorithmic *software* is – if not nonsensical – applicable at most to toy problems.

6.1.2. Requirements for Agent-Oriented Mechanisms

Below are listed only the main requirements that are effectively mirrored in mechanism architecture (6.2, 6.3) because: a) it is useless to repeat requirements established over twenty years ago; b) in a post-industrial society regarding the agent as service-provider (based on the very agent metaphor) is more relevant than looking for its weak or strong features (reflected in standards or just in advanced IT practice). (In parentheses examples are referred to.)

- The paradigm shift from *using* (conventional) *software* to *interacting with* (bodiless interface) *agents* is vital. (6.2.1, 6.2.2, 6.3.1, 8.2.1, 8.2.4.)

- Corollary1: Interfaces should be anthropocentric. (Idem. Details in 6.2.1.)

- Corollary2: In line with *Wa3* all input is natural, i.e., analog. (Idem. Details in 6.2.1.)

- Corollary3: In line with the paradigm of "computing as interaction" in "technologically unmanageable" environments (expanding, changing, unsure, and fuzzy) intentionality is not restricted to humans. Indeed, agents interact with humans and with their non-human environment consistent with their own intentions" [9]. (6.2.1, 6.3.3, 8.1.3, 8.2.4.)

- Corollary4: In line with *Wa4* cognition is regarded as holistic. Decision making must be based on: a) holistic approaches, requiring right-brain – intrinsically non-algorithmic – techniques; b) accepting uncertainty. (6.2.3, 6.3.2, 6.3.3, 8.3.3.)

The last corollary marks somehow the shift from the fourth to the fifth objective as well as from *requirements* to exploratory (innovative) *features*. There are four echelons:

- Replacing numbers by words as much as possible. (Integrating the word-based bar devised in 6.2 into the experimental model for simple but urgent decisions designed in 8.2.)

- Lessening the weight of *categorical* – mainly dichotomous – concepts. (6.2.2, 6.3.2, 6.3.3, 8.4.2)

- Lessening *graphocentrism* through *nontextual* interface components (8.2.4, 8.3.3, 8.4.2)

- Lessening *logocentrism* through *nonverbal* interface components (8.3.3, 8.4.2).

In short the mechanisms should work incorporated in an agent designed as service-providing software entity, based on multimodal interfaces and aiming at decision making with incomplete information.

6.1.3. Resource Limitations

The order is from abstract to concrete (the effect upon this thesis was rather in inverse order to that of the account; in parentheses are examples):

- *Depth of transdisciplinarity*. This limitation was threefold: a) no cooperation within "Prigogine niches" was set up ([62] or [61] had no feedback whatsoever); b) in some relevant disciplines the reigning paradigms are scarcely reevaluated (cognitive psychology); c) main application fields have no suitable theoretical framework for BR or JIT for the post-industrial society (service-oriented theory of value).

- *Conceptual framework*. No matter the disciplines they stem from, key concepts like *nondeterminism*, *uncertainty*, *cognition*, *chaoplexity* (including the old components the new concept is derived from), *stimulus*, *organization*, and –above all – *time* have no (scientific) definition or have a variety of (divergent) connotations (*organization* as "social arrangement" versus *organization* as "time derivative of *order*").

- *CSITAO terminology*. There are two kinds of conceptual hurdles: a) stemming from the way general concepts are mirrored in this thesis ("*non-algorithmic*" reflects "*uncertain*" as epistemic facet of "*nondeterministic*"); b) stemming from incompatible meanings concocted in CSIT itself (the Turing-machine-based definition of *algorithm* is inapplicable neither to "genetic *algorithms*" nor to so-called *programs* based on script languages). If the first type of difficulty was overcome – at least partially – by [14] the second one is an overwhelming endeavour for any PhD thesis.

- *Affordability*. Besides the whole range of logistic restrictions occurring in a medium-sized Romanian university, lacking a suitable API was most likely the most influential. Thus, it requires to be dealt with separately below.

6.1.4. Simulating Bodiless Agents

As explained in 2.3.2, 2.3.4, 2.4.2, the interface agent is *sine qua non*. Hence, if it cannot be implemented it must be simulated. However, if it is simulated by the decisional free will of its owner in an experimental model of a CSIT thesis, engineering credibility requires to prove indisputably that: a) the model *architecture requires it* to illustrate its innovative features; b) the *structure* involved *is unaffordable*; c) *validation is* still *unaffected*.

- *Architecture*. The nondeterministic behaviour of the complex interface agent is essential to achieve the first three thesis objectives (mainly 2.2, 2.3, 2.4, 4.3, 5.4).

- *Structure*. An *affordable* IDE means (according to *Pr5*): a) widespread (CSITAO intention); b) compatible with EU2020 modelling ([26] rationale); c) available (thesis prerequisite). *Available* means: accessible (here and now) and either offering Ada-like language primitives for advanced concurrent programming or allowing API-based multithreading. Since event-driven multithreading is not supported by any common API – including that of Windows 32 (mainly because of the drastic architectonic limitations imposed by object-orientation – nondeterministic behaviour must be emulated via one of the other two manners allowing *asynchronous interaction* through the interface (other than the usual keyboard or mouse interrupts): a) genuine exception handling (i.e., allowing dynamic propagation); b) script or mark-up languages (or at least other interpreted, not compiled software entities). For reasons detailed in 6.2.1 the second way was chosen for the first implemented mechanisms. (However, as shown in 7.2.3, for the experimental model needed by [26] at least the development of an Ada-like exception handler is unavoidable.)

Thus the only major service-oriented innovation currently implemented is the well-known – but rarely used – "*return-1*" (6.3.3, 7.2.3, 8.1.3, 8.1.4, 8.4.2, 8.4.3.1).

- *Validation*. Service-oriented validation in line with *Pr1*, *Pr2*, *Pr5*, and *Wa2* is performed *in embryo* for both mechanisms and *in ovo* for the real-world toy problem (8.1.2).

6.2. MULTIFUNCTIONAL WORD-BASED BAR FOR NON-ALGORITHMIC INPUT

The description is self-contained because the mechanism is: a) *autonomous* (designed to be applied beyond this thesis – first of all in [26]); b) *novel* (redundancy with previous research is minimal); c) *integrated* in the experimental model (thus, chapters 7 and 8 can be better focused on modelling and on model implementation). After summarising the *rationale for word-based interfaces* (6.2.1) and abridging *previous work* showing that *non-algorithmic software* does not start from scratch (6.2.2), the *generic* mechanism *architecture* is explained for the case of a *(pseudo)linear decision-input bar* (6.2.3). To be suitable for continuing education, the *psychophysical* (*logarithmical*) *bar* is prepared for (6.2.4).

6.2.1. *Rationale* for Word-Based Interfaces

The rationale does not refer explicitly to decision input because – besides being purposely *autonomous* and *aiming at decision making* – the mechanism (based on the *analog input bar* presented in 6.2.2) proved to be *general* and *ergonomic* (6.2.3) as well as very *easy to implement* 6.2.4). Thus, for the sake of simplicity the reasons will be presented together gathered them from above – mainly from the requirements for post-industrial decision support systems (6.1.1) and for agent-oriented mechanisms, respectively (6.1.2).

However, the first reasons stem from the start vector (2.2.2): *Pr4*, *Pr5*, *Wa2*, and above all *Wa3* asserting that *analog* input is *natural* and *general*. The reasons have been specialized for DSS (6.1.1): *PrPidsDM4* confronts both *numeric* input and *algorithmic* support (situations needing decisions and humans making them are *analog* and *nondeterministic*). *PrPidsDM5* asserts the *need of symbolic interfaces* (because of anthropocentrism) and reasserts the *role* of any *interface* (the symbols must be accessible *through* it).

Focusing on *post-industrial modelling* (from a definitely *decision oriented* stance) a cardinal reason emerges: interfaces must be *user friendly* and *ergonomic* (in boundedly rational terms "*simple*") because: a) humans must make decisions "Just-in-Time" and mostly in the absence of complete information; b) a common denominator is welcomed since there are two kinds of decisions, intentionality is not restricted to humans (6.1.2), and swift swapping between "manual" and "automatic" mode should be encouraged.

In short, if proper human decision making is challenging and hard to explain because of BR, this very BR should at least help to keep it as easy as possible.

6.2.2. Non-algorithmic Software. Previous Work

Aristotelian, bivalent logic – conventional software is based upon – resisted theoretical blows administered by various types of logic (e.g., logics for AI, fuzzy logic). Thus, decision support – and software as a whole – is still overwhelmingly algorithmic. In spite of this, previous CSITAO work shows that:

"DSS weaknesses stem from inappropriate conceptualising, based on rigid, algorithmic (i.e., deterministic, almost sequential, "computational", and atemporal processing), meant for decision making as "step by step solving of arising sub-problems", not for decision making as "continuous process of dealing with unexpected, potentially risky, fast changing situations requesting immediate - albeit not optimal - response" [13], [17].

In combining non-algorithmic software with word-based computing, the most daring linguistic variable suggested was *ethics*, since "the behaviour of software agents must show a wise blend of ethical intransigence and pragmatic effectiveness. Therefore, the different elements of ethics required in the design process need to correspond to categories of ethics as system, expressing various degrees of rigor. At one extremity, one has the strict deontological form of ethics [...], at the other end one has Epicurean act-based pragmatism [...] somewhere in between one can place rule-based utilitarianism" [9]. (This "ethical potentiometer" was never implemented since the PhD thesis intended to devise "user-driven ethical behaviour of self-aware agents" was abandoned.)

6.2.3. Generic Architecture of a (Pseudo)Linear Decision-Input Bar

Architectonic targets: a) Advancing decision support to tackle post-industrial situational chaoplexity based on bounded rationality (as main cognitive mechanism for decision making) together with "Just-in-Time" (as post-modern variant of "real time"). b) Conceiving a multifunctional input bar for decisional choices based on fuzziness, computing with words, cognitive psychology, non-algorithmic software and semantic validation. c) Illustrating the above by the design and implementation of a "Decision-Input Bar" instance applicable in common and urgent situations. The last target is postponed for and attained in 8.2.

Starting from the targets, the mechanism title is easy to explain:

- *Non-algorithmic input.* As shown in 6.2.2, it is in fact the IT mirroring of the paradigmatic shift towards recognizing the *non-algorithmic nature* of high-level *information processing* by humans. The – still unusual – concept is extended here from continuing education to decision making as a whole.

- *Input Bar.* The decisional choices are entered into the system expressed as pixel segments on (scrollbar-like) bars. The segment length represents the choice variable value.

- *Word-Based.* Boundedly rational decision making rejects both extremes of choice granularity: *two* choices (in line with the Aristotelian "excluded middle") or an *infinity* of choices (in line with the mathematical distortion of Zadeh's sound principles of fuzziness and fuzzy thinking [64]). (Similar problems are debated currently in the BISC community).

In short, "computing with words" should mean for decision making – above all when chaoplexity impairs "Just-in-Time" decisions – *Rationale 3* according to *Wa5* (in vital decisions, even *Rationale 4*, according to *Wa6*). Thus, "*Word-based*" means: "as many words as necessary, as less computing as possible".

- *Multifunctional.* To keep the interface simple (cognitive ergonomics is paramount for "Just-in-Time" decisions) structural differences should be kept minimal. Thus, an input bar for an action depending on a perception governed by a psycho-physiologic logarithmic law can look the same (indeed, a linear scrollbar and a volume potentiometer are very similar).

- *Successive prototyping.* Corollary of the above.

6.2.4. Preparing for Psychophysical (Logarithmic?) Dependence

For a self-contained and structure-oriented section the technical – albeit trans-disciplinary – information above suffices. (Applying self-recurrence to this "service-oriented thesis" the huge architectonic significance of logarithmic dependence for continuing education is questioned – in both meanings of the word – in the user-oriented section 7.4.4.). Here only examples of implementation-related aspects of successive prototyping are dealt with:

- *Function type.* There are two sorts of perception level: *biological* and *cognitive*. Hence, "logarithmic dependence" is too ambiguous for designing an input bar for an action depending on a perception governed by a psycho-physiologic logarithmic law. What is its analytical expression (*exponential*, or *sygmoidal*, or purely *logarithmic*)?

- *Graphic look*. Even if (types) of dependence are similar, some patterns got memetic value (and stability too). For instance, *certainty factors* can be input easily into a bar [92] but for a "*cos φ meter*" a circular form is more likely.

- *Granularity*. As shown in 6.2.3.1 it is quintessential for "Zadeh-word-oriented" input: The "ethical potentiometer" ([9], 6.2.2) had five discrete positions, the "thermogram" segments in Figure 6.1 differ not only in values, but also in *granularity* reflected in *scale*.
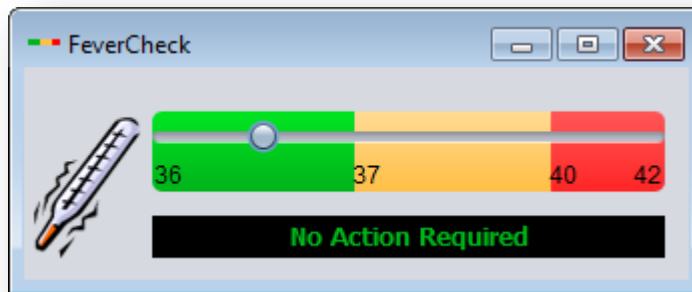
Figure 6.1. Linear fragment of a (pseudo)linear input bar.

6.3. NON-ALGORITHMIC SERVICE-ORIENTED DECISION-MAKING FRAMEWORK

Essentially different from the word-based bar above, the mechanism presented here is rather a set of cardinal design principles for post-industrial CSITAO applications. However, a sufficient yet paradoxical reason to label it as a post-industrial software mechanism, is the *rara avis* instruction: "*return -1*" (6.3.1). The next guideline for service-oriented software refers to *tackling uncertainty* caused by future contingent *in DSS* (6.3.2). Other basic development practices *challenge Chrysippean bivalent logic*, but within the frame of conventional algorithmic imperative programming languages (6.3.3). The apex is to realise the need of and to offer the tools for *switching* control from humans to *software* and back (6.3.4).

6.3.1. "*return -1*", a *Rara Avis* Counterpart of the Familiar "*return 0*"

To explain the (both innovative and essential) role of the "service-oriented semantics" given to a very rarely used variant of "return", a minimal analysis of (bad) programming practices is useful. There are three problems with a "return-type"[4] instruction, no matter the programming paradigm used: a) who returns? b) *what* does it return? c) it returns to *whom*?

---

[4] "*return-type*" is meant to emphasise that the analyse is language independent. However, it is presupposed that the OS has at least a *Windows API* and it is tacitly accepted that the programming language used for a mechanism should be a popular one, namely *C++* or *Java*. Similarly, "*otherwise*" should be regarded as pseudocode concept – namely including all programming language variants, first of all "*default*".

a) If the entity translates a usual algorithm from "START" to "STOP", namely if it is a (main) program receiving control from the OS or a subprogram having no data type (and value) attached to its name (e.g., a "procedure"), then "return" means "STOP". Otherwise – namely when the entity is a "function"– "return" embodies the function *value* (e.g., *y = f(x)*).

b) Confusion arises in languages where any procedure (main program included) is considered as a particular case of function - and not *vice versa* as both older programming languages and common sense require. As a result, any code entity must return "something", no matter how useless or – sometimes even – meaningless it might look. (However, since it exists syntactically, it can be put to work, having assigned some meaningful role.)

c) That should be straightforward: any *called* entity returns values to its *caller*, when it returns control. Thus, why should an application program care about return values, since they are useful – at most – to the OS (its only possible caller)? That is why most compilers don't care about the value – some compilers even ignore the instruction altogether.

On the other hand, in service-oriented applications software entities must have a non-algorithmic temporal dimension, i.e., they should be seen as *processes* or *threads* that provide a service to their caller. Obviously, any service provider – living or software entity alike – *must* keep its client informed about the service evolution. A minimal information should be about *success* (normally expressed by "*return 0*") or *failure* (unfortunately mostly ignored but, if signalled, usually expressed by "*return -1*"). There are three possible kinds of caller: a) the *OS* (practically the only caller treating the API functions as service providers, i.e., using as many return values as required by service robustness); b) an *application software* entity (the main program or another subprogram); c) the *end user* through the interface (either directly or via an interface agent).

Of course, a second value is mandatory because any "Yes" is meaningless without the possibility to say "No". (The values "0" and "-1" are borrowed from the API functions of early real-time OS, where, for historical reasons, errors had negative integer codes.)

In short, the innovation based on BR is: a vital architectonic feature ("service failed") can be expressed by a simple and until now unused instruction ("*return -1*").

6.3.2. Post-Industrial Decision Support, Incomplete Information, and Procrastination

This mechanism component is a mechanism *per se* [17], stemming from previous LBUS research (2.1.1). It is summarised here after [100], [17], [64] only because: a) it is a key constituent of the non-algorithmic decision-making framework; b) it is the first time it is applied to an experimental model (although not implemented in the first prototype).
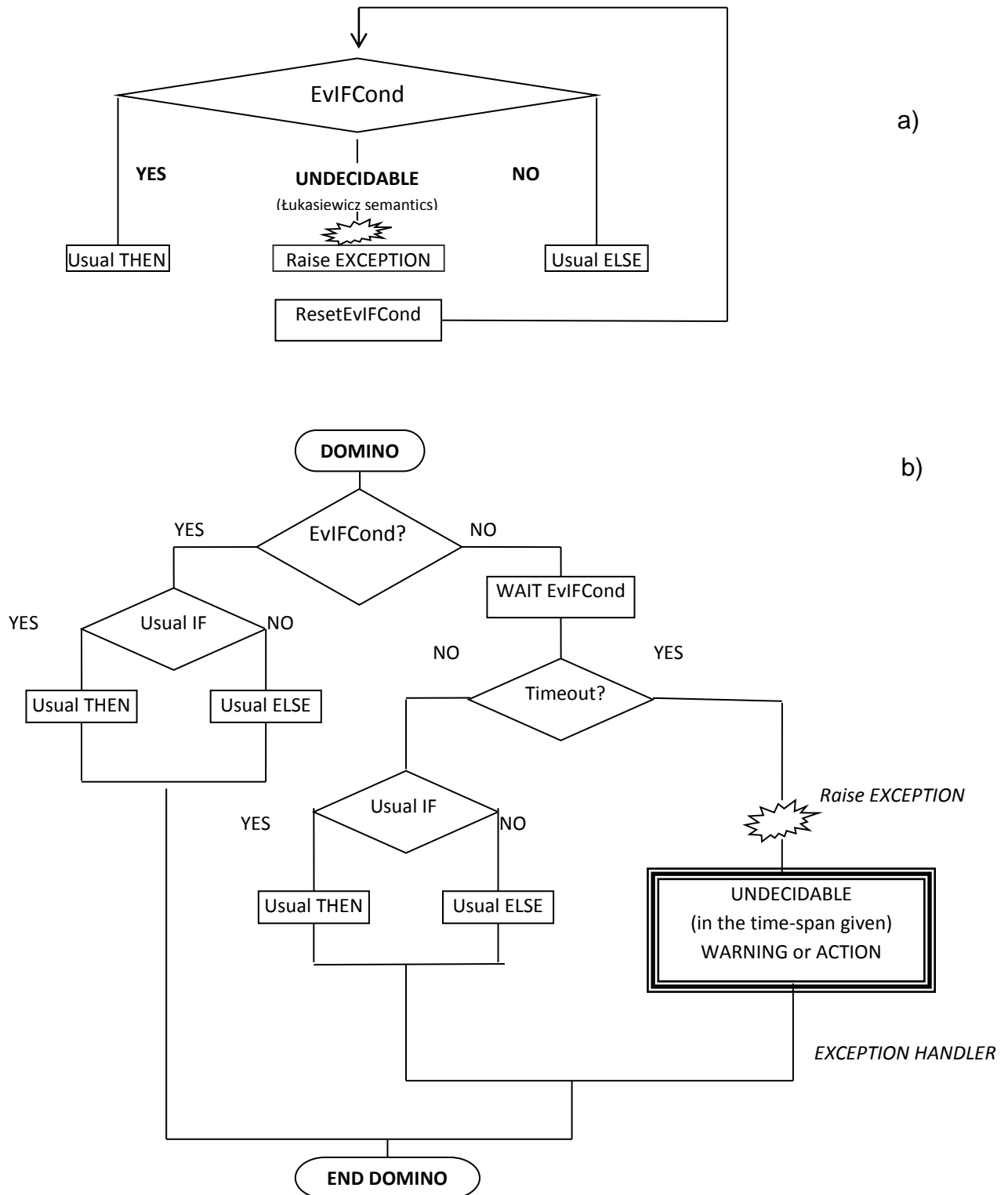
Figure 6.4. DOMINO (adapted from [17]) a) *Architecture*: trivalent logic semantics
b) S*tructure*: bivalent logic implementation (based on *Windows API*)

6.3.3. Other Non-Chrysippean Practices in Service-Oriented Software

After explaining the reference to *Chrysippus* and *why should it be OTHERWISE?* (6.3.3.1), it is shown how "OTHERWISE" is able to: get rid of "*tertium non datur*" (6.3.3.2) and *reconcile abduction with algorithmic software* (6.3.3.3).

6.3.3.1. Aristotle or Chrysippus? Why Should It Be OTHERWISE?

Chrysippus is referred to here as "pillar of bivalence" because: a) Aristotle as "father of philosophy" is a better counterbalance to Lao Tzu, whereas Chrysippus as "father of logic" is the originator of formal languages (including a strange but unquestionable definition of "IF … THEN"). b) In Stoic logic "disjunction is exclusive and non-truth-functional" [22] c) Despite its tough deterministic stance, he was a forerunner of the trivalent "IF [22].

Thus, "non-Chrysippean practices" refer to allowing flexible and varied service providing within the structural frame of popular programming languages. Both are based on extending the use of "OTHERWISE" in conditional statements.

6.3.3.2. Replacing "IF" by "SWITCH" with "OTHERWISE"

As shown in Figure 8.4, it means liberating the application design from the mental pressure of "*tertium non datur*". The usual reference to the "excluded middle" is here avoided since: a) there are *multiple* architectonic *alternatives*, nothing about some *intermediate value*; b) mainly during the "Service-Outlining Dialog", the "otherwise" option is more than just another possibility. Indeed, it offers the advantages of an "emergency exit": security, robustness, "Just-in-Time" improvise, and so on.

6.3.3.3. Reconciling Abduction-Based Reasoning with Algorithmic Software in DSS

Abduction-based reasoning is relevant here – and for this thesis as a whole – because: a) as based on "the best explanation" it is closely related to BR; b) moreover, it is a type of nonmonotonic reasoning appropriate for decision making in dynamic environments with incomplete information; c) it can be reconciled with CWA (hence with conventional software) via "OTHERWISE" as shown in Figure 8.4; d) an essential category of services, namely *diagnosis*, relies heavily on it.

6.3.4. Detaching "Manual" from "Automatic" Control in Service-Oriented Software

Acknowledgments: a) this section was attached to this chapter after the thesis has been assessed at different echelons; b) the arrows in Figure 5.1 too; c) neither the section, nor the arrows are necessary because the very problem of "detaching" the two processes is incongruous; d) on the contrary the problem of "switching" is ubiquitous – hence trivial (any tele- or interphone responder shows it daily); e) moreover, switching is so straightforward in almost[5] all real-world situation that it is unnoticed; f) "detaching" was meant here as "mentally" not "technically"; g) worse, "detaching" is not part of the *solution*, but of the very *problem*: paradigm *shifting* (not *switching*) needs a preliminary step: admitting that other

---

[5] "Almost" means that there are some unfortunate exceptions like Apollo 13 or Fukushima

paradigm *may* (or *could*) exist and that any research should be assessed according to *its* start vector; h) claiming to be *conservative* is a sign of great *sincerity* but is of little *help*.

Immediate causes for "attaching" 6.3.4 to a thesis it does not belong to were some important criticisms like: a) it is dangerous to use "chaoplexity" without having defined "chaos"; b) the experimental model does not illustrate the thesis title because "pattern recognition" is regarded as involving artificial neural networks or similar IT techniques.

- Haken asserted the threshold principle based on *noticing* (observing, verifying, even establishing), not *explaining* (even less *defining*) the difference between the states (order vs. disorder) of electrons in metals manifesting superconductivity.

- Complexity was studied *before* and *without* defining "chaotic", "self-organization"– or even some "more tangible" antinomes: "simplicity", "cosmotic", "(exogenic) organization".

- There are real-world situations where it is vital to accept that: a) there are two kinds of decisions; b) intentionality is not restricted to humans; c) switching from "manual" to "automatic" mode should be encouraged and swift.

- Metaphors apart, "pattern recognition" could be legitimate for humans too (a "pattern" is – at least macroscopically – holistic, whereas "recognition" may be linked rather to "cognition" than to "machine learning" (there are yet some differences between "learning" and "clustering").

- It may be legitimate to put the *ends* ("pattern recognition") above the (sometimes useless) *means* ("(un)supervised learning").

As a result, Figure 5.1 can be commented upon in 8.3.3 and formulated as open question in 9.3, based on three "credal beliefs":

- The prevalent paradigm is valid for "automatic control". Decisions are focused on precision and are made by robots. They are mathematics-based, algorithmic, and carried out mainly through *object*-oriented IT. Time is either noninteresting (the algorithm stops when the problem is solved) or circular ("return" means not "stop", it means restarting an endless loop).

- The new paradigm is valid for "manual control". Decisions are focused on bounded rationality and are made by humans. They are semiotics-based, non-algorithmic, and carried out mainly through *process*-oriented IT. Time is "Caesium Time" only in simple situations, it must be similar to "Carbon Time" [12], [8] because services (decision support included) are for humans ("*return*" must be semantically enriched, since "return -1" is mandatory for warning the user that the service failed).

- In the industrial (*product*-oriented) era, the prevalent paradigm was *sufficient*; in the post-industrial (*service*-oriented) era, both paradigms are *necessary*.

In short: the input bar is applicable no matter the paradigm involved, while the guiding principles are aimed to become a *PIPE* (*P*ost-*I*ndustrial *P*rogramming *E*ntity[6]), as substantiated in 8.3 and implemented in 8.4. Whether it would be an *ADVANCED* one is assessed in 9.2.2 and validated (or not) through future work outlined in 9.3.1.

---

[6]*Programming Entity* is a provisional label until there is enough evidence to give up the obsolete "programming" and call the "entity" by its name: *protoagent* (reasons are given in 8.3.4).

SEVENTH CHAPTER

Boundedly Rational Experimental model(s) for EU2020 Targets

Man cannot remake himself without suffering,
for he is both the marble and the sculptor.
ALEXIS CARREL

After presenting the key problem of continuing education, namely the *postmodern "educational chaoplexity"* (7.1), because of speeding up this thesis, the second subchapter is reduced to the level allowed by cooperation results achieved so far [26], presenting *e-teaching as boundedly rational (sub)system*. Focusing on the temporal hiatus intrinsic to continuing education the solution proposed is to *extrapolate* a lasting topic (*The Golden Ratio*, 7.3) and a lasting behaviour (*The Damascus Blade*, 7.4).

7.1. POST-MODERN EDUCATIONAL CHAOPLEXITY. BOUNDEDLY RATIONAL MODEL

Before launching the concept of "EDucational CHaoplexitY" (EDCHY) – here because this thesis is published before [26] – it should be filtered to serve it. Therefore, here EDCHY is regarded as the key problem able to be settled via BR as educational strategy. As a result, first the title must be explained: *Why Post-Modern*? (7.1.1) and *Why Chaoplexity*? (7.1.2). Further, the *first attempt to include bounded rationality in e-teaching* is outlined (7.1.3). Finally, it is shown that BR can be used as *antidote to educational chaoplexity* (7.1.4), i.e., as mechanism able to alleviate the temporal hiatus intrinsic to continuing education (3.3).

The necessary and sufficient reason to promote BR as key remedy to educational chaoplexity – i.e., as cardinal mechanism able to alleviate the temporal hiatus repeatedly mentioned above – can be abridged as: BR is a psychologic, hence lasting, feature [26].)

Thus the background is set up for the "framework able to manage educational chaoplexity based on BR as common denominator of, mechanism for, and connection between the two facets of continuing education: e-teaching and e-learning" (third thesis objective).

On the other hand, as regards the newest EU2020 research, the even stronger emphasis on BR as medication is due to the focus on psychology ([62], [61]) as well as to the obvious research trend in the area of interest. (Indeed, among the most relevant work published in 2011 referring chaoplexity, a third refers also to education.) The main difficulty is that "sufficient reason" to tackle the problem does not entail always also "sufficient groundwork" to solve it. That is why both [62] (focused on BR as *means*) and [61] (focused on e-teaching as *ends*) aim at convincing psychologists to cooperate with computer scientists in devising the framework for continuing education.

Since cognitive psychology – as both phylogenetic achievement and corpus of know-ledge – has a lower time derivative than the other fields/disciplines involved in continuing education, it should be the crux of any e-teaching project.

In short, both kinds of reasoning, *serial* (based on *binary* logic) and *parallel* (based on *non-monotonic* logics), must constitute the texture of any teaching endeavour dedicated to continuing education. Confining a kind of reasoning to a specific brain hemisphere is a rather acceptable oversimplification to start with. Unfortunately, cognitive psychology – while consistent and established – seems rather inappropriate as corpus of knowledge because of a predominantly deterministic (left brain hemisphere, serial, "von Neumann-like") approach. Thus a paradigmatic shift based on the innovations brought by EU2020 research becomes urgent. The first is (only partially) outlined below.

7.2. E-TEACHING AS BOUNDEDLY RATIONAL (SUB)SYSTEM

Before investigating "teaching", it is useful to analyse the prefix "*e-*" considering the quintessential and multiple role of e-teaching for two EU2020 theses (7.2.1). As very often, time is able to *split systems*: in continuing education *teaching* is performed *now*, whereas *learning* comes *much later* (7.2.2). Maybe *modelling teaching* needs also a prefix: *meta* (7.2.3). Thus, teaching could be able to *reunite the system*, *catalysing self-teaching* (7.2.4).

7.3. EXTRAPOLATING LASTING TOPICS. THE *GOLDEN RATIO*

In essence, to accomplish the first thesis objective (2.2.1), it must be proved that the major new role of BR as "educational mechanism" can be put into service due to its (anthropogenetic?) feature of "psychological stabiliser" (through negative feedback, 5.3.2, 5.3.3). The proof is done in three steps: a) choosing an interesting topic that was a *"fixed point" in history* (7.3.1); b) investigating its *memetic stability* that assure its usability (7.3.2); c) suggesting a *boundedly rational way to extrapolate* similar topics in e-teaching (7.3.3). Since such topics are prone to "anecdotal evidence", an exercise in *self-recurring memetic engineering* seems welcomed (7.3.4).

7.3.1. *Divina proportia* as "Fixed Point" in History

The telling, on-going, and triumphant journey of the "Divina proportia" is compiled abridged below from two sources: a modern general purpose encyclopedia [http://en.wikipedia.org/wiki/Golden_ratio] and a highly specialized mathematics-oriented resource [163], highlighting from a thesis stance some differences to be commented upon in 7.3.2.

7.3.2. Memetic Stability

Three memetic features of such topics should be focused on to ease applying them in continuing education: a) *lastingness* (they are a leitmotif in cultural history); b) *ubiquitousness* (they permeate all cultures); c) *effectiveness* (they are active now in education).

7.3.3. Boundedly Rational Extrapolation in E-Teaching

Choosing the golden ratio to carry out a modern, wide-reaching, interdisciplinary, and international educational endeavour is enough an (albeit anecdotal, 7.3.4) evidence to support the idea that the meme is active and of great consequence for education; moreover, Its memetic stability ensures that such topics will be even weightier for *continuing* education. As regards the claim – crucial for the whole EU2020 research – that applying such topics in teaching is organically linked to BR, it is defended throughout this thesis mainly starting from 4.1.1 – but most explicitly in 7.1.3 and 7.1.4. Perhaps the most promising aspect substantiating this link in the Moncton experiment is that the incongruity between stability and creativity seems to vanish (7.2.4). Indeed, the golden ratio "can be found in many areas of mathematics and real life, including architecture, music, art, and nature and can be expressed in many different forms which may be surprisingly complex and interconnected. Very often, authors refer to this number as expression of beauty of our world. […] its interdisciplinary nature combined with rich mathematical relationships make it attractive for teachers and students as it helps in building multiple connections between mathematics and other between mathematics and other subjects and real-life applications" [56]. Keeping on with stability (searching everywhere the same ratio) the children become creative (they make "surprisingly complex and interconnected" assumptions no matter of finding new instances of the ratio looked for).

7.3.4. Self-Recurring Memetic Engineering. What Time Is It?

In 7.3 – and in 7.4 even more – there is a "narrative touch" (why mentioning Vitruvius or Chopin?), hence the thesis is exposed from a standard scientific stance, because it uses *anecdotal* evidence instead of *scientific evidence*.

7.3.4.1. How Scientific Is Still the "Scientific method"?

In short, using in the very foundation of "Scientific method" terms or syntagms like "repeated sampling", "posterior belief", "predictions about", "prior probability" involves a particular perception of time. This perception *is not* – and could not be – *the same* for scientists of the main disciplines involved, because their very concepts of time are deeply divergent. Thus, they do not *measure* the time they *perceive* and vice versa. Comments below.

7.3.4.2. "Machine" or "Test"? Same Turing but different meanings of time in "return-1"

It seems strange that, in spite of being the brainchild of the same father, the Turing *machine* and the Turing *test* are treated differently: in Control engineering the test is – of course – ignored, while in AI (where the test was aimed at) the interest is still focused on the *deterministic algorithm*, not at all on the *nondeterministic dialogue* involved by the test

(nobody investigates what is in fact tested and what tools are used; worse, the test is often mentioned but almost never used).

The stances are expressed linking the meaning of "return" in C/C++/Java-like programs (6.3.1, 6.3.4) to the tacitly accepted perception of time (Figure 7.1). For the sake of conciseness, the working concepts in [12], [8] are kept without commenting upon: "Physical ("Caesium Time", *TCs*), Psychological ("Carbon Time", *TC*), Agent ("Silicon Time", *TSi*)".
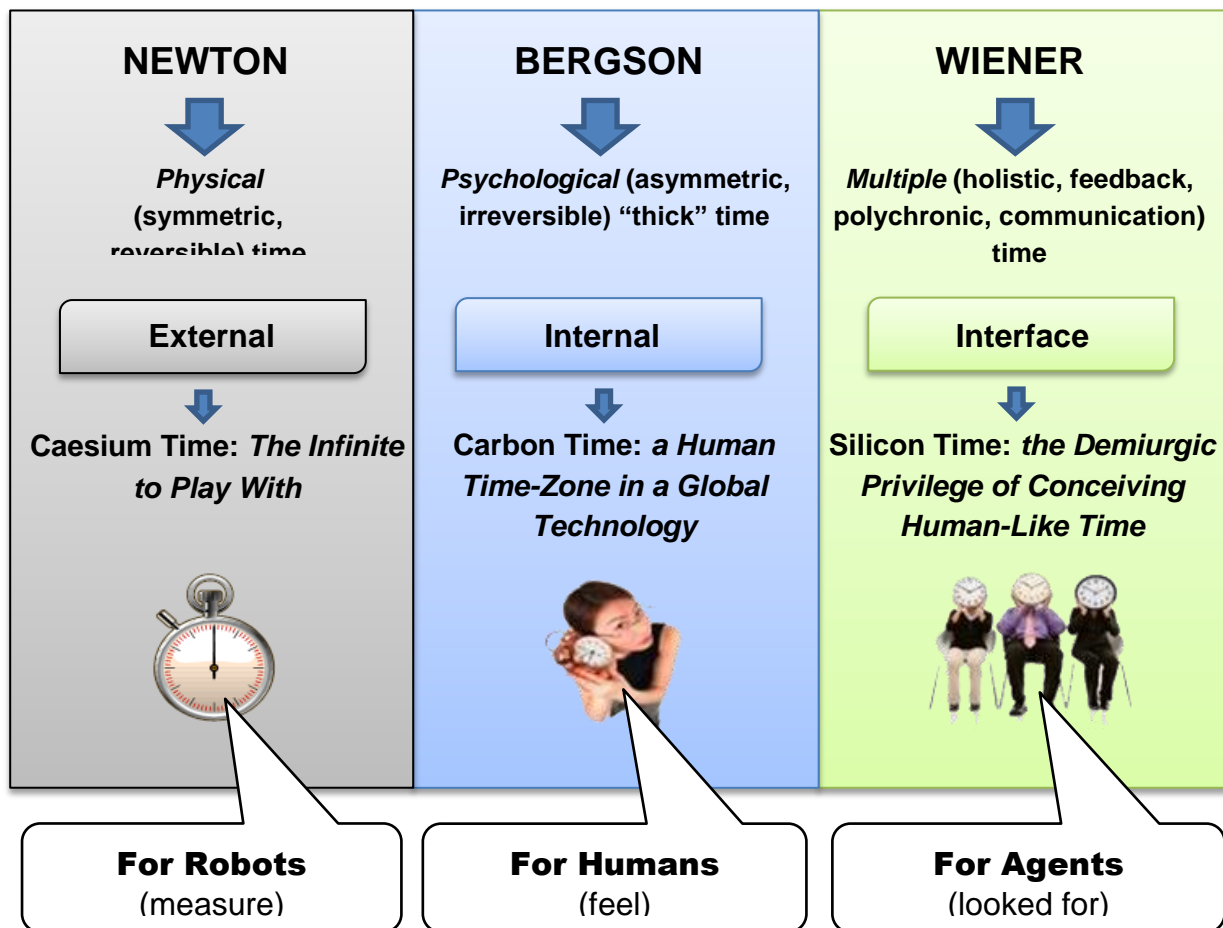
Figure 7.1. Three ideas of time, Bayes was unaware of (abridged and adapted from [8])

- *Automatic Control*. Time is Newtonian (*TCs*): linear, infinite, symmetrical (reversible), precisely measurable via its inverse magnitude (frequency measured by crystal oscillators: 2^{15} Hz). Infiniteness is emulated through circularity. Here the Turing-machine-based definition of *algorithm* is slightly distorted: "*return*" is valid *ad litteram*, in its initial meaning of returning from a callee (the loop body) to the caller (the program entity where the loop is carried out). Nevertheless, within the callee the algorithm is undistorted: "*return*" means "*halt*".

- *CSIT* (product-oriented). Time is linear and infinite in theory. In practice time is ex-pressed by algorithmic sequentiality, in a manner similar to that described for the callee: "*return*" is synonimous with "*stop*" or "*exit*" meaning "*halt*".

- *AO* (process-oriented). Time is Bergsonian (*TC*): linear, infinite, asymmetrical (irreversible).Perhaps Husserlian too ("thick time"). Any service provider – natural or virtual alike – must have a similar time (*TC* or *TSi*). Hence, "*return*" means reporting after the service is finished: if successfully then "*return 0*", else "*return -1*". Cognition, decision making, nursing, learning, and so on are *processes* requiring *TC*. Any algorithmic modelling based on *TCs* is pointless – except when performed by automata.

All explanations, approaches, examples, and warnings stemming from Carrell [65], Wiener [12], [8], Gigerenzer [127], [128], [129], or other leading 20th century scientists are underestimated. Worse: a) mathematicians practically ignore the problem: "Mathematics is atemporal (nobody was fired because Fermat's Last Theorem was proved only after more than three centuries!)" [16], [64]; b) psychologists and computer scientists model "user profiles" based on statistic (or even Bayesian) methods (strangely, nobody tried to model an "infant profile" for teaching the mother tongue!).

Corollaries: a) investigating "the time memeplex (*Tx*, based on memetic engineering)" [8] is urgent because the memes suggesting that post-industrial high-level software (e.g. DSS, e-Teaching) can still be algorithmic become vicious, disregarding basic human features; b) as in most cases of paradigm shifting, memetic engineering can be applied in a first phase only in its primitive form used in this thesis; c) transdisciplinarity is mandatory; d) until refining the "scientific method", ostracising anecdotal evidence is counterproductive.

7.4. EXTRAPOLATING ANCIENT BEHAVIOURS. THE *DAMASCUS BLADE*

Even without prior knowledge of psychology, it is well-known that behaviours are extremely lasting. Hence, they can illustrate the role of BR as "educational mechanism" much more convincingly than widespread topics – albeit very famous ones (7.3). The three steps are similar to those above: a) choosing the pervasive habit of *scoring* (instead of counting) (7.4.1); b) investigating the related *innumeracy memeplex* (7.4.2); c) proposing a boundedly rational way to exploit simplicity in e-teaching based on not numerical mathematics (7.4.3), therefore, 7.4.3 becomes a call to teamwork (for [26] it is vital); d) preparing a more general and more inclusive extrapolation: from "Homo Algorithmicus" to "Homo Logarithmicus" (7.4.4).

7.4.1. In (Pre)History Scoring Was Easier

Obviously, behaviour has a much richer (pre)history than any topic – despite how famous it could be. Indeed, the "Fixed Point" approach in 7.3.1 could diminish the relevance tending to transform the substantiation into a pure narrative. The new, much more focused approach is based on etymologic evidence because it is: a) highly relevant; b) osmotically linked not only to BR but to "Just-in-Time" too; c) a lever for advancing the shift towards the fifth thesis objective (2.2.1, 5.4.3); d) a lever for "applied transdisciplinarity" (3.2.3.1, 3.2.4.1, 5.1.2, 5.2.4, 7.1.4, 7.3.3); e) a rich source of serendipity (7.4.3, 7.4.4).

7.4.2. The Innumeracy Memeplex

Both keywords in the title bewilder because they are yet syncretic neologisms (defined in [14], referred to in 3.2.4, 7.3.2). It becomes clear that: a) from a memetic perspective *innumeracy* is inseparable from *illiteracy* (etymologic evidence below); b) despite their unbreakable bond they are distinct in real-world situations (to "reason with *numbers*" is much more difficult than to "reason with *letters*"; c) both stances are vital for teaching – prefixed with "e-" or in any traditional clothing (7.4.3).

7.4.3. Extrapolating Comparisons and Ratios, Not Numerical Mathematics

In fact, some steps in this direction - substantiating the conceptual preeminence of *words* over *numbers* and endorsing BR as effective *cognitive tool*– are visible in the mechanisms proposed (e.g., the word-based bar for non-algorithmic input, 6.2) or in the experimental model (e.g., the toy problem, 8.4). On the other hand the first rough idea of a boundedly rational IT framework for holistic cognition and a first (meta?)model for continuing education (focused on e-teaching) are given in [26].

As regards *Not Numerical Mathematics*, except very abstract aesthetical reasons, not even passionate mathematicians would prefer the exact trigonometric formulas for the golden ratio presented in 7.3.1, to the (boundedly) rational appearance as *relevant geometric ratio* or as quotient of successive Fibonacci numbers (since here time is intensely involved, this aspect needs comprehensive future research, 9.3).

In short to be efficient – in any intellectual endeavour but above all in teaching - the role of numbers should be weakened whenever it promotes simplicity – however not on every occasion (indeed, innumeracy is almost always both possible and dangerous).

7.4.4. From "Homo Algorithmicus" to "Homo Logarithmicus"?

The quote from [32] in 6.2.5 includes (historical) information to emphasize that: a) mathematics had a meandrous entry into psychophysics; b) the *logarithm* has a paramount role in nature, humans included (mirrored also in CSIT through the basic *information theory* of Nyquist, Hartley and Shannon); c) moreover, its close related *exponential* and *sigmoid* functions had a crucial impact upon CSITAO research (for instance in stigmergic *self-organisation* [16]); d) focusing the emphasis on EU2020 research, the *sigmoid* is essential for emergence in chaoplex environments [26]; e) *comparisons* show to be deeper linked to BR than expected a year ago and yet not enough studied (6.2.5, 9.3)

In this context "user-oriented" in a "service-oriented thesis" means a *caveat*: in services involving cognition (e.g., DSS for high-level decision making or e-teaching for continuing education) information should be presented in an outer shell most palatable for the boundedly rational end user. Thus, if previous qualitative validation of similar services evidenced that comparisons expressed using *logarithmic functions* get more approval than measurement results or methods expressed using complicated formulae (examples in 7.3.1) the "scientific method" should be replaced with "anecdotal evidence" without worrying about numbers and deductions. (Indeed, *user* acceptance is more important than *academic* acceptance – above all when vital decisions are needed "Just-in-Time".)

EIGHTH CHAPTER

Implementing the Experimental Model for Visual Patterns

Streben wir nicht allzuhoch
Hinauf, dass wir zu tief nicht fallen mögen
SCHILLER "Wallenstein"

First the atypical, *service-oriented* model *validation* is dealt with, outlining its *rationale*, *features*, and *consequences* upon the experimental model (8.1). Then the two *non-algorithmic mechanisms* designed in Chapter 6 are applied in the model: the *word-based bar for simple but urgent decisions* (8.2) and the *decision-making framework to service-oriented dialog* (8.3). Now, the mechanisms are *merged in visual pattern recognition problems* (8.4).

8.1. SERVICE-ORIENTED VALIDATION. RATIONALE, FEATURES, CONSEQUENCES

After summarizing the *basic difficulties* of *quality management in a service-based society* (8.1.1), *qualitative validation and its variants applicable* to the mechanisms and toy real-world problems put forward by this thesis are presented (8.1.2). On this basis the subject extensions as regards the experimental model are justified: *visual patterns* instead of *e-teaching* (8.1.3) and *visual patterns* as a whole instead of *visual pattern recognition* (8.1.4).

8.1.1. Quality Management in a Service-Based Society. Basic Difficulties

The topic is abridged and adapted after [68], because it seems to have been "the first Romanian project to apply agent-oriented paradigms in open, uncertain and dynamic industrial environments; [...] it appears as one of the first European attempts to adjust quality management to the Knowledge Society, via agent-orientation" [65].

The major problems related to quality – dangerously amplified for a post-industrial (mainly service-based) society [60] are: *Quality is hard to measure*; *Quality is highly contextual*; *Quality is hard to describe*.

8.1.2. Qualitative Validation in Engineering and Its Variants Applicable in This Thesis

As regards qualitative validation: "How do we measure human-centeredness? Since anthropocentrism entails shifting from quantity (testing the *technological efficiency* of the application) to quality (validating the *target-oriented effectiveness* of its actual use), focus shifts from "building the *system right*" ("white-box testing", in line with *specifications*) toward "building the *right system*" ("black-box testing", in line with *ergonomics*) [150]" [68].

Paraphrasing the paraphrase [93] of Dertouzos' query [109] the essence lies in a question (and the trouble in its answer): "What is the horsepower of your interface?" In other words, a defendable experimental model must be at the same time *concept-driven* (since it is *model* in *PhD research*) and *context-tailored* (since it is *experimental* in *Engineering Sciences*). That means a delicate balance between a credible validation and a "Just-in-Time" implementation.

8.1.3. Why *Visual Patterns* Instead of *e-Teaching in Continuing Education*?

The question was dealt with throughout this thesis from the very beginning (the fourth objective) from various angles, the two basic reasons being: a) lacking yet a conceptual model for e-teaching in continuing education, any credible validation was impossible (mainly in 2.3.4); b) the necessary pre-eminence of architecture over structure in any human-centred endeavour – first of all in exploratory research (mainly in 2.4.2). However, there are also less explicitly stated reasons – or better said, exploitable benefits of the new domain – that are worth to be mentioned:

- *Promoting the fifth objective*. Obviously, the instances of all three echelons of communication modalities shifting from *mathematics* towards *semiotics* (nonnumeric, nontextual, nonverbal, 3.2.3.2, 5.4.3. 6.1.2) are easier to illustrate, defend and validate within a simpler experimental model, where "simpler" means explicitly bounded rational, illustrating convincingly the band between BR and JIT.

- *Highlighting the thesis pillars: bounded rationality and "Just-in-Time"*. It would have been rather strange fighting structural complexity inside a chaoplex model (3.3). For instance, the e-teaching agent would have required a very demanding transdisciplinary word-based ontology with operational temporal dimension.

- *Socratic Duologue*. Even more difficult since there are two boundedly rational agents sharing in intensive interaction the same ontology "Just-in-Time" (5.4.3, 5.4.4).

- *Familiarity*. Besides the benchmark problem (2.3.4, 3.1.2, 3.5.1), the very domain of visual pattern recognition is seen likewise from both paradigmatic perspectives – in spite of the fixed idea that pattern *recognition* involves *clustering* achieved via artificial neural networks. (Indeed, it is weird to link an essential *human* feature to an *algorithmic* procedure.)

8.1.4. Why *Visual Patterns* Instead of *Visual Pattern Recognition*?

On the contrary to the restrictions above, expanding the model from mere recognition to the most challenging domain of visual pattern as such is due to serendipity, promising but not fine-tuned as research (as a result the thesis title was not modified accordingly). The main conceptual scope extensions are due not only to the fifth objective of this thesis but also to [26] and are here clustered to defend the extension and the paradigm it serves:

- *Authentic Pattern Recognition*. The apparently pleonastic qualifier "*Authentic*" is necessary to delimit the model and its implementation from any link to Artificial Neural Network-based clustering (6.3.4, 8.1.3). In fact it is not even always visual e.g., when information about service features is got by spoken language.

- Pattern Designating. In usual (face to face) communication it means "*to point at*" clearly enough that the interlocutor (biologic or virtual alike) should "re*COGNIze*" the pattern aimed at. In CSIT jargon it means: assigning to a linguistic variable a value from the set of constants applicable in the given context.

- Pattern Demarcating. Similar but distinct: delimiting a spatial region on an image clearly enough that the application should be able to assign unambiguously a value from the set mentioned above.

- Pattern Processing and Transmission. Albeit structural detail, it must be mentioned because of its role in validating the model.

All "*Pattern X*" features are illustrated in the model – some of them in yet primeval form.

8.2. APPLYING WORD-BASED INPUT TO SIMPLE BUT URGENT DECISIONS

In line with the new paradigm the toy problem is *defined* via its architectonic *attributes*, not *specified* via its measurable *constituents* (8.2.1). Based on these service macrofeatures, the *design space* is outlined (8.2.2) and instantiated for *the first prototype* (8.2.3). Now *implementing the (pseudo)linear-bar instance* is straightforward (8.2.4).

8.2.1. Defining a Child-Care Toy Problem: Fever Checking

For the sake of clearness, the well-known problem chosen to illustrate the mechanism is not described. Instead, its suitableness is revealed in the light of the features sought for:

- Bounded rationality. Decision making is simple in both situations: "manual control" (a mother with her child in vacation, does not need thermometer, tacit knowledge suffices) and "automatic control" (in intensive care, no need for a nurse to ring the bell).

- "Just-in-Time". Archetypal for "Rationale 4" (2.2.2, 6.2.3).

- Holistic, non-algorithmic decision making. The mother is her own "interface agent", tacit knowledge is non-algorithmic *par excellence*.

- Semiotics-based. The presence of numbers could be delusive (what-if using Fahrenheit thermometer?) *Telling* (sic!) are the *concepts* the choices/actions are based upon.

- Genuine Zadehian Fuzziness. In spite of health being a very fuzzy (and context-dependent) concept, no human decision-maker needs triangular norms (or worse, fuzzy probabilities!) for fuzzification. Besides, concepts are just a few (in line with the "5 +/- 2" rule of cognitive ergonomics).

- Seed of Psycholinguistic Expressiveness. The multimodal perception (here the use of colours) lessens the logocratic pressure of concepts needing some natural language (a first step from "Computing with *words*" towards "Computing with *images*").

- Multifunctionality. The modular design illustrated in Figure 8.1 is meant to allow the same design to be used for a variety of linguistics variables (e.g., beliefs expressed as certainty factors [92]). Obviously, the bar is labelled as "(pseudo)linear" because the "magnifying factor" is adapted to the (subjective) importance of the temperature interval. Therefore,

the "bar fragments" are concatenated in the experimental model interface (no thermogram is "split into pieces").

    - *Successive prototyping*. Corollary of the above.

8.2.2. Design Space

The most general design space for a **S**ervice-**O**riented **D**ecision-**M**aking **A**pplication (SODMA) using a *Socratic* interface agent is a subset of the Cartesian product:

$$\mathbf{S}\text{SODMA} = \mathbf{S}\text{SO} \times \mathbf{S}\text{DM} \times \mathbf{S}\text{Socrates}$$

where for this thesis and the EU2020 research cluster

$$\mathbf{S}\text{Socrates} = \mathbf{S}\text{maieutics} \times \mathbf{S}\text{agents}$$

and

$\mathbf{S}$SO = {*nondeterministic_behaviour, parallelism, qualitative_validation, Carbon_time*}.

$\mathbf{S}$DM = {*bounded rationality, "Just-in-Time", uncertainty, anthropocentrism*}.

$\mathbf{S}$maieutics = {*heutagogy, dialog, captology, ethical_behaviour*}.

$\mathbf{S}$agents = {*multimodality, intentionality, nonverbal_communication, Silicon_time*}.

When some design-space dimensions are multifaceted and comprehensive (e.g., anthropocentrism) the granularity problem is avoided redefining the *dimension* as *subspace* and its *aspects* as *dimensions*.

8.2.3. Role and Scope of First Prototype

The *overt* role is to highlight the innovative architectonic of service-oriented decision making. Thus, the practical worth of the mechanism – even within a toy problem – was anticipated in 6.3.4. Indeed, in an intensive care unit humans and equipment are compelled to switch control to each other because humans need rest whereas equipment is not subject to Hippocratic Oath.

Figure 8.1 outlines the scope of the first prototype presenting three segments corresponding to a situation where care action urgency is comprised of three urgency levels as regards decision making: Level 1 (third segment: high fever, urgent), Level 2 (second segment: moderate fever, semi-urgent), and Level 3 (first segment: no fever, no urgency).

Though, paradoxically, the input bar in Figure 8.1 is totally useless, since in both kinds of control decisions are made without any thermogram: if action is urgent, the bell is ringed "automatically" by the equipment or the physician is called "manually" by the mother. Moreover, even for a real-world situation the application needs an interface mostly when humans take control of the situation and must have updated information to make their decisions (thus the bar is rather a primeval DSS than an actual input bar).

The prototype has a much more important *hidden* role too: to reconcile this thesis with stances familiar within the prevalent paradigms, sending some messages to researchers and developers in the areas of both control engineering and DSS:

- a) There are mechanisms devised from an explicit (post-industrial) paradigmatic perspective (here service-oriented nondeterministic decision making) applicable in real-world problems independent of any paradigm [92].
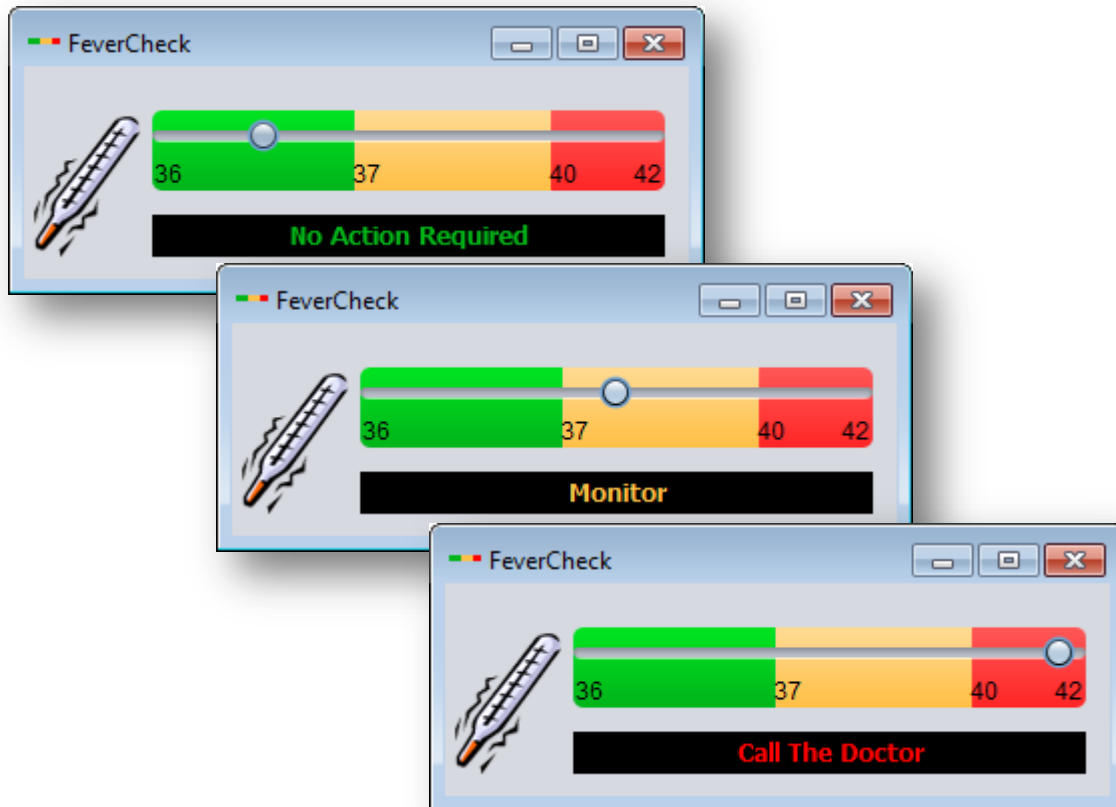
Figure 8.1. The three linear segments of the (pseudo)linear input bar.

- b) Corollary: as shown in 8.2.4 they can be implemented using conventional algorithmic software engineering.
- c) Not even the fundamental difference between "Caesium time" and "Carbon time" (6.3.4, 7.3.4.2) is perceptible for the end users: the first is concealed in the automatic system ("technology" has no time) while the second is the only time that counts.
- d) Corollary: asynchronous events are not perceived as such.

8.2.4. Implementing the (Pseudo)Linear-Bar Instance

Carrying out the implementation of the linear input-bar instance revealed itself as simple and straightforward as expected, mainly as regards technology, resources and components involved. Thus, common conventional object-oriented programming sufficed:

- *Technology*
- *Components and resources*

Since the newness of the bar is rooted in its architecture, the only (somehow) relevant code samples here (Figure 8.2) are related to the segments and the actions to be taken.

```
          JSlider source = (JSlider)e.getSource();
          if (!source.getValueIsAdjusting()){
            int knob_position = (int)source.getValue();
              if ((knob_position>p1) && (knob_position<=p2))
                  doNoAction();
              if ((knob_position>p2) && (knob_position<=p3))
                  doMonitorAction();
              if ((knob_position>p3) && (knob_position<=p4))
                  doCallDoctorAction();
          }
```

Figure 8.2. Code sample for the (pseudo)linear input bar.

The three zones (bar fragments) for "fever check", are interpreted as follows:
   a) *Healthy* – temperatures between 36°C and 37°C, marked by green background;
   b) *Slightly sick* – temperatures between 37°C and 40°C , orange colour;
   c) *Dangerously sick* – temperatures between 40°C and 42°C, red colour.

The input consists in dragging the "knob" on the slider to a proper position in a zone, triggering (or not) an immediate action:
   a) NO ACTION – if healthy; no action is required
   b) MONITOR, REPEAT – if doubtful, apply periodical rechecks;
   c) "CALL THE DOCTOR" ACTION – if very sick, hesitation can be harmful.

8.3. APPLYING THE DECISION-MAKING FRAMEWORK TO SERVICE PROVIDING

To be able to validate as mechanism *in embryo* the framework designed in 6.3, *a toy sub-problem of the experimental model is defined* in 8.3.1. On its basis, are outlined the *mechanism essence* (8.3.2), features (8.3.3) and *innovative aim* (8.3.4).

8.3.1. Defining a Toy Problem: Outlining Service-Requirements

Besides being integrable in the visual pattern recognition problem defined in 8.4, the toy problem must be relevant not just for showing the mechanism as "ADVANCED" but also for this thesis as a whole including its real application domain: continuing education. Thus, according to the objectives (2.2.1) it should be a significant part of a "nontrivial service to be provided (from a holistic perspective, within a user-centred application) by an agent-oriented interface in uncertain and changing environments" that allows "exploring e-teaching as boundedly rational system". Considering that in [26] teaching is based on e-maieutics an appropriate problem is the dialogue-based first part of service providing: *outlining service-requirements*. Likewise, because the benchmark is a program transmitting the picture of Lena (3.5.2), the toy problem is based on various situations when different people could be interested in components of the picture getting processed.

On the other hand, this section is also a partial validation test, not only for the mechanism but also for the fifth objective (2.2.1), as explained in 8.3.4: the script for a dialog expressing service context and requirements, based on a genuinely anthropocentric mechanism must be understandable to a boundedly rational service beneficiary – even if the immediate script user is the application developer. Thus, the dialog between the toy service *beneficiary* (here "Lena's mother" wanting to know whether her daughter still wears the hat she gave her), and the service *provider* (here the "entity" responding to the phone call: answering machine, interface agent or human) is outlined as follows:

8.3.2. Mechanism Essence: **A**nthropocentric and **D**ecision-**O**riented

Here essence means: a) any service-oriented development mechanism *must facilitate* intense HCI (human-computer interaction[7]): the application itself becomes an almost unremarked extension of the interface; b) to be helpful to service-oriented decision making the mechanism *must facilitate* tackling incomplete information. (Moreover, for this thesis "essence" means also organic integration with BR and JIT.)

From an explicitly implementation stance, for this framework it means:

- *Anthropocentric*. a) All functionality is *available only* through the interface. b) All functionality is *easy accessible* (user-friendliness is paramount for fighting both chaoplexity facets: *reducing cognitive* complexity and *hiding structural* complexity). c) Both essential features of HWI (human-*world* interaction, not human-*computer* interaction) must prevail: interfacing is *analog* and *multimodal*. d) Likewise, both essential features of cognition: *holism* and *nondeterminism*.

- *Decision oriented*. e) High level decision is *still* (sic!) a distinctly human attribute; thus, any DSS must be service-oriented to justify its "Support" attribute. Accordingly, the three following features are a *must*, i.e., any mechanism should illustrate them. f) When the real-world situation *allows* it, some decisions/actions can be entrusted to automata (including robots); on the other hand, when the real-world situation *requires* it, some decisions/actions must be assisted by non-algorithmic software (including bodiless agents). g) To achieve decision-maker acceptance, Carbon time is *sine qua non*. h) In chaoplex situations swapping between automatic and human control must be carried out "Just-in-Time" (Figures 5.1, 9.1).

8.3.3. Mechanism Features: **V**erbal, **A**bductive, **N**on-**C**hrysippean

To impair redundancy with both the mechanism outline in 6.3 and its integration into the experimental model in 8.4, the seven features are demonstrated by Figures 8.4 – 8.11.

- *Verbal-oriented*. Despite trying in 8.4.2 to model also non-*verbal* communication, the mechanism *per se* is unable to prove convincingly more than non-*textual* communication. On the other hand, it was illustrated by the previous mechanism (described in 6.2. implemented in 8.2.3), as shown in Figure 8.1, where all input is both *analog* and *word-based*.

---

[7] The term is used here because "computer" is compatible with both model *architecture* (agent-oriented interface) and *structure* (interface agent simulated by the very end user).

Hence, the first two features are proved as well as the first component of the third one (*multimodality* is illustrated only in 8.4.2).

Though, the toy sub-problem is cardinal for validating the fourth feature too, through "*return value*" as shown in 6.3.1: a) *Holism* is present because the end user[8] is enabled to assess the (im)possibility of providing the *whole* service after carrying out only the *first part* – even more, just a *dialog*! b) *Nondeterminism* is present by the very *process* nature of any service, as expressed in Figure 8.3 through the meaning – and *practical consequence* – of "*return*" to the caller, here the user through the interface (normally via an interface agent, but sometimes directly, i.e., simulating the agent as in 8.4).
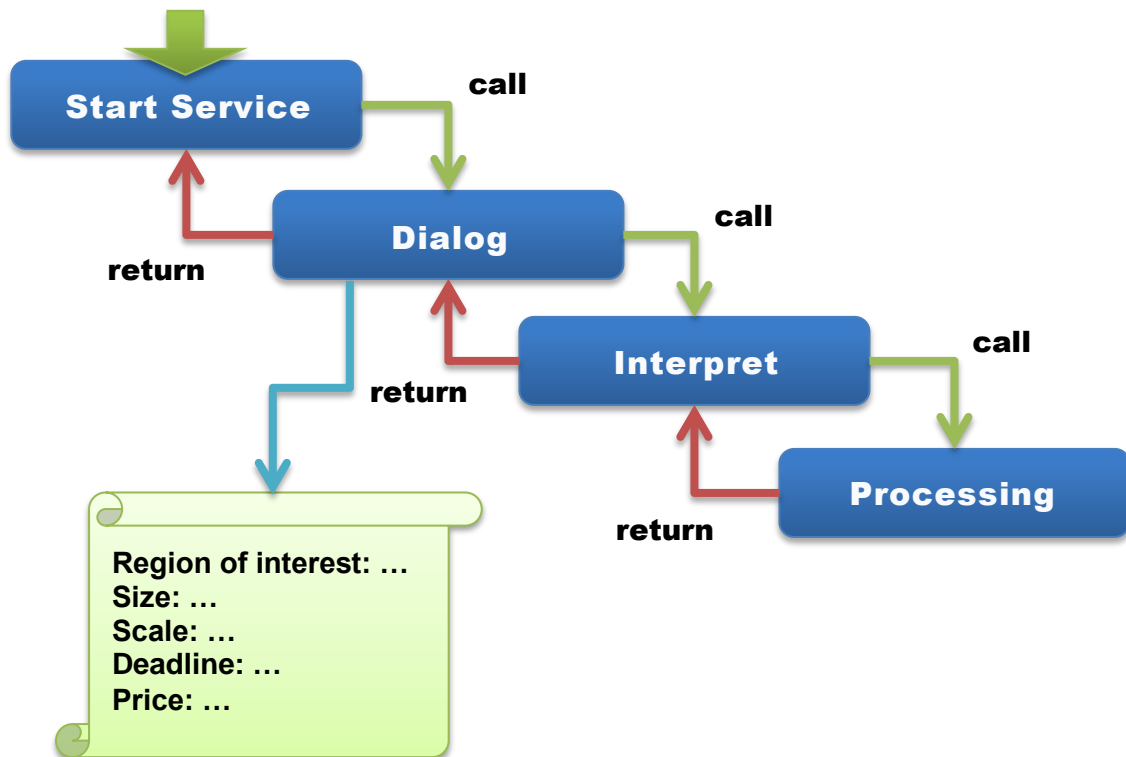
Figure 8.3. Embedded calls expressing the *process* nature of services.

- *Abduction-oriented*. Regarding Figure 8.9 it seems clear that the practical worth of this feature for service providing is limited because of the intrinsic weaknesses of abductive reasoning: in diagnosis the *cause* (of many possible causes) cannot be inferred apodictic-ally from the evidence regarding the *effect* (6.3.3.3). However, clustering the unlikely causes under the cognitive umbrella of "*otherwise/default*" helps reducing uncertainty in decision making to the future contingents. Thus, "*otherwise/default*" – mandatory for getting rid of the binary straitjacket – is useful also for supporting decision making with incomplete information: the robot is instructed what action to perform, the human decision maker is "less uninformed".

---

[8] While in 8.4 the "application end user" is the overall service beneficiary, for this sub-problem the "application-compo-nent end user" is the programmer – better said the application developer – because he/she is informed through "return" about the dialog outcome to be able to make the decision how to proceed (as *programmer*) or whether to proceed or not with the application (as *service provider*).

- *Non-Chrysippean logic concepts expressed in popular programming languages*. On the other hand, Figure 8.9 appears to illustrate a major instance of BR applied in CSIT: multifunctionality is implemented extremely simple by eliminating "*IF*" in high-level modules. Indeed, there are only multiple choice instructions in Figure 8.9, because any nontrivial service must have a variety of non-hierarchical options.

On the contrary, as regards the trivalent "*IF*" (6.3.2) – vital for procrastinating decisions involving future contingents – this thesis has no contribution except integrating it into the mechanism and for the first time into an experimental model.

In short the mechanism applies BR to convey "service-oriented semantics" via straightforward binary syntax, using only existing instructions as "*RETURN*" or "*SWITCH*".

8.3.4. Mechanism Innovative Aim: Engineering Device for 'Balanced Decision'

This section should be read in two keys: a) an *extension* of 8.3.2 and 8.3.3 (the advisor's stance) and b) an *introduction* to 9.3.3 (the PhD student stance, decisive for this thesis). Both stances rely on two batteries of facts – regarding *balanced automation* and *expert system brittleness* – and both acknowledge the *problem*: high level control was never satisfactorily supported by CSIT, neither for large scale systems (where full automation eventually failed), nor for strategic decision making (where algorithmic software failed to satisfy soon after starting, as both expert systems and DSS begun to show in the early nineties).

The conjecture that follows is mentally acceptable but cannot be defended in this thesis because the author lacks engineering background, real-time programming skills using powerful IDE (e.g., as offered by PDP minicomputers when automation was king), and process-oriented application development experience.

"The focus of BASYS is to discuss how human actors, emergent technologies and even organizations are integrated in order to redefine the way in which the value-creation process must be conceived and realized. [...] BASYS 2010 expects to discuss new approaches in automation where synergies between people, systems and organizations needs to be fully exploited in order to create high added-value products and services" [4]. This quote proves that the topic of "Balanced automation" is focused on in a way very similar to its initial approach in the mid-nineties. (The topic is commented upon in [118] where Camarinha-Matos, Terano, Martin, and Johannsen are quoted related to *integrated systems engineering*, *fuzzy engineering*, *appropriate automation*, and similar relevant terms.)

It may be conjectured that the cause is related to the implication chain below starting with the working assumption that DSS failed because they lacked credibility:

Credibility → "open to inspection" → "able to be inspected" → human-oriented interaction → reduced cognitive complexity → boundedly rational interface → non-algorithmic software → anthropocentric design → suitable mechanisms (for instance, *ED*).

Why "*ED*"? "Engineering" is self-explaining. "Device" suggests that it is neither predominantly algorithmic (based on circular time), nor purely non-algorithmic (based on human-

like agent time) because its main objective is to swap online control between "automatic" and "manual".

8.4. MERGING THE MECHANISMS IN VISUAL PATTERN RECOGNITION PROBLEMS

More than expected, the practical effects of Moore's Law – here regarding broad-band technology – shaped the evolution of the experimental model both negatively (no problem, no research, no benchmark, 2.3.4) and positively: the *toy problem* defined in 8.3.1 was significantly *extended and adapted, regardless of benchmarks* (8.4.1). Thus, the *general architectonic framework* (8.4.2) embraces all innovative features of the mechanisms defined in 6.2, 6.3 and applied in 8.2, 8.3. Those features are illustrated by *code samples of "semiotic-oriented software engineering"* (8.4.3). Finally, the experimental model is validated (8.4.4) according to 8.1.2.

8.4.1. Extending and Adapting the Toy Problem Regardless of Benchmarks

Paradoxically, technological progress added a third vulnerability[9] to the experimental model. However, it was rather easy to surmount it due to the unexpected evolution as regards the conceptual shift from Aristotle towards Lao Tzu allowing to conceive (5.4.3), set up requirements for (6.1.2), develop (6.3), and implement (8.3) mechanism features enabling an embryonic "Semiotic-Oriented Software Engineering" (SOSE2, the quotes suggest that much more transdisciplinary research is needed before daring to assert the birth of a new branch of software engineering – in fact SOSE1 should be already accepted as sub-branch of AOSE). As a result, the toy-problem narrative was reformulated to involve an interface displaying enhanced functionality (mainly supporting decision making) that allows demonstrating all new features *in actu*. Relating to an experimental model – not to the core of a commercial application – the architectonic framework (8.4.2) is "general" as abstraction level not as scope (common features of service-providing applications are included in the model but are not focused on).

8.4.2. General Architectonic Framework

   - *Avoiding numbers.* The region of interest is delineated – and transmitted as actual parameter – without any geometric reference to the position on the image (Figure 8.6).

   - *Using natural language.* The region is outlined and stored using words (Lena's mother *pronounced* the word "*hat*", she did not expressed the word in any kind of digital translation). Thus, the three images in Figure 8.5.a mean: take from image *A* the region *B* (interpreting the word "hat") and process it (Figure 8.10) to yield image *C* as required during the dialog (here just doubling the size).

---

[9] The first two were: a) avoiding continuing education as target application domain; b) simulating the interface agent. Both have been overcome as shown in 2.3.4, 3.5.1, 8.3.1 and 1.3.2, 2.3.2, 2.4, 6.1.4 respectively.

- Fighting graphocentrism. In the second prototype (not yet convincingly implemented because of simulating the interface agent) the concept "*hat*" is not expressed textually but through mouse movements that have nothing to do with the character string "*hat*".

- Fighting logocentrism. In a later prototype the client could avoid uttering "*hat*" either via mouse movements as above or indicating the region of interest through body language.

Perhaps even more important – albeit less noticed than the shift from numbers to other symbols – is reducing the weight of *dichotomous* concepts as shown in 6.2.2, 6.3.2, 6.3.3, 8.3.3. This trend is reflected in two manners of getting rid of the semantic principle of bivalence: whenever possible offering a large range of alternatives (Figure 8.9) and – when the context requires or allows the simplification of "*tertium non datur*" – choosing only the most likely variant and treating the other as explicit or implicit exception (Figure 8.7).

8.4.3. Technology: Code Samples of "Semiotic-Oriented Software Engineering"

Referring the unbiased concept "technology" in the title is the result of compromise between (huge) frustration about *object-oriented IDEs* as *major hindrance of CSIT research* (8.4.3.1) and (modest) expectations about the effectiveness of *illustrating new software engineering by outworn tools* (8.4.3.2).

8.4.3.1. Object-Oriented IDEs as Major Hindrance of CSIT Research

If the awkwardness of embedded "*IFs*" in Figure 8.9.b is easily avoided by the "*SWITCH*" in Figure 8.9.a, it is hard to keep the cognitive separation of *architecture* and *structure* – vital for any engineering endeavour – when calling a (service-oriented) subprogram is expressed conventionally as in Figure 8.4.b.

```
int returnValue, processingResult;                                         a)
// call the processing module: execute_processing(...)
processingResult = execute_processing(originalImage,partialImage,resultImage,
                                      scaleValue);
returnValue = processingResult;
return returnValue;
// the return value propagated to caller(fig. 8.3)
```

```
// call the processing module: execute_processing(...)               b)
execute_processing(g_mem,originalImage,partialImage,g_mem.resultImage,
               scaleValue,g_mem.retValProcessing);
g_mem.retValInterpret=g_mem.retValProcessing;
// the return value of service providing propagates dynamically from
// callee to caller(fig. 8.3)
```

Figure 8.4. Calling a subprogram: a) commonsensical; b) conventional Java variant.

Unfortunately, the commonsensical variant in Figure 8.4.a is impaired by several semantic and syntactic difficulties:

- The originary sins of a language family stemming from an efficient (twenty years ago) but tiresome (always) macroassembler are lasting, despite minor cosmetic improvements. For instance, a procedure-like subprogram is seen as a "void function" instead of keeping the normal idea of functions as subclass of procedures. Moreover, global variables have to be carried literally in an object from a module to another (Figure 8.11).

- Elementary programming techniques, necessary for rational application development (including structured or modular programming) are inapplicable without clumsy outmanoeuvring irrational shortcuts as shown in Figure 8.4. As a result even potential advantages of combining related IDEs are lost: thus, the *JavaScript* dialog suggested in Figure 8.8 had to be written in *Java* to allow acceptable integration in the experimental model.

- The drawbacks above are aggravated when developing service-oriented applications even somewhat more complex than a website. Referring again to Figure 8.8, the benefit of using an interpreter-based language for an obviously non-algorithmic dialog was lost too. This is acutely disagreeable when other software tools to model nondeterministic real-world situations, like multithreading or exception handling, are practically unusable in object-oriented IDEs – if available altogether.

The consequences are far-reaching (8.4.4, 9.3.2, 9.3.3).

8.4.3.2. Illustrating Semiotic-Oriented Software Engineering by Outworn Tools

In fact this Illustration is the role of the code samples but 8.4.3.1 was necessary to avoid distracting attention from the innovative features, hidden by ungainly outflanking. Now the samples can be focused on as the *structural* mirroring of the *architectonic* framework (8.4.2).

All three images in the code of "Interpret" (Figure 8.6 and Figure 8.4) are handled by words in plain English expressing pointers: `originalImage` is a constant, `partialImage` an input parameter, and `g_mem.resultImage` an output parameter. They point to the three images in Figure 8.5.

Here is illustrated more than the simple way of getting rid of bivalence by offering more than two alternatives: for post-industrial decision making in uncertain and highly dynamic environments "standardising" the "*DEFAULT*" in "*SWITCH*" enables all decision-oriented features (6.2.2, 6.3.2, 6.3.3, 8.3.3) – above all the vital guarantee that always *something* is done (either an automatic action is performed or an emergency message is conveyed).

Besides avoiding "*IFs*", even when bivalence is accepted as simplification the code shows how a cardinal leitmotif of this thesis, the cameleonic "return" (6.3.1, 6.3.3, 6.3.4, 7.2.3, 7.3.4.2, 8.1.3, 8.1.4, 8.3.3, 8.4.2, 8.4.3.1, 8.4.4, 9.3.2, 9.3.3) is easily implemented using variable return values.

8.4.4. Validating the experimental model, in spite of "hostage syndrome"

Probably this is the first purely qualitative validation of an engineering model in Romania. Certainly it is the first such validation for an experimental model of a CSIT PhD thesis. On the other hand, it is obvious (albeit not explicitly acknowledged) that: a) conferring a PhD is

based on an intrinsically qualitative validation; b) the quality of researcher (PhD student) and the quality of research (thesis) are hard to be evaluated separately; c) even more so in engineering; d) even more so in CSIT. As a result the model validation should follow the guidelines for service validation (8.1) applied within an "engineering-compatible" framework (9.1.1, because it must encompass the whole thesis). Thus, a vicious circle is inexorable: the same PhD commission evaluates thesis and experimental model, being subject to CSIT hostage syndrome. To reduce the favourable empathy involved, the model must be evaluated related strictly to its output: how does it mirror (sic!) the features it is aimed at. This task is easy to fulfil, due to the second mechanism – devised in 6.3 and applied in 8.3 – regarded here as *ad hoc* decomposable in its design space features (8.3.2 – 8.3.4). Consequently, the experimental model is validated pairing features with figures (either yielded by running the model or implementation code samples):

- **A**nthropocentric.

a)

b)
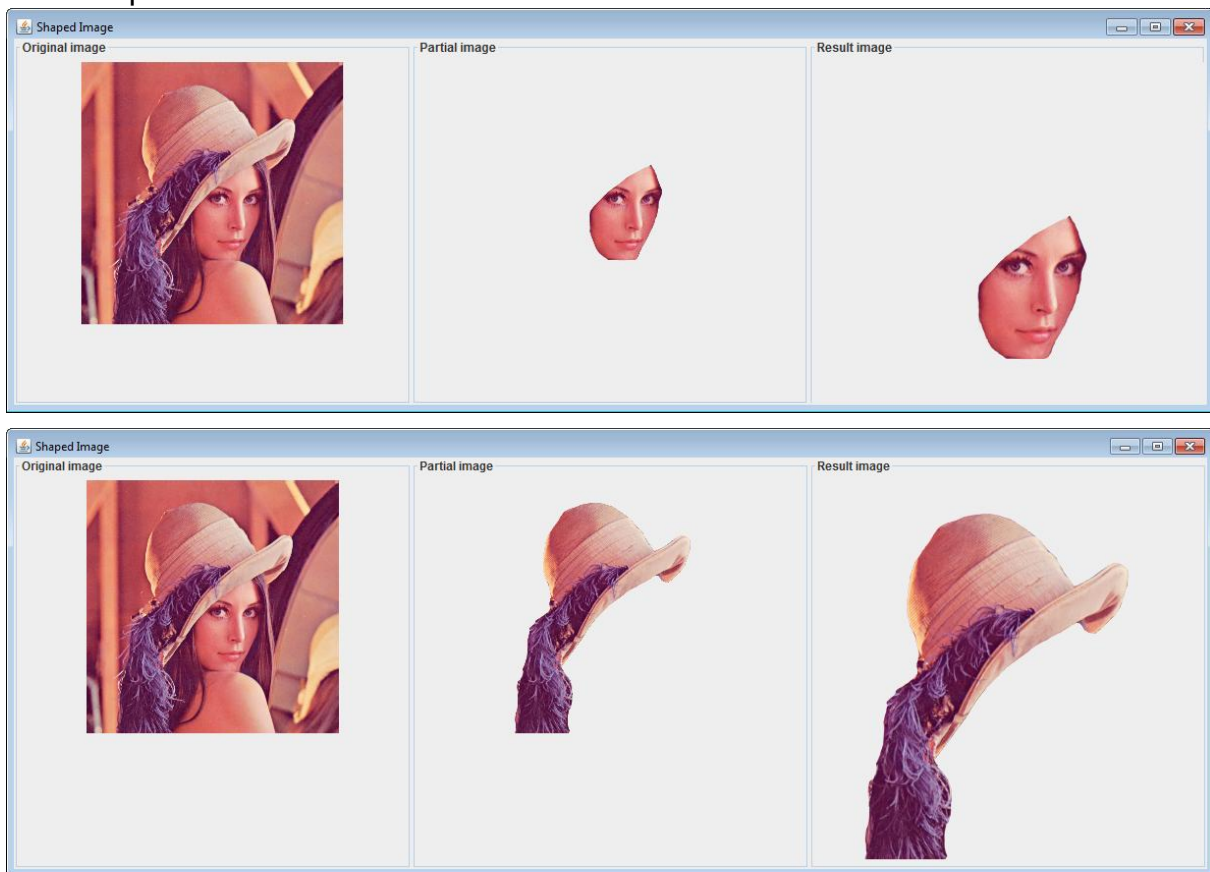
Figure 8.5. Image-based validation: original, region of interest, processed region.
a) Region of interest: "*face*"; b) Region of interest: "*hat*".

```java
public void interpret(GlobalMemory g_mem, String[] requestset) {
    // this function is called by "dialog", interprets the requirements
    // specifications and calls "execute_processing"

    g_mem.retValInterpret = GlobalMemory.SERVICE_FAILED;
    // preparing the next prototype

    String roiName = requestset[0];
    double scaleValue = Integer.parseInt(requestset[1]);
    // interpreting the requirements from requestset
    BufferedImage partialImage = (BufferedImage) g_mem.parts.get(roiName);
    BufferedImage originalImage = g_mem.originalImage;
    // preparing arguments for calling processing

    // call the processing module: execute_processing(...)
    execute_processing(g_mem, originalImage, partialImage,
                g_mem.resultImage, scaleValue, g_mem.retValProcessing);
    g_mem.retValInterpret = g_mem.retValProcessing;
    // the return value of service providing is propagates dynamically
    // from callee to caller(fig. 8.3)

    return;
    // control is returned to dialog
}
```

Figure 8.6. Avoiding numbers as much as possible: Code of "Interpret".

- **D**ecision-Oriented.

```
Start Service

returnValue = SERVICE_SUCCEEDED
.
. // trying to provide service
.
. // "if" (see comments below) the service is not provided:
returnValue = SERVICE_FAILED
. // trying to fix it
.
. // "if" (see comments below) fixing successful:
returnValue = SERVICE_SUCCEEDED

Return returnValue
```

Figure 8.7. Pseudo "Exception handling": meaningful "*RETURN*" still without "*IFs*"

- **V**erbal.

```java
public void dialog(GlobalMemory g_mem) {
      // for the time being it remains as a function called by WinMain;
      // here WinMain is missing because it is outside the dialog itself

      g_mem.retValDialog = GlobalMemory.SERVICE_SUCCEEDED;
      // preparing the next prototype

      String roiString;
      String scaleString;

      roiString = JOptionPane.showInputDialog("Region of interest:");
      // since this is a DLL module it does not use "return" inline with
      // 6.3.1, hence no service result can be verified
      scaleString = JOptionPane.showInputDialog("Scale factor:");
      // idem

      String requestset[] = { roiString, scaleString };
      // the vector is used to have a common structure for both "mother"
      // and "detective" case

      interpret(g_mem, requestset);
      // call "interpret"
      g_mem.retValDialog = g_mem.retValInterpret;
      // the return value of service providing is propagates dynamically
      // from callee to caller(fig. 8.3)
      return;
      // because of using DLL modules "return" is here confusing and
      // useless
}
```

Figure 8.8. Script, or pseudocode, or narrative of a post-industrial dialog?

- **A**bductive, **N**on-**C**hrysippean.

```
                                          a)
switch (client){
  case MOTHER:{
    // call "mother" dialog
    break;
  }
  case SECOND:{
    // call "second" dialog
    break;
  }
  .
  .
  .
  case DETECTIVE:{
    // call "detective" dialog
    break;
  }
  default:{
    doSomethingIfOtherwise();
    // warning no client today
  }
}
```

```
                                          b)
if (client == MOTHER){
// call "mother" dialog
}
else
  if (client == SECOND){
  // call "second" dialog
    .
    .
    .
  }
  else
    if (client == DETECTIVE){
    // call "detective" dialog
    }
    else {
      doSomethingIfOtherwise();
      // warning no client today
    }
```

Figure 8.9. From Aristotle towards Lao Tzu, even in *Java*, avoiding "*IFs*"
a) Using "*SWITCH*" to easily avoided "*IFs*", b) embedded "*IFs*".

- **E**ngineering.

```
public void execute_processing(GlobalMemory g_mem, BufferedImage imga,
         BufferedImage imgb, BufferedImage imgc, double scaleFactor) {

    // preparing the next prototype
    g_mem.retValProcessing = GlobalMemory.SERVICE_SUCCEEDED;

    // apply a scale operation on the region of interest
    AffineTransform at = new AffineTransform();
    at.setToScale(scaleFactor, scaleFactor);
    AffineTransformOp op = new AffineTransformOp(at,
                        AffineTransformOp.TYPE_BICUBIC);
    imgc = op.filter(imgb, null);

    // shows the images with all requirements applied
    displayImages(imga,imgb,imgc);

    return;
    // control is returned to "interpret"
}
```

Figure 8.10. Yielding the required image. Code of "Processing".

- **D**evice.

```java
public class GlobalMemory {
    final static int MOTHER = 1;              // simplest case
    final static int SECOND = 2;              // dummy case/stub
    final static int THIRD = 3;               // dummy case/stub
    final static int FOURTH = 4;              // dummy case/stub
    final static int DETECTIVE = 5;           // most complex case
    final static int SERVICE_FAILED = -1;     // failed service
    final static int SERVICE_SUCCEEDED = 1;   // successful service

    int clientType;

    BufferedImage originalImage;  // handle original image
    BufferedImage resultImage;    // handle result image

    Shape ROI_shape;         // shape designating the region of interest
    double scaleValue;       // required by affine tranformation
    // for possible extensions to other kind of situation where
    // also diminishing could be considered;

    HashMap<String,Object> parts = new HashMap<String,Object>();
    // partition of the original image, e.g. hat and face respectively,
    // see figure 8.5.

    int retValInterpret;    // return value of interpret
    int retValProcessing;   // return value of processing
    int retValDialog;       // return value of dialog
}
```

Figure 8.11. Carrying global memory throughout the application.

NINTH CHAPTER

Evaluating: The Good, the Bad, and the Future Contingent

Mir selber ist, was mir gelang, gar spät gelungen,
Doch mehr nun freut mich, dass ich rang als was errungen
FRIEDRICH RÜCKERT "Weisheit des Brahmanen"

The evaluation is made against three frames of reference: the **thesis** (*accomplishing the objectives*, 9.1), the **author** (self-evaluation: *summarising the original contributions*, 9.2), and the **field** (*open problems*, 9.3). However, to ease evaluation from other scientific perspectives too, the thesis ends with a summary of its contributions rewritten in line with *established frameworks* (9.4).

9.1. ACCOMPLISHING THE THESIS OBJECTIVES

After setting up an *evaluation framework* (9.1.1), the thesis *achievements and failures* are assessed against it (9.1.2). Taking the research context into account, the *expectations for EU2020 theses* are also contemplated (9.1.3).

9.1.1. Evaluation Framework

Evaluating the thesis without a clear framework could be subject to irrelevance because:

a) Exploratory research in CSITAO involving paradigm shifts increases the risk of biased evaluation, no matter the paradigm defended.

b) "Engineering-compatibility" and qualitative validation are yet hard to merge.

c) Requiring the experimental model to be defended in the third (penultimate) technical report was a mixed blessing: it allowed to have a "Plan B" (four objectives) but diluted "Plan A" (the very wording of the most daring fifth objective involved postponing and downgrading its evaluation until the experimental model was assessed).

d) Failing to attract researchers in humanities (psychologists, sociologists, educational scientists, linguists, etc.) in an inherently transdisciplinary research despite two papers published by Elsevier [62], [61] brings in an even more one sided evaluation.

To avoid augmenting the bias (in this stage evaluation is – inevitably – predominantly a self-evaluation) all assessments below are steered by the following changes occurred after asserting the objectives in 2009 (in parentheses are shown the reasons among those stated above for setting up the framework):

a) Defending non-algorithmic software for decision support and acknowledging in the same time the *sine qua non* role of algorithmic software in control engineering yielded an unfinished – hence exposed – research about the deep differences between various temporal dimensions (a).

b) Most explanations regarding the experimental model are based on code sample written in the user-unfriendly Java language – because neither Ada# nor Python satisfied software engineering expectations "Just-in-Time" (a, b) (9.3).

c) The fifth objective was added to with "*and substantiating first results in embryonary SOSE development rules implementable using common IDEs*" (c, b). Likewise, all later sub-objectives were merged into coherent objectives (c, d, b).

d) Lacking transdisciplinary support, the thesis had to become more self-reliant shifting in part the target (as application domain aimed at) from continuing education towards decision making (d, b).

9.1.2. Achievements and Failures

To avoid ambiguities all evaluations refer to objectives but *evidences* state explicitly in parentheses the subchapters, or (sub)sections containing the proof that a specific (sub)objective or component was met (if necessary, some comments are added). For the sake of readability, the objectives (2.2.1) are restated or repeated below.

OBJECTIVE 1. *Revisiting thoroughly the concept of bounded rationality, in view of its roles in a post-industrial (service-based) society. Choosing a Lingua Franca for holistic approaches able to promote transdisciplinarity (mainly as regards psychologists). Expressing bounded rationality in terms of this language.*

The concept of *bounded rationality*, was not just systematically revisited – from psychologic feature to subconscious approach (4.1) and from conscious hindrance to legitimate excuse for incoherent decision-making (4.2) but was redefined as polysemantic. Acknowledged as cognitive mechanism favouring simplicity (4.1) and illustrated as basic psychologic mechanism able to counteract cognitive complexity (4.3.1), BR was investigated related to decision making, behavioural economics, approximation, and uncertainty (4.2) setting up its main role in the post-industrial era: fighting cognitive chaoplexity (4.3).

Since the major new role of BR as "educational mechanism" was hard to confine in the classical conceptual framework, and for CSIT reasons far beyond this thesis – including holistic approaches in the post-industrial era (5.1.1), semantic web and general culture (5.1.2) – the Lingua Franca had to be a metascience and the only suitable found was GST (General System Theory) because it is able to express in a transdisciplinarily palatable jargon the vital relationship between cognition and cybernetic, automatic, or intentional systems (5.2).

On this groundwork BR was expressed in terms of GST, including the ambivalent key aspect of BR as feedback: a) long-term quasi-stability is preserved through BR acting as negative feedback (5.3.3); b) short interludes of creativity can be boosted through BR acting as positive feedback (5.3.4).

OBJECTIVE 2. *On this basis, substantiating the ambivalence of bounded rationality (cognitive limitation and IT guiding principle) within the agent-orientation paradigm, in applications destined to perform in dynamic and uncertain environments). Therefore: a) Investigating preterminologic BR (mainly the anthropogenetic divergence between optimization and simplicity). b) Exploring the role of BR as*

"psychological stabiliser" (through negative feedback). c) Extending the analyse to (largely preterminologic) synergy as (boundedly rational) resource amplifier.

As archetypal application destined to open, dynamic, and uncertain environments was chosen the EU2020 thesis "Non-deterministic e-Teaching in Uncertain, Dynamic Environments. Experimental Model Based on Memetic Engineering" [26] where the AO paradigm is *sine qua non*. In the challenging environment of post-modern educational chaoplexity (7.1.1, 7.1.2). BR was substantiated as both *cognitive limitation* and *IT guiding principle* (7.1.3, 5.1.4).

Both history and psychology show that "simple" was always paramount, whereas "best" became arguable when mathematics became (too) complicated (4.1.1).

BR as "psychological stabiliser" was proved in three steps: choosing an interesting topic (7.3.1) or a pervasive habit (7.4.1); investigating *memetic stability* that assure their usability (7.3.2, 7.4.2); proposing a boundedly rational way to exploit simplicity in e-teaching via extrapolating similar topics (7.3.3) and behaviours (7.4.3).

To achieve inter-paradigmatic synergy, modelling requires innovative (i.e., nondeterministic, noncategorical, agent-oriented) software (5.4.4).

OBJECTIVE 3. *Instantiating this approach for continuing education, via a framework able to manage educational chaoplexity based on bounded rationality as common denominator of, mechanism for, and connection between the two facets of continuing education: e-teaching and e-learning.*

The framework able to manage educational chaoplexity based on BR as common denominator was carried out only for e-teaching since no research started yet as regards service-oriented e-learning. However, regarding EDCHY as the key problem of permanent education able to be settled via BR as educational strategy, based on a first attempt to include BR in e-teaching (7.1.3), it was shown that BR can tackle EDCHY and that it is able to alleviate the temporal problem intrinsic to permanent education (7.1.4).

Here comes in the first failure – or, at least, major vulnerability – of this thesis (2.4.3, 3.1.2, 9.1.1): failing to cooperate with social scientists, any models based on BR as basic "educational mechanism" aimed at tackling chaoplexity (4.3.1, 5.2.4, 5.3.3, 5.4.4, and practically the whole seventh chapter) is not *trans* but *pseudo-multi*disciplinary, entailing the unacceptable risk of dilettantism. As a result, some vital aspects for [26] cannot be seen as conclusions, but have to be labelled as expectations (9.1.3).

OBJECTIVE 4. *Validating the approach by carrying out an experimental model of a nontrivial service to be provided (from a holistic perspective, within a user-centred application) by an agent-oriented interface in uncertain and changing environments. To ensure the qualitative validation soundness, the application field chosen is "Visual pattern recognition".*

The model *architecture* (8.4.2) expressed all the requirements to fulfil the objectives, its *structure* (8.4.3) implemented all of them; thus *validation* was carried out (8.4.4) simply by pairing features with figures.

Here comes in the paramount inconvenience of this thesis: trying to demonstrate new paradigms through IDEs that are out-of-date even from an old paradigm perspective.

Although not a failure *per se* it proved to be an alarming hindrance. Thus, the problem is serious, affects any exploratory CSIT research and cannot be solved within the time-span of EU2020 theses; it is still open for the next future (9.3.2, 9.3.3).

OBJECTIVE 5. *Exploring the paradigmatic shift towards building Computer Science rather on semiotics than on mathematics and substantiating first results in embryonary SOSE development rules, implementable using common IDEs.*

Since the "first results" are (self)evaluated as being original and consequential, to impair redundancy they are summarised (9.2) as such.

9.1.3. Expectations for EU2020 theses

At the moment when this thesis is finished there is just one active EU2020 thesis [26]; thus the expectations regard e-teaching models and have as time horizon November 2012:

- Bounded rationality, is much more than an excuse for poor decision making and becomes vital for continuing education because – as key psychological feature – it is *the most stable* dimension involved.

- To be sustainable in the long run any educational endeavour must be modelled based on BR. In continuing education, to overcome the temporal hiatus between teaching and learning, this educational strategy will become *a must*.

- As regards *teaching* it proves quite difficult to solve the "separation paradox" (2.1.2, 3.2.3, 3.4.1, 7.1.4, 7.2.2, 7.3.4) without an intense transdisciplinary endeavour, since it lacks credible performance metrics.

- Any metamodel of teaching should be based on psychosomatic features (first of all on BR) and can be validated so far through convincing – albeit circumstantial – evidence.

- Helplessness in managing situations too chaoplex for human BR can be lessened investigating the real world according to the huge potential of BR itself. (Unthinkable without psychologists playing the first violin.)

- Corollary: transdisciplinary teamwork is mandatory. Teams should be led by psychologists, not by computer scientists.

- Unfortunately, cognitive psychology – while consistent and established – seems rather inappropriate as corpus of knowledge because of a predominantly deterministic (left brain hemisphere, serial, "von Neumann-like") approach.

- Since time is inexorably linked to the nature of (nontrivial) services, software should be based on *processes* not on *programs*, i.e., on nondeterministic software.

9.2. SUMMARISING THE ORIGINAL CONTRIBUTIONS

To *facilitate* their evaluation, original contributions are organised in decreasing order of importance: *conceptual pillars* (9.2.1), *apparatus* (9.2.2), *approaches* (9.3.3), and other innovative outcomes, *effects of serendipity* (9.2.4). Hence 9.2.4 will be presented even more abridged than 9.2.1 (just three examples). Why? Because a holistic boundedly rational approach is better than a reductionist one that forces the evaluator to be a "two pass compiler", referring uncomfortably to sections above.

9.2.1. Conceptual Pillars

The first two main conceptual pillars of this thesis existed *per se* long time ago (for instance BR in its preterminological era) but were remodelled separately and merged together into service-oriented decision making as follows:

Bounded rationality. In line with the much extended first objective BR was:

a) *Redefined as polysemantic*, adding three new meanings to the syncretic connotation of "hindrance/excuse for poor decisions": a1) lasting psychologic *feature*, critical for nontrivial decision making; a2) main (decisional) *mechanism* in service-oriented (online) decision support, based on incomplete information; a3) basic e-teaching *strategy* for continuing education tending to become a cardinal educational *guiding principle*.

b) *Expressed coherently* in GST. Systemic attributes as "*negative feedback*" or "*stability*", vital for applying BR as mechanism, are mentally easy accessible (Q1, Q4, Q3) to social scientists (e.g., to express transdisciplinary research with BR as "cognitive engine").

c) *Substantiated* as regards meanings a2) and partially a3) in experimental models (Q4, Q3, Q1, 3.e) validated *in ovo* (Q4, Q4C, Q1, 3.d). Thus, in the challenging environment of post-modern educational chaoplexity BR was ascertained as both *cognitive limitation* and *IT guiding principle* and was proved as "*psychological stabiliser*". In short BR was applied in managing educational chaoplexity as *common denominator* of, *mechanism* for, and *connection* between the two facets of continuing education: *e-teaching* and *e-learning*.

"**Just-in-Time**". The concept was:

a) *Upgraded* from the status of label for an essential inventory strategy (in the industrial era) to a *sine qua non* requirement for (nontrivial) service providing (in the post-industrial era) and more general (Q4, Q4C, 3.a, 3.e, 3.d) for any decision making.

b) *Semantically enriched*. As superseder of "*real time*" it becomes a *raison d'être* feature of any service and of any decision making (Q4, Q4C, 3.a, 3.b).

c) *Merged with bounded rationality*. As a result of the compound concept "BR + JIT" (Q4, Q4C, Q1), this thesis endorses previous claims [64] adding to Zadeh's "*Rationale 2 for granulation: precision is costly*" [87]: "*Rationale 3: precision is unnatural*" (from a BR stance) and for decision making in chaoplex and risky situations, even "*Rationale 4: precision is harmful*" (from a JIT stance).

Agent-Orientation. It is the third conceptual thesis pillar but will be commented upon only below since no original contribution is to mention at the conceptual echelon.

9.2.2. Apparatus/Mechanisms

The term "apparatus" was chosen from the exploratory research perspective to suggest a cognitive *modus operandi* while "mechanisms" reflects the engineering science perspective. The order is of decreasing importance as "apparatus" (considering the validation process, it is also the order of increasing importance as software engineering "mechanisms"). Thus, here are mentioned a general *principle* for online decision support and two non-algorithmic mechanisms for word-based modelling:

- ***Swapping between times (to make balanced decision)***. The importance of asserting and proving the time pattern in Figure 9.1 is highlighted by the fact that neither control engineers, nor mathematicians, nor IT professionals acknowledge the time dissimilarity.
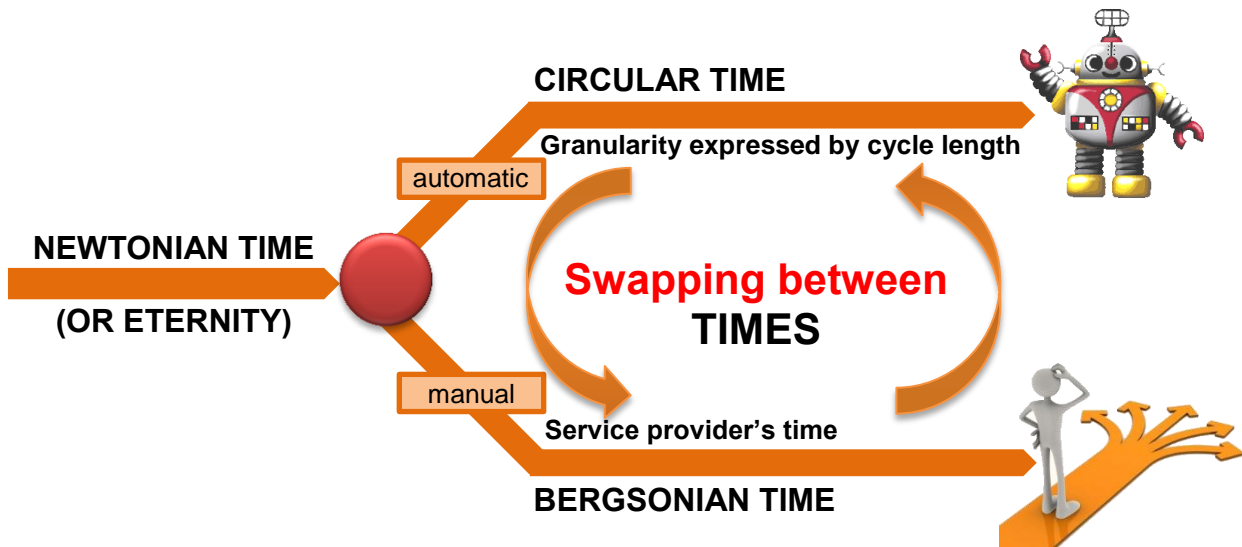

CIRCULAR TIME

Granularity expressed by cycle length

automatic

NEWTONIAN TIME

(OR ETERNITY)

Swapping between TIMES

manual

Service provider's time

BERGSONIAN TIME

Figure 9.1. What time is it? Swapping from time to time(s).

Automatic control: decisions are *algorithmic* and made by *robots*. Time is either noninteresting (algorithm *stops* when a problem is solved) or circular ("*return*" restarts a loop).

Manual control: decisions are *boundedly rational* and made by *humans*. Time is Newtonian in simple situations, and must be Bergsonian in chaoplex situations because services (decision support included) are for humans ("*return*" was semantically enriched, since "*return -1*" is mandatory for warning the user that the service failed).

In the industrial (*product*-oriented) era, the prevalent (algorithmic) paradigm was *sufficient*; in the post-industrial (*service*-oriented) era, both paradigms are *necessary*. Hence swapping between times is mandatory and decisions should be "balanced" (Q4C, Q4, 3.d).

- ***ADVANCED***. The service-oriented decision-making framework was validated qualitatively for all the letters in the backronym. It goes beyond Zadehian "Computing with *words*" towards "Computing with *images*", in its semiotic *spirit* and not within its mathematical *distortion*[10].

- ***Decision input bar***. The multifunctional bar for decision input is: a) devised from an explicit post-industrial perspective (service-oriented nondeterministic decision-making); b) universal (usable for all kind of uncertain input, and for all psychophysical laws governing

---

[10] "The basic lessons of "Computing with Words" were subsumed conceptually to fuzzy sets, sometimes yielding ironic side effects: refusing to accept that Zadeh's aim was to demythify the Number, accomplished mathematicians try to reconcile the Boolean infrastructure of IT with fuzzy sets theory moulding complex theories where instead of dealing with two integers, computer scientists have to consider the continuum of reals!" [64]. Worse: engineers too!

cognition Q4, Q2); c) applicable to real-world problems independent of any paradigm (Q4); d) implementable using conventional algorithmic software engineering.

- ***Illustrating SOSE with outworn IDEs*** (in applications destined to perform in dynamic and uncertain environments). ADVANCED should work incorporated in an interface agent. This macro-architectonic feature (service-providing process, based on multimodal interfaces and aiming at decision making with incomplete information) required by the model was the only feature yet unaffordable with popular IDEs. All other innovative features could be validated qualitatively using plain *Java* (i.e., giving up the major advantages of using the dialog-oriented *Java Script*, to avoid the architectural drawbacks of a Web application). For instance, "non-Chrysippean practices" allowing flexible and varied service providing were expressed straightforwardly in *Java*, replacing "IF" by "SWITCH" and using "DEFAULT".

9.2.3. Approaches

Perhaps excepting the last one, all approaches are customary. Hence, here only value added is abridged.

- ***Anthropocentrism***. Emphasis was on: a) symbolic interfaces; b) fighting both chaoplexity facets: *reducing cognitive* complexity and *hiding structural* complexity; c) interfacing is *analog* and *multimodal*; d) autonomous behaviour from all its sources: living beings, automata, and software; e) shifting from quantity (testing the *technological efficiency* of the application) to quality (validating the *target-oriented effectiveness* of its actual use). (Q1)

- ***Holism***. The bond is twofold and strong: a) cognition is holistic and boundedly rational (*Wa4*, Q1, Q4); thus, any holistic approach is anthropocentric *par excellence*; b) if some predictable services could be canned (and handed over to machines) no service could be assessed (or adequately provided) if conceived as "decomposable" (validation is holistic, hence qualitative). Right-brain style supplements the limited left-brain algorithmic procedures (non-textual pseudocode for "Dialog" (Figure 8.8) with user-oriented comments, pattern recognition in "Interpret", (Figure 8.6) image-based validation of mechanisms (Figure 8.5)). To restore the "holos" of the human brain, where BR comes from, *semiotics* is vital for answering questions like: "What is the horsepower of your interface?"

- ***Agent-Orientation***. Having no agent in a work aiming to be "probably" the "first authentically agent-oriented thesis in Romania" impairs chances of passing on a research legacy – not even as open questions. Thus, the experience in trying – and failing – to implement complex interface agents is reduced to counterposing beliefs (in parentheses are ideas proved less important):

- For nontrivial services, provider agents must be bodiless because (for the time being) they are interface agents. (Bodiless agents are used when robots are unaffordable.)

- The fundamental hindrance in developing interface agents is caused by poor ontologies with temporal relations. (Agents are processes and popular IDEs don't support for event-based thread synchronization and exception-based reactivity.)
- For a protoagent it is sufficient to have access to the interrupt subsystem and to build on it (Ada-like) exception handlers. (A software entity could be labelled as "*agent*" iff it is treated by the operating system as *thread*, i.e., as atomic, sequential, asynchronous, and dynamic entity.)
- Making decisions *in behalf* of humans, agents are inherently nondeterministic. (Robots are "agents with body" and can react deterministically to stimuli when polling their environment "Just-in-Time".)

- ***Transdisciplinarity***. Choosing GST as *Lingua Franca* for psychologically-oriented addressees was much more than a linguistic bridge as proved by [62], [61], despite their forced dilettantism.

- ***Exploring memetic engineering***. Etymology extended both *time range* and *cultural space* of memeplexes, proving their memetic stability and giving incentives for further research [26]. Example: "*Robot*" may be descended from a word that meant "slave labor", and was later generalized to just "labor." (Other examples of "concepts-memes" in 9.2.4.)

9.2.4. Effects of Serendipity

In a thesis intrinsically tributary to heuristics – from *Zeitgeist* to topics to approach – most of such effects are hard to be distinguished from other thesis outcomes. On the other hand, due to the very manner of arriving at, they are either minor (skipped over) or of transdisciplinary nature (very shortened here). They are related to linguistics because most results are about etymology – including folk etymology – stemming from the transdisciplinary approach above linking semiotics to memetics. Moreover, the three examples below are due to the research "etnolinguistic environment" they come from:

- *Order and computer science*. The German term "Rechner" proves an old connection between ordering and computing as mental processes. This research di*RECT*ion (Rex, Recht, Rector, *reg*lage) may lead to other links between paleo-mathematics and semiotics.

- *Strange linguistic coincidences.* Why are *counting* and *narrating* etymologically related? (Bernard Werber shows in "Encyclopedie Du Savoir Relatif Et Absolu" that there are word pairs similar to "count/recount": "compter/raconter", "zählen/erzählen"). Such tracks are worth to be followed proving the usefulness of "*not numerical mathematics*".

- "*La ţanc*". If the term comes from the Dacian substratum, the linguistico-memetic exercise acquires a new transdisciplinary dimension: "*La ţanc*" becomes the first substratum-based term that enters not only the IT idiom but perhaps the Romanian scientific terminology altogether.

9.3. OPEN QUESTIONS

Are they *significant* and *innovative* enough to be *questions* and to be let *open*? Thus, besides land marking a "new frontier" they should be read in the much modest key of the expected role the author can play in their future investigation: *future work* within the *EU2020 theses* cluster in 2012 (9.3.1), *medium-horizon CSITAO* research (9.3.2), and taking part in *other CSIT research*, labelled in Roman cartographic style with "*Hic sunt leones*" (9.3.3).

9.3.1. Proposed for EU2020 theses

At this moment EU2020 theses means actually [26] and the following is seen from its perspective. Thus, the questions that remained open when this thesis was completed need a minirationale to be accepted as valuable research legacy: *Why is* **Question** *important to continuing education? Because* **Supposition**

- *Q1: Linguistics (as part of Semiotics) is paramount.* **S1**: *Learning the mother tongue is obviously boundedly rational; teaching babies seems to be too. Moreover, the methods seem pervasive, language-independent, and almost unchanged since anthropogenesis.* Hence, teaching (meta)models should try to find out the methods mothers use (labelled or not as "dynamic knowledge", or "skill", or "know-how", or even "life experience").

To enable a smooth passing to the next open question, here is the telling instance of *logarithm*: *logos* ratio, reckoning + *arithmos* number.

- *Q2: Logarithms are "natural" no matter the base.* **S2**: *Decomposing "CSITAO", logarithms are paramount for all parts: CS (binary logarithm for hardware), IT (common logarithm for conventional software), AO (natural logarithm for anthropocentric applications).* Indeed, the *high propension to comparisons* should be investigated focused on the *logarithmic function*. Examples: a) the concept of equality is linked to both "*nil*" and "*zero*"; b) Shannon's unacceptable technocentric[11] *information theory* could survive in the post-industrial era *because* it is based on logarithms; c) nonverbal communication via *linear* input bars should be extrapolated through *psychophysical* input bars based firstly on logarithms but also on related (exponential, sigmoid, and so on) functions. Hence, teaching metamodels should shift the focus from conventional mathematics to modern, human-centred (non-numeric and even non-verbal) mathematics. (Of course, any mathematics is intrinsically *symbolic*, but was paleo-mathematics always *verbal*, even in solar clocks or at Stonehenge?)

- *Q3: Bounded rationality as twofold feedback.* **S3**: *Since BR is a – perhaps is THE – main cognitive mechanism and cognition involves inventiveness (e.g., "Eureka"-like effects) it is likely that BR could boost creativity (via positive feedback).* However, as shown: a) the link between BR and simplicity supports the prevalence of BR as psychological stabiliser (via negative feedback); b) it is challenging to prove that the same mechanism – here BR – could generate antithetic types of feedback. Hence, a GST based

---

[11] Anthropocentric approaches would need rather something that evaluates *certainty* at the *destination* instead of *uncertainty* at the *source*.

and cybernetic-oriented investigation should be carried out starting from the idea of local feedback loops within simulated discernable educational subsystems. Could "bipolar disorder" be a promising research path based on swapping between feedback loops, to diminish both "fruitless stability" and "vicious creativity"?

- **Q4**: *Boundedly rational perception of different times is vital for service providing.* **S4**: *This holds for decision making and for teaching too. The relationship between time and decisions is supposed to be that shown in Figure 9.1.* Time is Newtonian ("Caesium Time") only in simple situations where it does not matter significantly. When chaoplexity counts time must be perceived/managed by service users similarly to Bergsonian ("Carbon Time") because nontrivial services (decision support, teaching, intensive therapy, etc.) are for humans also when they are provided by robots. From an AOSE stance it is necessary to find out what kind of time – and in what context – could be treated safely as preemptive resource. (Perhaps that requires investigating the time memeplex based on memetic engineering.)

- **Q4C (corollary)**: *Establishing agents as non-algorithmic software entities[12].* Only after answering *Q4* could start a real debate regarding the status (or even the definition) of "*algorithm*" in a service-oriented society. That should: a) legitimate (non)algorithmic software and suitable mechanisms to implement it; b) let SOSE – or at least SOSE1 – to become a genuine branch of software engineering; c) promote developing "online DSS" based on "balanced decision making" (where "balanced" has the same meaning as in "balanced automation").

9.3.2. Proposed for medium-horizon CSITAO research

Noticeably, most open questions regard the fifth thesis objective. Indeed, the possibility to build Computer Science rather on Semiotics than on Mathematics seems to be more than a single paradigmatic shift. Thus, to persist in using names metaphorically, before accomplishing the shift from *Kelvin* to *Zadeh* it would be pointless to try the shift from *Zadeh* to *Lao Tzu*. Though, considering the (self)evaluation as well as the open questions above, the technically closed objective could (and should) become the kernel of a future CSITAO thesis, removing its confinement to exploration. Some key facets are the open questions unanswered or uncared for within EU2020 research:

- Is the archetypal *yin-yang* symbol (suggesting both *sigmoid* and *linear nonseparability*) just a metaphor or is it mathematically significant?

- What is the relationship between BR, synergy, nonverbal communication, and psycholinguistics? What relations in nontextual/nonverbal ontologies are applicable in SOSE?

- Why are so many exact trigonometric formulae or infinite series to express the golden ratio when no user cares about them?

---

[12] The FIPA standard defining the *agent* as *process* was a necessary and huge step forward but it is obviously not sufficient for boosting a paradigm shift. Indeed, it is almost a selfcontradiction: standards are overlooked mainly *because* they conserve all obsolete facets of prevalent paradigms.

- Close related question: on the other hand, why the simplest way to get an idea about the numeric value of the ratio is to calculate not the geometric ratio itself but the quotient of successive Fibonacci numbers? (The answer looked for regards the role of time in boundedly rational approaches to risk management in a post-industrial society.)

- Why is "Innumeracy" a much newer concept than "Illiteracy" and what is their relationship to BR? (The investigation should consider the seminal work of Gigerenzer, as well as the ideas of Nadin, Nake, and Paulos.)

- What about reviving other semiotic-oriented unfinished research regarding Computer-Aided Semiosis or "Silicon time" based on Husserlian "thick time" (for a primeval consciousness of bodiless agents)?

- Is the danger of "*semiotic endogamy*" real? One of the possible side-effect implication chains of modern IT is: Semantic Web → Social Networks → Folksonomies → Linguistic Closure. Taking into account Wittgenstein's caveat that the limits of our language are the limits of our world, could GST act as "domain mini-ontology-Kernel"?

9.3.3. Proposed for other CSIT domains. "Hic sunt leones"

This section is postponed and contains are only keywords or suggestions:
a) Anthropocentric assessment of information oriented towards plausibility at destination
b) CSIT oriented mathematics of time or at least "space-time" as in the d'Alembertian.
c) Eco "*intentio*-ns" vs time: *auctoris*/past, *operis*/present, *lectoris*/future
d) Does autonomous behaviour imply initiative or control? Does it imply both or none of them?
e) Are *educational* and *situational* chaoplexity equivalent? (Could e-teaching and DSS use the same SOSE tools?)

9.4. SUMMARY OF ORIGINAL CONTRIBUTIONS, REFORMULATED

The main results refer to the following:
- **Concepts:** a) *Bounded Rationality* was: *redefined as polysemantic* lasting psychologic feature, *mechanism* for decision support based on incomplete information, *strategy* for continuing education (sections: 4.1, 4.2, 4.3, 5.1.1, 5.1.2, 5.3.3, 5.3.4, 7.1.1, 7.1.3); *expressed coherently* in GST for transdisciplinary (sections: 5.1.1, 5.1.2, 5.2.4, 5.3.3, 5.3.4); substantiated as stabilizing *mechanism* for, and *connection* between subsystems of continuing education (sections: 7.1.3, 7.1.4, 7.3.2, 7.3.3). b) "*Just-in-Time*" („la ţanc", JIT) was: *upgraded* from the status of label for an essential inventory strategy (in the industrial era) to a *sine qua non* requirement for service providing (in the post-industrial era) (sections: 3.4.1, 3.4.2); *semantically enriched* (as superseder of "*real time*" it becomes a *raison d'être* feature of any service and of any decision making) (in section: 3.4.3); *Merged with bounded rationality*, the compound concept "BR + JIT", allowed adding to Zadeh's assertion on precision: "*Rationale 3: precision is unnatural*" (from a BR stance) and

"*Rationale 4: precision is harmful*" (from a JIT stance) (sections: 3.2.3.1, 4.2.3, 5.4.3, 6.2.3, 8.2.1, 8.4.2).

- **Mechanisms:** a) "*Balanced decision*" in chaoplex situations. Swapping between *automatic* control (robots decide deterministic based on algorithms, time is circular: "*return*" restarts a loop) and *manual* control (humans decide nondeterministic, based on BR (time is irreversible: "*return*" is mandatory for service finishing) (sections: 6.3.4, 7.3.4.2, 8.3.2, 8.3.4); b) *Service-oriented decision-making framework*. Meaning: anthropocentric (multimodal, analog interaction), oriented on decisions based on uncertainty (future contingent, abduction, procrastination), semiotics (nonnumeric, nontextual or nonverbal software), non-Chrysippean (multiple alternatives replacing "IF" by "SWITCH" with "DEFAULT") (sections: 6.3.1, 6.3.2, 6.3.3, 8.2.2, 8.2.3, 8.3.2, 8.3.3, 8.4.3.1); c) *Multifunctional bar for analog input oriented on decisions* is: universal (usable for all kind of uncertain input, and for all psychophysical laws governing cognition), applicable to real-world problems independent of any paradigm, implementable using conventional algorithmic software engineering (sections: 6.1.2, 6.2.1, 6.2.3, 6.2.4, 8.2.1, 8.2.3); d) *Illustrating elements of Semiotic-Oriented Software Engineering* with outworn IDEs (object oriented, without exception handling, with primitive multithreading) (sections: 8.4.1, 8.3.2).
- **Approaches:** Are based on: a) *Anthropocentrism* (symbolic interfaces, reducing cognitive complexity and hiding structural complexity); b) *Holism* (cognition is holistic and boundedly rational, no trivial service could be assessed (or adequately provided) if conceived as "decomposable", validation qualitative); *Agent-Oriented* (agents are bodiless because they are interface agents); *Transdisciplinarity* (Choosing GST as *Lingua Franca* for psychologically-oriented addressees); e) *Exploring memetic engineering* (memetic stability verified through etymology, cultural spaces, compared linguistics) (sections: 3.2, 5.1.1, 5.1.2, 5.2.3, 5.2.4, 5.4.3, 5.4.4, 6.1.2, 7.1.3, 7.3.4, 8.1.1, 8.3.4).
- **Effects of serendipity:** especially in Romanian terminology („la ţanc", innumeracy) (in section 7.4.3).

In nuce, this thesis should be regarded as having attained its target if the concept of "*Bounded Rationality*" will be subject to a semantic inversion for all stakeholders involved (first of all decision makers) being perceived as versatile human-oriented modelling mechanism instead of hard to avoid multifaced hindrance.

Author's Work

Glossary

AW1.   Bărbat, B.E., R.D. Fabian, C.I. Brumar. *CSITAO Carnap-like Glossary*, http://bcu.ulbsibiu.ro/digitale/doctorate/glossary_csitao.pdf

I. Articles in ISI journals with impact factor

AW2.   Ralf Fabian, Misu-Jan Manolescu, Loredana Galea, Gabriela Bologa, *Bounded Rationality through the Filter of the Lisbon Objectives*, International Journal of Computers, Communications & Control, IJCCC, Băile Felix-Oradea, Romania, 2010, Agora University Editing House, ISSN 1841-9836, E-ISSN 1841-9844, Vol. V (2010), No. 5, pp. 710-718.

II. Transdisciplinary papers related to the EU2020 targets published in international proceedings other than CSIT

AW3.   Constantin Oprean, Ralf D. Fabian, Cristina I. Brumar, Boldur E. Bărbat, Bounded Rationality for "Just In Time" Education, 2nd World Conference on Psychology, Counselling and Guidance, Procedia-Social and Behavioral Science Journal, May, 2011, pg. 983-987 Antalya, Turkey, ELSEVIER, ISSN: 1877-0428

AW4.   A.E Lascu, Ralf Fabian, *e-Semiotics for Romanian-German Transcultural Interfaces*, The Good, the Bad and the Unexpected: The User and the Future of Information and Communication Technologies, Sapio, Bartolomeo et al. (eds), Moscow, Russian Federation, May 2007: Conference Proceedings. Brussels, EU-COST Action 298 Participation in the Broadband Society, VOL II., 2008, pg. 737-742, ISBN: 978-92-898-0042-6

AW5.   C. OPREAN, C.V. KIFOR, B.E. BĂRBAT, A. BRAŞOVEANU, R.D. FABIAN, *Bounded Rationality in Computer Science Curricula*, Proceedings of the 2010 International Conference on Frontiers in Education: Computer Science & Computer Engineering, FECS 2010, eds. Hamid R. Arabnia, Victor A. Clincy, Azita Bahrami and Ashu M. G. Solo, July, 2010, Las Vegas, Nevada, USA, CSREA Press, ISBN 1-60132-143-0, pp. 135-140

AW6.   C. Oprean, C. I. Brumar, C.V. Kifor, R.D. Fabian, B.E. Bărbat, Post-Industrial Quality for Sustainable Development, Proceedings of the 1st International Conference on Quality and Innovation in Engineering and Management, Cluj-Napoca, March, 2011, pg. 159-162.

AW7.   Boldur E. Bărbat, Ralf Fabian, Cristina Brumar, Roxana Muntean, *Bounded Rationality and approximation in modern artificial intelligence*, Proceedings of The International Workshop - New Approaches, Algorithm and Advanced Computational Techniques in Approximation Theory and its Applications, Sibiu, Romania, September, 2007, pg. 64-67, Lucian Blaga University Press, ISBN 978-973-739-949-2.

III. Paper in Thomson Reuters indexed Journals and Proceedings

AW8. Ralf Fabian, Alexandru-Nicolae Marcu, *Natural language processing implementation on Romanian ChatBot*, Proceedings of the 9th WSEAS International Conference on SIMULATION, MODELLING AND OPTIMIZATION, Budapest Tech, Hungary, September 3-4, 2009, pg. 440-445, WSEAS Press, ISSN: 1790-2769, ISBN: 978-960-474-113-7.

AW9. Ralf Fabian, Daniel Hunyadi, Emil. M. Popa, *Syntactic pattern model classification with total fuzzy grammars*, Proceedings of the 12th WSEAS International Conference on Computers - New Aspects of Computers, Heraklion, Greece, July 2008, pg. 317-321, Published by WSEAS Press, ISSN 1790-5109, ISBN 978-960-6766-85-5.

AW10. Emil. M. Popa, Ralf Fabian, Cristina Brumar, *A Bounded Rational Review of Approximation and Undecidability in Economic Modelling*, Proceedings of the 12th WSEAS International Conference on Computers - New Aspects of Computers, Heraklion, Greece, July 2008, pg. 303-308, Published by WSEAS Press, ISSN 1790-5109, ISBN 978-960-6766-85-5.

AW11. Ralf Fabian, Pleşca Sorin, *Stigmergy-based Software Toolkit for Virtual Enterprises*, Proceedings of the 11th WSEAS International Conference on COMPUTERS, Agios Nikolaos, Crete Island, Greece, 2007, pag. 438-441, ISSN 1790-5117, ISBN 978-960-8457-95-9.

AW12. Vasile Crăciunean, Cristina Elena Aron, Ralf Fabian, Ioan-Daniel Hunyadi, *Multi Level Recursive Specifications for Context Free Grammars*, Proceedings of the 11th WSEAS International Conference on COMPUTERS, Agios Nikolaos, Crete Island, Greece, 2007, pag. 275-280, ISSN 1790-5117, ISBN 978-960-8457-95-9.

AW13. Vasile Crăciunean, Ralf Fabian, Ioan-Daniel Hunyadi, Emil M. Popa, *Fix point internal hierarchy specification for context free grammars*, Proceedings of the 11th WSEAS International Conference on COMPUTERS, Agios Nikolaos, Crete Island, Greece, 2007, pag. 247-251, ISSN 1790-5117, ISBN 978-960-8457-95-9.

IV. Papers indexed by other international databases

AW14. Ralf D. Fabian, Dana Simian, *Bounded Rationality and Visual Pattern Transmission*, Proceedings of the European Computing Conference, Paris, France, April, 2011, WSEAS Press, ISBN: 978-960-474-297-4, pg. 421-426

AW15. Ralf Fabian, Emil Marin Popa, *Fuzzy Extension on Context-free Grammars*, Proceedings of 2nd Annual SEERC Doctoral Conference, Thessaloniki, Greece, June 2007, SEERC Publicher, ISBN: 978-960-89629-5-8
http://adnanmenderes.academia.edu/MuratArman/Papers/437149/European_Union_Enlargement_towards_the_Western_Balkans_Identity_Transformation_as_a_Foreign_Policy_Instrument

AW16. Vasile Crăciunean, Ralf Fabian, Emil. M. Popa, *Total Fuzzy Grammar Driven Architecture for Intelligent Software Sytems*, WSEAS Transactions on Computers, Issue 2, Volume 6, February 2007, pag. 248-253, ISSN 1109-2750.

AW17. Vasile Crăciunean, Ralf Fabian, Emil. M. Popa, *Algorithm for Optimal Decomposition of Software Applications*, WSEAS Transactions on Computers, Issue 2, Volume 6, February 2007, pag. 242-247, ISSN 1109-2750.

AW18. Ralf Fabian, Vasile Crăciunean, Emil M. Popa, *Intelligent system modeling with total fuzzy grammars*, Proceedings of the 8th WSEAS International Conference, Mathematical Methods and Computational Techniques in Electrical Engineering (MMACTEE), Bucharest, Romania 2006, pag. 82-87, ISSN 1790-5117, ISBN 960-8457-54-8.

AW19. Ioan-Daniel Hunyadi, Emil M. Popa, Ralf Fabian, Ionela Mocan, *Translation for intermediate code*, Proceedings of the 8th WSEAS International Conference, Mathematical Methods and Computational Techniques in Electrical Engineering (MMACTEE), Bucharest, Romania 2006, pag. 93-98, ISSN 1790-5117, ISBN 960-8457-54-8.

AW20. Vasile Crăciunean, Ralf Fabian, Emil M. Popa, *Package architecture optimization in software application design*, Proceedings of the 8th WSEAS International Conference, Mathematical Methods and Computational Techniques in Electrical Engineering, Bucharest, Romania, 2006, pag. 99-102, ISSN 1790-5117, ISBN 960-8457-54-8.

V. Papers related to previous PhD research

AW21. Ralf Fabian, Vasile Crăciunean, Emil M. Popa, *Development hierarchy for project architecture*, The Annual International Scientific Conference of Pedagogic Staff And Scientific Researchers Second Edition, Education and Academic Research Structures of The Knowledge-Based Society, Volume I - Economy, Engineering, May, 2008, Sibiu, Romania. pg. 369-375, ISSN 1844-5381, *ALMA MATER* Publishing House.

AW22. Vasile Crăciunean, Ralf Fabian, Florin Stoica, *Package clustering algorithm for enhancing huge project design,* The Proceedings of the Eight International Conference on Informatics in Economy, Academy of Economic Studies, Bucharest, 2007, pag. 1091-1097, ISBN 978-973-594-921-1.

AW23. Ralf Fabian, Vasile Crăciunean, *Updatable fuzzy grammar system*, The Annual International Scientific Conference of Pedagogic Staff And Scientific Researchers First Edition, Alma Mater University Of Sibiu, May, 2007, Sibiu, Romania. pg. 403, ISSN 1843 - 8288, *ALMA MATER* Publishing House

AW24. Ralf Fabian, *A Method of Describing Algorithms based on String Replacement*, INFORMATION & KNOWLEDGE AGE, The Proceedings Of The Seventh International Conference On Informatics In Economy, Faculty of Economic Cybernetics, Statistics and Informatics, Department of Informatics in Economy, Bucharest, 2005, pag. 404-408, ISBN 973-8360-04-8.

AW25. Ralf Fabian, *Online study program design and deontological issues*, International Workshop E-learning Aspects in Medicine and Nursing, MEDINF 2007 e-Health Days in Sibiu, Medical Informatics, Telemedicine, Biostatistics and Clinical Epidemiology, organized in the frame of the research grant DANTE CEEX 73-2006, November, 2007, ISBN 978-973-739-592-4, Lucian Blaga University Press.

AW26. Ralf Fabian, *Tendinţe în dezvoltarea programelor de studiu online*, International Workshop E-learning Aspects in Medicine and Nursing, MEDINF 2007 e-Health Days in Sibiu, Medical Informatics, Telemedicine, Biostatistics and Clinical Epidemiology, organized in the frame of the research grant DANTE CEEX 73-2006, November, 2007, ISBN 978-973-739-592-4, Lucian Blaga University Press.

AW27. Ralf Fabian, *Modelarea prin Maşini cu Stări Abstracte*, Conferinţa Economică Ştiinţifică Internaţională „BINOMUL SĂRĂCIE-BOGĂŢIE ŞI INTEGRAREA ROMÂNIEI ÎN UNIUNEA EUROPEANĂ", Facultatea de Ştiinţe Economice, Universitatea „Lucian Blaga" din Sibiu, 2005, pag. 515-523, ISBN 975-739-101-2.

AW28. Ralf Fabian, *Development of Techniques for Process Modeling With Abstract State Machines*, International conference „The Impact of European Integration on the National Economy", The Faculty of Economics and Business Administration, Babeş-Bolyai University, Cluj-Napoca, 2005, pag. 244-252, ISBN 973-651-007-0.

AW29. Ralf Fabian, *Tree Grammar Processing*, Conferinţa Economică Ştiinţifică Internaţională „ROMÂNIA – EXIGENŢE ÎN PROCESUL DEZVOLTĂRII, DIN PERSPECTIVA INTEGRĂRII ÎN ANUL 2007", Facultatea de Ştiinţe Economice, Universitatea „Lucian Blaga" din Sibiu, 2004, ISBN 973-651-992-9.

AW30. Ralf Fabian, Cristina Elena Aron, *Pattern Matching with Tree Grammars*, The 5th Biennial International Symposium SIMPEC 2004, University "Transilvania" of Braşov, Faculty of Economic Sciences, Braşov, 2004, pag. 148-153.

AW31. Ralf Fabian, *Common Graphical User Interface*, A VI-a Conferinţă Internaţională în Informatică Economică, Facultatea de Cibernetică Economică, Statistică şi Informatică, Bucureşti, 2003, pag. 275-279.

AW32. Ralf Fabian, *Interfaţa grafică cu utilizatorul* Al V-lea seminar româno-german în Teoria aproximărilor şi aplicaţiile ei, Universitatea Româno-Germană Roger, Sibiu, 2003.

References – State of The Art

[1]   Andersen, B., G. Ree, I. Sandaker. A Web of Learning Opportunities. *European Journal of Education*, Special Issue: *BuildingEuropeanLearningCities and Regions*, **45**, 3, 481–493, Interscience Wiley, 2010.

[2]   Arakji, R.Y., K.R. Lang. Adoption and Diffusion of Business Practice Innovations: An Evolutionary Analysis. *International Journal of Electronic Commerce*, 5, 1, Fall, 145 168, 2010.

[3]   Ashbaugh, M., R. Benguria. Dido and Isoperimetry. *International Conf. on the Isoperimetric Problem of Queen Dido and its Mathematical Ramifications*, Chartage, 2010. http://math.arizona.edu/~dido/didon.html;

[4]   BALANCED AUTOMATION SYSTEMS 2010. *9th IFIP International Conference on Information Technology for BALANCED AUTOMATION SYSTEMS (BASYS 2010)*, Valencia, Spain, http://158.42.104.38/ocsystem/index.php/basys/basys2010.

[5]   Bărbat, B.E. E-Maieutics. Rationale and Approach. *Int. J. of Computers, Communications & Control*, 3, Supplement: Suppl. S, 40-54, http://www.britannica.com/bps/additionalcontent/18/33373698/EMaieutics-Rationale-and-Approach, 2008.

[6]   Bărbat, B.E. From e-Learning to e-Nursing, Applying Non-Algorithmic Paths. *Medinf 2007 Workshop: E-Learning aspects in medicine and nursing.* 29th International Conference of the Romanian Medical Informatics Society, Sibiu, 2007.

[7]   Bărbat, B.E. Interface Agents for Transcultural Communication. A Framework. *The good, the bad and the challenging: The user and the future of information and communication technologies* (B.Sapio *et al*, Eds.), Conf. Proc., COST Office, Brussels, Vol. 2, 666-674, 2009.

[8]   Bărbat, B.E. NEWTON, HUSSERL, WIENER: A Temporal Golden Braid. (Invited paper at *ICCCC 2010*). *Abstracts of ICCCC Papers, International Conference on Computers, Communications & Control*, 12, Agora University Editing House, Oradea, 2010.

[9]   Bărbat, B.E., A. Moiceanu, H. Anghelescu. Enabling Humans to Control the Ethical Behaviour of Persuasive Agents. Chapter 13 in E. Loos, E. Mante-Meijer, L. Haddon (Eds.) *The Social Dynamics of Information and Communication Technology*, 191- 203, Ashgate, Aldershot, UK, 2008.

[10]   Bărbat, B.E., A. Moiceanu, *I, Agent. The good, the bad and the unexpected: The user and the future of information and communication technologies* (B. Sapio et al, Eds.), Conf. Proc. Moscow, COST Office, Brussels, **1**, 357-365, 2007.

[11] Bărbat, B.E., A. Moiceanu, I. Pah. Gödel and the "Self"ish Meme. *Gödel – Heritage and Challenge.* Interdisciplinary Symposium, RomanianAcademy, Bucharest, 2007.

[12] Bărbat, B.E., 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.

[13] Bărbat, B.E., R.D. Fabian, C. Brumar, R.S. Muntean. Bounded Rationality and Approximation in Modern Artificial Intelligence. *Proc. of the International WorkshopNew approaches, Algorithms and Advanced Computational Techniques in Approximation Theory and its Applications* (D. Simian, D.F. Sofonea, Eds.), 64-76, 2007.

[14] Bărbat, B.E., R.D. Fabian, C.I. Brumar. *CSITAO Carnap-like Glossary*, http://bcu.ulbsibiu.ro/digitale/doctorate/glossary_csitao.pdf

[15] Bărbat, B.E., S.C. Negulescu, A.E. Lascu, E.M. Popa. Computer-Aided Semiosis. Threads, Trends, Threats. *Idem*, 269-274, Agios Nikolaos, Crete, 2007.

[16] Bărbat, B.E., S.C. Negulescu, S. Pleşca. Emergence as Leverage and Non-Algorithmic Approaches in Agent-Oriented Software. *Studies in Informatics and Control Journal,* 16, 4, 321-332, 2007. http://www.ici.ro/ ici/ revista/sic 2007_4/art01.html, 2007.

[17] Bărbat, B.E.DOMINO: Trivalent Logic Semantics in Bivalent Syntax Clothes. *Int. J. of Computers, Communications & Control*, **2**, 4, 303-313, http://www.journal.univagora.ro/download/pdf/94.pdf, 2007.

[18] Belciug Smaranda, *Machine learning Techniques in Computer Aided Diagnosis*, PhD thesis, Faculty of Mathematics – Computer Science, University of Pitești, 2010.

[19] Berends H., W. Vanhaverbeke, R. Kirschbaum. *Knowledge management challenges in new business development: Case study observations.* J. of Engineering and Technology Management, 24, 4, 314–328, Elsevier, 2007.

[20] Blackmore, S. Dangerous Memes; or what the Pandorans let loose. In *Cosmos and Culture:Cultural Evolution in a Cosmic Context*, (S. Dick, M. Lupisella, Eds.), NASA 297-318, 2010.

[21] Boaz, D.P. (Dechen Wangdu). *The Noetic Revolution Toward an Integral Science of Matter, Mind and Spirit.* Copper Mountain Institute. www.coppermount.org www.davidpaulboaz.org Draft, 2011.

[22] Bobzien, S. Ancient Logic. *The Stanford Encyclopedia of Philosophy (Fall 2008 Edition)*, E.N. Zalta (ed.), http://plato.stanford.edu/archives/fall2008/entries/logic-ancient/, 2008.

[23]   Boehm, S., C. Land. *The 'Value' of Knowledge: Reappraising Labour in the Post-Industrial Economy*. Chapter 29 in (D. Jemielniak, J. Kociatkiewicz, Eds.) *Handbook of Research on Knowledge-Intensive Organizations*, IGI-GLOBAL, 479-494, 2009, http://www.igi-global.com/chapter/value-knowledge-reappraising-labour-post/20870.

[24]   Bousquet, A. Chaoplexic warfare or the future of military organization. *International Affairs*, **84**, 5, 915–929, Wiley Online Library, 2008.

[25]   Bousquet, A. *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity*.ColumbiaUniversity Press, NY, 2009.

[26]   Brumar C.I., *Sustainable Development in spite of Educational Chaoplexity. State of the Art*, First Technical Report, LBUS, September 2011, http://bcu.ulbsibiu.ro/digitale/doctorate/Cristina_Brumar_Antalya_Presentation_paper.ppt

[27]   Cepeda Lucas, L.F. *Towards a Theory on the Design of Adaptive Transformation: A Systemic Approach*. Monograph. School of Advanced Military Studies, United States Army Command and General Staff College Fort Leavenworth, Kansas, 2010.

[28]   Clegg, S., Kornberger, M., Rhodes, C. *Organizational ethics, decision making, undecidability.* The Sociological Review, **55**, 2, 393-409(17), Blackwell Publishing, 2007.

[29]   Coben D., AT THE SHARP END OF EDUCATION FOR AN ETHICAL, EQUITABLE AND NUMERATE SOCIETY: WORKING IN A SAFETY-CRITICAL CONTEXT. *Proceedings of the Sixth International Mathematics Education and Society Conference*, (U. Gellert, E. Jablonka C. Morgan, Eds), 2, 9-22, Freie Universität Berlin, 2010.

[30]   Das, S. FOUNDATIONS OF DECISION-MAKING AGENTS. Logic, Probability and Modality. World Scientific Publishing Co. Pte. Ltd., Singapore, 2008.

[31]   Desai. A.C. Libertarian Paternalism, Externalities, and the 'Spirit of Liberty': How Thaler and Sunstein are Nudging Us Toward an 'Overlapping Consensus'). *Law and Social Inquiry*, **36**, 1; Univ. of Wisconsin Legal Studies Research Paper No. 1121, 2010. http://ssrn.com/abstract=1639103

[32]   Destefano, N., A. Souto Martinez. The additive property of the inconsistency degree in intertemporal decision making through the generalization of psychophysical laws. *Physica* A, **390**, 10, 1763-1772, 2011.

[33]   Douven, I. Abduction, *The Stanford Encyclopedia of Philosophy* (Spring 2011 Edition), E.N. Zalta (ed.), http://plato.stanford.edu/archives/spr2011/entries/abduction/.

[34] Duffy, G., B. Bowe. A Framework to Develop Lifelong Learning and Transferable Skills in an Engineering Programme. *3rd International Symposium for Engineering Education.* UniversityCollegeCork, 2010.

[35] Dziţac, I., B.E. Bărbat. Artificial Intelligence + Distributed Systems = Agents. *Int. J. of Computers, Communications & Control,* IV, 1, 17-26, (http://www.britannica.com/bps/ additionalcontent/18/36182542/Artificial-Intelligence-Distributed-Systems-Agents), 2009.

[36] Esposito, A., et. al. (Eds.), *Multimodal Signals: Cognitive and Algorithmic Issues.* LNAI 5398, Springer Verlag BerlinHeidelberg, 2009.

[37] Fabian R., D. Hunyadi, E. M. Popa, Syntactic pattern model classification with total fuzzy grammars, Proceedings of the 12th WSEAS International Conference on Computers - New Aspects of Computers, Heraklion, Greece, July 2008, pp. 317 321, Published by WSEAS Press, ISSN 1790 5109, ISBN 978-960-6766-85-5

[38] Fabian R., Online study program design and deontological issues, International Workshop E-learning Aspects in Medicine and Nursing, MEDINF 2007 e Health Days in Sibiu, Medical Informatics, Telemedicine, Biostatistics and Clinical Epidemiology, organized in the frame of the research grant DANTE CEEX 73 2006, November, 2007, ISBN 978 973 739 592 4, Lucian Blaga University Press.

[39] Fabian R.D., E. M. Popa, Fuzzy Extension on Context-free Grammars, Proceedings of 2nd Annual SEERC Doctoral Conference, Thessaloniki, Greece, June 2007, SEERC Publicher, ISBN: 978-960-89629-5-8

[40] Fabian R.D., M-J. Manolescu, L. Galea, G. Bologa. Bounded Rationality through the Filter of the Lisbon Objectives. *Int. J. Computers, Communications & Control,* Băile Felix-Oradea, Romania, Agora University Editing House, **V**, 5, 707-714, 2010.

[41] Fabian R.D., Pleşca S., Stigmergy-based Software Toolkit for Virtual Enterprises, Proceedings of the 11th WSEAS International Conference on COMPUTERS, Agios Nikolaos, Crete Island, Greece, 2007, pag. 438-441, ISSN 1790-5117, ISBN 978-960-8457-95-9.

[42] Fabian, R.D., *Bounded rationality as useful limitation in e-teaching*, Third Technical Report, LBUS, September 2011, http://bcu.ulbsibiu.ro/digitale/doctorate/Ref_4_Bounded_Rationality_as_Useful_Limitation_in_e-Teaching.ppt

[43] Fabian, R.D., *Bounded Rationality in Humans and Agents. State of the Art.* First Technical Report, LBUS, November 2010, http://bcu.ulbsibiu.ro/digitale/doctorate/Ralf_Fabian_Ref1_Presentation.ppt

[44]   Fabian, R.D., *Bounded Rationality versus Chaoplexity: Optimal Is Not Always Better*. Second Technical Report, LBUS, February 2011, http://bcu.ulbsibiu.ro/digitale/doctorate/Ref_2_Bounded_Rationality_to_manage_Complex_Situations_Optimal_is_not_%28always%29_Better.ppt

[45]   Fabian, R.D., *Visual pattern recognition based on bounded rationality. Experimental model*. Third Technical Report, LBUS, June 2011, http://bcu.ulbsibiu.ro/digitale/doctorate/Ref_3_Visual_Pattern_Recognition_based_on_Bounded_Rationality_Experimental_Model.ppt

[46]   Filip, F.G., Sisteme suport pentru decizii. Subcap 1.3.5 "Catre sisteme informatice antropocentrice" (p. 23-26) *(Editia II revazuta si adaugita a lucrarii de la #6), Ed. TEHNICA, Bucuresti*, 2007, ISBN978-973-31-2308-8, I+XIX+372p. http://www.acad.ro/carti2007/carte07_02FF.htm

[47]   Georgescu, A.V. B.E. Bărbat. Modelling Time in Protensional Agents. *Proc. of the 8th WSEAS International Conference on SIMULATION, MODELLING and OPTIMIZATION (SMO' 08)*, (J.Mª Zamanillo Sáinz de la Maza, P.L. López Espí, Eds.), 200-203, Santander, Cantabria, 2008.

[48]   Gray, R.D., Q.D. Atkinson, S.J. Greenhill. Language evolution and human history: what a difference a date makes. *Philosophical Transactions of the Royal Society,* B, 366, 1090-1100, 2011.

[49]   Hase, S., C. Kenyon. Heutagogy: A Child of Complexity Theory. *Complicity: An International Journal of Complexity and Education*, **4**, 1, 111-118, 2007.

[50]   Hibbs, C., S. Jewett, M. Sullivan. *The Art of Lean Software Development: A Practical and Incremental Approach*. O'Reilly Media, Inc., Sebastopol, CA, 2009.

[51]   Hiltz, K., J. Backa, A. Blandford. The roles of conceptual device models and user goals in avoiding device initialization errors. Interacting with Computers, 22, 5, 363-374, Elsevier, 2010.

[52]   Kirst, P., E. Hofmann. *Supplier integration and the challenge of relationship-exit strategies*. LOGISTIKMANAGEMENT, Part 5, 397-425, Springer, 2008.

[53]   Koumakhov, R. Conventions in Herbert Simon's theory of bounded rationality. *Journal of Economic Psychology*, doi:10.1016/j.joep.2009.03.001, 2009.

[54]   Lascu A.E, R. Fabian, e-Semiotics for Romanian-German Transcultural Interfaces, The Good, the Bad and the Unexpected: The User and the Future of Information and Communication Technologies: a transdisciplinary conference organised by COST Action 298 "Participation in the Broadband Society". VOL II., Moscow, Russian Federation, 2008, pg. 737-742, ISBN: 978-92-898-0042-6

[55]   Lazzerini B., F. Marcelloni, M. Vecchio. A multi-objective evolutionary approach to image quality/compression trade-off in JPEG baseline algorithm. *Applied Soft Computing* 10, 548–561, Elsevier, 2010.

[56]   Manuel, D. *et al.* AMAZING MATH-SCIENCE- ARTS CONNECTIONS Getting Insights Into the Golden Ratio. Chapter 12 in *Interdisciplinarity for the Twenty First Century*. Proceedings of the Third International Symposium on Mathematics and its Connections to Arts and Sciences (B. Sriraman, V. Freiman, Eds.), 205-221, Informations Age Publishing, 2011.

[57]   Matzel Louis D., Stefan Kolata, Selective Attention, Working Memory, and Animal *Intelligence, Neuroscience & Biobehavioral Reviews*, **34**, 1, Elsevier, 2010, Pages 23–30 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2784289

[58]   Nualláin, S.Ó. Remarks on the foundations of biology. *Cosmos and History: The Journal of Natural and Social Philosophy*, **4**, No 1-2, 2008.

[59]   Odell, J. E-mail. From: James Odell, Date: Mon, Jan 5, 2009, Re: Future Standards To: Boldur Barbat, 2009.

[60]   Oprean C., C. I. Brumar, C.V. Kifor, R.D. Fabian, B.E. Bărbat, Post-Industrial Quality for Sustainable Development, *Proceedings of the 1st International Conference on Quality and Innovation in Engineering and Management*, Cluj-Napoca, March, 2011, pg. 159-162.

[61]   Oprean C., C.I. Brumar, M.Canţer, B.E. Bărbat. Sustainable Development: e-Teaching (Now) for Lifelong e-Learning, 2nd World Conference on Psychology, Counselling and Guidance, *Procedia-Social and Behavioral Sciences Journal*, Antalya, 2011, 988-992, ELSEVIER, ISSN: 1877-0428.

[62]   Oprean C., R.D. Fabian, C.I. Brumar, B.E. Bărbat. Bounded Rationality for "Just In Time" Education, 2nd World Conference on Psychology, Counselling and Guidance, *Procedia-Social and Behavioral Sciences Journal*, Antalya, 2011, 983-987, ELSEVIER, ISSN: 1877-0428.

[63]   Oprean, C. A Bumpy Ride towards Reform: Higher Education Challenges Journeying from Sibiu to Lisbon via Bologna. *EUprofile, Public Service Review: European Union,* **18**, 66-67, 2009.

[64]   Oprean, C., C.V. Kifor, B.E. Bărbat, A. Braşoveanu, R.D. Fabian. Bounded Rationality in Computer Science Curricula. *Proceedings of the 2010 International Conference on Frontiers in Education: Computer Science Computer Engineering, FECS 2010,* (WORLDCOMP'10), Las Vegas, CSREA Press, 135-140, 2010.

[65] Oprean, C., C.V. Kifor, B.E. Bărbat, D.D.M. Banciu. E-Maieutics in Post-Industrial Engineering Education. *Studies in Informatics and Control Journal*, **19**, 1, 55-66, 2010.

[66] Oprean, C., C.V. Kifor, S.C. Negulescu, B.E. Bărbat. Innovating Engineering Education, to Face the Knowledge Society. *Proc. of the Balkan Region Conference on Engineering and Business Education & Int.Conf. on Engineering and Business Education*, Sibiu, 80- 85, 2009.

[67] Oprean, C., C.V. Kifor, S.C. Negulescu, B.E. Bărbat. Paradigm Shift in Engineering Education. More *Time* Is Needed. *Innovation and Creativity in Education. Procedia - Social and Behavioral Sciences*, **2**, 2, 3580-3585, Elsevier Ltd, 2010.

[68] Oprean, C., S.C. Negulescu, C.V. Kifor, B.E. Bărbat, M. Zerbeş. Knowledge-Based Approach to Affordable Technological Innovation. *Proc. of the 6th International Conference on Management of Technological Changes*, *(C. Rusu, Ed.)*, 161-165. Alexandroupolis, 2009.

[69] Ostrom, C.S., W.J. Martin, J. Zacharakis. Autopoiesis and the Cosmology of Postmodern Adult Education. *Adult Education Quarterly*, **58**, 4, 299-317, 2008.

[70] Picot, A., R. Reichwald, R. Wigand. Information, organization and management. Springer, 2008.

[71] Piranfar, H., R. Matthews. A complexity view of organisational reputation. *International Journal of Environmental Technology and Management*, **8**, 1, 87-102, 2008.

[72] Poole, D.L., A.K. Mackworth. *Artificial Intelligence. Foundations of Computational Agents*. CambridgeUniversity Press, 2010.

[73] Popa E.M., R.D. Fabian, C. Brumar, A Bounded Rational Review of Approximation and Undecidability in Economic Modelling, Proceedings of the 12th WSEAS International Conference on Computers - New Aspects of Computers, Heraklion, Greece, July 2008, pp. 303 308, Published by WSEAS Press, ISSN 1790 5109, ISBN 978-960-6766-85-5.

[74] Popa, E.M. A.V. Georgescu, B.E. Bărbat. E-Learning with Protensional Agents: Playing Guitar. *Proc. of the 12th WSEAS International Conference on Computers* (N.E. Mastorakis *et al* Eds.), 252-256, Heraklion, Crete, 2008.

[75] Rosenfeld A., S. Kraus. Modeling Agents through Bounded Rationality Theories. *Proceedings of the Twenty-First International Joint Conference on Artificial Intelligence* (IJCAI-09), 264-271, 2009.

[76] Santiago, F. Human resource management and learning for innovation: pharmaceuticals in Mexico. UNU-MERIT Working Paper Series, 2010.

[77]   Santos Ana C., Behavioural and experimental economics: are they really transforming economics?, *Cambridge Journal of Economics*, **35**, 4, Oxford University Press, 2011.

[78]   Schuster, S. BRA: *An Algorithm for Simulating Bounded Rational Agents*. Springer Science+Business Media, LLC. Published online, 2010, http://ideas.repec.org/a/kap/compec/v39y2012i1p51-69.html

[79]   Shoham, Y. *Computer Science and Game Theory*. Computer Science Department, StanfordUniversity, 2008.

[80]   Smart, P, *et al*. Development of a Controlled Natural Language Interface for Semantic MediaWiki. *Proceedings of the Workshop on Controlled Natural Language*, Springer-Verlag, Heidelberg, 2010.

[81]   Stenning, K.,M. van Lambalgen. *Human reasoning and cognitive science*, MIT Press, 2008, http://mitpress.mit.edu/books/chapters/0262195836chap1.pdf.

[82]   Strang, D. Learning by Example: Imitation and Innovation at a Global Bank. Princeton University Press, 2010

[83]   Thagard, P. Cognitive Science. *The Stanford Encyclopedia of Philosophy (Summer 2010 Edition)*, E.N. Zalta (ed.), URL = http://plato.stanford.edu/archives/ sum2010/entries/cognitive-science/, 2010.

[84]   Veeraswamy K.. S. Srinivas Kumar. *Adaptive AC-Coefficient Prediction for Image Compression and Blind Watermarking*, Journal of Multimedia, vol. 3, no. 1, Academy Publisher, New York, 2008.

[85]   Vuori, T. J. Piik. The coevolution of academic research and industry practice: evidence from the US car industry. Int. Journal of Society Systems Science, 2, 4, 313 - 333, 2010.

[86]   Wu Feng, Xiaoyan Sun, *Image Compression by Visual Pattern Vector Quantization (VPVQ)*, Snowbird, Utah, 2008, http://research.microsoft.com/en- us/people/fengwu/vpvq_dcc_08.pdf.

[87]   Zadeh, L.A., Tufiş, D., Filip, F.G., Dzitac, I. (Eds.), *From Natural Language to Soft Computing: New Paradigms in Artificial Intelligence*, RomanianAcademy Publishing House, 2008.

[88]   Zuckerman, I., S. Kraus, J.S. Rosenschein, G.A. Kaminka. *An adversarial environment model for bounded rational agents in zero-sum interactions*. AAMAS 2007, 538-546, 2007. Updated, 2010.

References – Sources of Ideas

[89]   Agent Link III. *Agent based computing. Agent Link Roadmap: Overview and Consultation Report.* University of Southampton, sept. 2005. http://www.agentlink.org/roadmap/al3rm.pdf.

[90]   Armour, P.G. The Five Orders of Ignorance. *Comm. ACM*, **43**, 10, 17-20, 2000.

[91]   Baquero Fernando, Evolution and the nature of time, *International Microbiology*, vol.8, n.2, pp. 81-91, 2005. http://scielo.isciii.es/scielo.php?pid=S1139-67092005000200002&script=sci_arttext

[92]   Bărbat B.E., F.G. Filip, Human-Oriented Analog Knowledge Input, **42**, *Internationales Wissenschaftliches Kolloquium*. Fakultät für Informatik und Automatisierung, Technische Universität Ilmenau, 461-464, 1997.

[93]   Bărbat, B.E. *Agent-Oriented Intelligent Systems.* Romanian Academy Publishing House, Bucharest, 2002 (in Romanian, "Grigore Moisil" Prize of the RomanianAcademy).

[94]   Bărbat, B.E. Captology for Anthropocentric. *Large Scale Systems: Theory and Applications 2001* (F.G. Filip, I. Dumitrache, S.S. Iliescu, Eds.), Elsevier, IFAC Publications, 214-219, 2001.

[95]   Bărbat, B.E. Stances, Paths, and Semantics in Artificial Intelligence. *Acta Universitatis Cibiniensis*, **XLIII**, Technical Series E. Computer Science and Automatic Control, 11-16, Sibiu, 2001.

[96]   Bărbat, B.E. The Impact of Broad-Band Communication upon HMI Language(s). (Chapter 7.) Communicating in the world of humans and ICTs. (Chapter 8.) In L. Fortunati (Ed.) *COST Action 269. e-Citizens in the Arena of Social and Political Communication*, pp. 113-142, EUR21803, Office for Official Publications of the European Communities, Luxembourg, 2005.

[97]   Bărbat, B.E., C. B. Zamfirescu, S.C. Negulescu. The Best from Ants and Humans: Synergy in Agent-Based Systems. *Studies in Informatics and Control Journal*, **13**, 1, 47-59, 2004. http://www.prodlogsys.ici.ro/ici/revista/sic2004_1/art5.pdf

[98]   Bărbat, B.E., N. Bulz. E-World and Real World. From Analysing Concepts towards Integrating Approaches**.** *Proc. of the WOSC 13th International Congress of Cybernetics and Systems*, University of Maribor in cooperation with Encyclopaedia of Life Support Systems, **1**, 47-57, 2005.

[99]   Bărbat, B.E., R. Creţulescu. Affordable Affective Avatars. Persuasion, Emotions and Language(s). *Proc. of the 1ˢᵗ Balkan Conf. in Informatics (BCI'2003)* (Y. Manolo-poulos, P. Spirakis, Eds.), Publ. Centre Technological Educational Institute of Thessaloniki, 25-35, 2003. http://delab.csd.auth.gr/~bci1/Balkan/25Barbat.pdf

[100]   Bărbat, B.E., S.C. Negulescu. From Algorithms to (Sub-)Symbolic Inferences in Multi-Agent Systems. *Int. J. of Computers, Communications & Control*, **1**, 3, 5-12, 2006. (Paper selected from the *Proc. of ICCCC* 2006.) http://journal.univagora.ro/download/pdf/42.pdf

[101]   Bendor, J. *Bounded rationality*. International Encyclopedia of the Social & Behavioral Sciences, 1303-1307, Elsevier Ltd, 2001.

[102]   Björn Jónasson, *Ein kleines Buch über die Runen*, GUDRUN Publishing, 2002.

[103]   Bobeanu C., Filip F.G., A simulation shell for more humanized Decision Support Systems. In: Proceedings*, 7th European Simulation Symposium, ESS '95, Erlangen-Nuremberg, 26-28 October, SCS Publications,* 1995, p.268-272

[104]   Bobeanu, Carmen-Veronica, Filip F.G., An anthropocentric approach to developing modern simulation based decision support tools. In: *L. M. Camarinha - Matos and H. Afsarmanesh (Eds.) Balanced Automation Systems II, Chapman & Hall, London*, 1996, p. 491- 499.

[105]   Carnap, R. (1948). *Introduction to semantics.* Harvard University Press, Cambridge, MA.

[106]   Constantinescu Paul, *Sinergia, informaţia şi geneza sistemelor: Fundamentele sinergeticii*, Ed. Tehnică, Bucuresti, 1990.

[107]   Dawkins, R. *The Selfish Gene* (30th Anniversary edition). OxfordUniversity Press, 2006.

[108]   Dennett Daniel C., *The intentional stance*, MIT Press, 1989.

[109]   Dertouzos, M.L. *WHAT WILL BE: How the New World of Information Will Change Our Lives.* Harper Collins Publishers, New York, NY, 1997.

[110]   Diasakos, T.M. Bounded Rationality and Strategic Complexity I: H. A. Simon's Pair of Scissors, 2006.

[111]   Eco, U. *A Theory of Semiotics*. Bloomington: IndianaUniversity Press, 1976.

[112]   Eco, U. *The Limits of Interpretation*. Bloomington, Indiana University Press, 2005.

[113] Fabian R.D., A Method of Describing Algorithms based on String Replacement, *Proceedings Of The Seventh International Conference On Informatics In Economy, INFORMATION & KNOWLEDGE AGE, Faculty of Economic Cybernetics, Statistics and Informatics*, Department of Informatics in Economy, Bucharest, 2005, pp. 404-408, ISBN 973-8360-04-8.

[114] Fabian R.D., C. E. Aron, Pattern Matching with Tree Grammars, The 5th Biennial International Symposium SIMPEC 2004, University "Transilvania" of Braşov, Faculty of Economic Sciences, Braşov, 2004, pp. 148-153.

[115] Fabian R.D., Common Graphical User Interface, Proceedings Of The Sixed International Conference On Informatics In Economy, Faculty of Economic Cybernetics, Statistics and Informatics, Department of Informatics in Economy, Bucharest, 2003, pp. 275-279.

[116] Fabian R.D., Development of Techniques for Process Modeling With Abstract State Machines, International conference „The Impact of European Integration on the National Economy", The Faculty of Economics and Business Administration, Babeş-Bolyai University, Cluj-Napoca, 2005, pp. 244-252, ISBN 973-651-007-0.

[117] Fabian R.D., V. Crăciunean, E. M. Popa, Intelligent system modeling with total fuzzy grammars, Proceedings of the 8th WSEAS International Conference, Mathematical Methods and Computational Techniques in Electrical Engineering (MMACTEE), Bucharest, Romania 2006, pag. 82-87, ISSN 1790-5117, ISBN 960-8457-54-8.

[118] Filip F.G., B.E. Bărbat. *Industrial Informatics. New Paradigms and Applications.* (In Romanian.) Ed. Tehnică, Bucureşti, 440 pages, 1999.

[119] Filip F.G., C.I. Filip, Decision support systems: from job aids to intelligent assistants . In: *Manufacturing, Modelling,Management and Control (P. P. Groumpos, A. P. Tzes, eds.)* , ISBN-13: 978-0-080-43554-1, ISBN-10: 0-080-43554-8, Imprint: PERGAMON (Elsevier)*, 2001.

[120] Filip F.G., DSS for entreprise and management reengineering: towards anthropocentiric systems. In: *Proc. CESA '96 IMACS Multiconference, Symp on "Modelling, Analysis & Simulation" (P. Borne, Ed.)*, vol. 1, 1996, p. 438-443.

[121] Filip F.G., Fabrication moderne: une approche anthropocentrique pour les systemes d'informations. *In Cahiers des enseignementes francophone en Roumanie, module "Conception integree des systemes mecaniques et mecatroniques", UPB-INP Grenoble*, 1996, p. 60-70.

[122] Filip F.G., Towards more humanized real-time Decision Support Systems. In: *L.M. Camarinha -Matos and H. Afsarmanesh (Eds.). Balanced Automation Systems: Architectures and Design Methods*. Chapman & Hall, London, 1995, p. 230-240.

[123] Filip, F. G., DSS: human factors and the hypointegrated enterprise. *In N. Kussoulas, P. Groumpos (Eds.). In: Proceedings, Large Scale Systems; Theory and Applications, Patras*, July 15-17, Vol. I, 1998, p. 438-443.

[124] Filip, F. G., Information systems: from job aids to intelligent assistants. *Acta Universitatis Cibiniensis, Vol. XXXVIII, Sibiu*, pp. 1-9, 1999, 2000.

[125] Filip, F.G., B. Barbat. Informatica industriala ; noi paradigme si aplicatii. *Ed. Tehnica, Bucuresti*. Subcap 1.3.3 "Sisteme antropocentrice", 1999, p. 40-45.

[126] FIPA TC Agent Management. *FIPA Agent Management Specification*. Standard SC00023K (2004/18/03). http://www.fipa.org/specs/fipa00023/SC00023K.pdf, 2004.

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

[128] Gigerenzer, G., P.M. Todd, ABC Research Group. *Simple Heuristics That Make Us Smart*. OxfordUniversity Press, Oxford, 1999.

[129] Gigerenzer, G., R. Selten. *Bounded Rationality*. MIT Press, Cambridge, 2002.

[130] Haken H. *Information and Self-Organization: A Macroscopic Approach to Complex Systems*, Springer-Verlag, Germany, 1988.

[131] Haken H. *Synergetics - an Introduction*. Springer-Verlag, Berlin, 1983.

[132] Hatchuel, A. Towards Design Theory and expandable rationality: The unfinished program of Herbert Simon. *Journal of Management and Governance*, **5**, 3-4, 2002.

[133] Heckman C.E., J.O. Wobbrock. Put your best face forward: anthropomorphic agents, e-commerce consumers, and the law. *Proc. 4th Int. Conf. on Autonomous agents*. ACM Press, 435-442, Barcelona, 2000.

[134] Heylighen, F. *The Science of Self-Organization and Adaptivity*, The Encyclopedia of Life Support Systems, 2002.

[135] Hunyadi I. D., E. M. Popa, R. Fabian, I. Mocan, Translation for intermediate code, Proceedings of the 8th WSEAS International Conference, Mathematical Methods and Computational Techniques in Electrical Engineering (MMACTEE), Bucharest, Romania 2006, pp. 93-98, ISSN 1790-5117, ISBN 960-8457-54-8.

[136] Hutchinson, J. Culture, Communication, and an Information Age Madonna, *IEEE Professional Communication Society Newsletter*, **45**, 3, New York 2001, http://www.cs.cmu.edu/~chuck/lennapg/pcs_mirror/may_june01.pdf.

[137] Indurkhya, B. Approximated Semantic Transference: A Computational Theory of Metaphors and Analogies. *Cognitive Sciences*, **11**, 1987.

[138] Israel Giorgio, The Science of Complexity: Epistemological Problems and Perspectives, *Science in Context*, **18**, 3, Cambridge University Press, 2005.

[139] Jaros Gyorgy G., Synergy of Complements in Living Systems, http://www.isss.org/primer/jaros.htm, (accessed sept. 2011).

[140] *Joint Photographic Experts Group, official site*, http://www.jpeg.org, (accessed Sept. 2011).

[141] Kahneman, D. *Maps of Bounded Rationality: Psychology for Behavioral Economics.* Lecture (when receiving Nobel Prize; revised version). Stockholm, Nobel Foundation, 2002.

[142] Luck, M., P. McBurney, C. Priest. A Manifesto for Agent Technology: Towards Next Generation Computing. *Autonomous Agents and Multi-Agent Systems*, 9, 203-252, Kluwer Academic Publishers, 2004.

[143] Macarie Breazu, *Contributions To The Development Of Data Compression Methods*, PhD thesis, Technical University of Cluj-Napoca, Faculty of Electronics and Communication, October 2000.

[144] Manson, S. M. *Bounded rationality in agent-based models: experiments with evolutionary programs*, International Journal of Geographical Information Science, 20, 9, 991-1012, 2006.

[145] *Maximum Compression homepage*, http://www.maximumcompression.com (accessed Sept. 2011).

[146] Microsoft MSDN Windows API List, http://msdn.microsoft.com/en-us/library/ff818516(v=vs.85).aspx (accessed Sept. 2011).

[147] Munson C. David, Jr., A Note on Lena, IEEE *Transactions on Image Processing*, Vol. 5, No. 1. Jan. 1996, http://www.cs.cmu.edu/~chuck/lennapg/editor.html

[148] Nake F., *Die Erträgliche Leichtigkeit der Zeichen. Ästhetik, Semiotik, Informatik*, AGIS-Verla Baden-Baden, 1993.

[149] Nake, F., *Der semiotische Charakter der informatischen Gegenstände*, in: Bayer, U. (Hg.): Festschrift zu Ehren von Elisabeth Walter, Baden-Baden, AGIS, 1997.

[150] O'Keefe, R.M., D.E. O'Leary. Expert system verification and validation; a survey and tutorial. *Artificial Intelligence Review*, 7, 3-42, 1993.

[151] Parris, B. An agent-based approach to value theory and wealth distribution in economics. *Proc. of MODSIM05: International Congress on Modelling and Simulation: advances and applications for management and decision making* (A. Zerger, R.M. Argent, Eds.), MODSIM, Melbourne, Vic., 1077-1083, 2005.

[152] Raab, M., G. Gigerenzer. *Intelligence as smart heuristics*. In (R.J. Sternberg, J. Davidson, J. Pretz, Eds.), Cognition and intelligence (p. 188-207). Cambridge, CambridgeUniversity Press, 2005.

[153] Rubinstein, A. *Modeling Bounded Rationality*. MIT Press, Cambridge, 1998.

[154] Signal and Image Processing Institute -Image Database, University of Southern California, http://sipi.usc.edu/database/, (accessed Sept. 2011).

[155] Simon, H. A. Rationality in psychology and economics. *Journal of Business*, 59, 209–224, 1986.

[156] Simon, H.A. Bounded rationality and organizational learning. *Organization Science* 2,1, 125–134, 1991.

[157] Simon, H.A. *Models of Bounded Rationality*. MIT Press, Cambridge, 1997.

[158] Sugimori, Y., K. Kusunoki, F. Cho, S. Uchikawa. *Toyota production system and Kanban system materialization of just-in-time and respect-for-human system*. International Journal of Production Research, **15**, 6, 553-564, 1977.

[159] Thagard, P. *Mind: Introduction to Cognitive Science*, second edition, Cambridge, MA: MIT Press, 2005.

[160] *The Lenna Story*, http://www.cs.cmu.edu/~chuck/lennapg/, (accessed Sept. 2011).

[161] *The MPEG home page*, http://mpeg.chiariglione.org/ (accessed Sept. 2011).

[162] Van Sell, S.L., I.A. Kalofissudis. *The evolving essence of the science of nursing. A complexity integration nursing theory*. E-book online, ISSN 1108-7366, ICUS and Nursing Web Journal, 2002.

[163] Weisstein, E.W. *Golden Ratio*." From MathWorld--A Wolfram Web Resource. http://mathworld.wolfram.com/GoldenRatio.html

[164] Whitlock, J.J. Memetic Engineering and Public Acceptance. *23rd Annual Conference of the Canadian Nuclear Society*, Toronto, 2002. http://www.nuclearfaq.ca/ J_J_ Whitlock_memetic_engineering_(website).pdf.

[165] Zambonelli, F., A. Omicini. Challenges and Research Directions in Agent-Oriented Software Engineering. *Autonomous Agents and Multi-Agent Systems*, 9, 253-283, Kluwer Academic Publishers, 2004.