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

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- 2011 -

1. Introduction. (Bounded) Paradigmatic Shifts

1.1. ABOUT THE TOPIC

    1.1.1. Thematic Context

    1.1.2. Historical Context

1.2. ABOUT THE FABRIC

    1.2.1. Abbreviations

    1.2.2. Contents Organization

1.3. ABOUT THE AUTHOR

    1.3.1. Motivation

    1.3.2. Paradigmatic Arguments

    1.3.3. Intentions

    1.3.4. Thanks

2. Bounded Rationality Vs Chaoplexity: Best Is Not Always Better

2.1. EVOLUTION OF THE TOPIC AT LBUS

2.1.1. Prehistory (2001-2009)

2.1.2. Historical Period (2009-2011)

2.1.3. Author's Pre-Thesis Work

2.2. DEFINING THE PROBLEM

2.2.1. Objectives

2.2.2. Start Vector. (Premises and Working Assumptions)

2.2.3. Road Map Based on Idoneity. (Criteria)

2.3. EXPLAINING THE TITLE

2.3.1. Bounded Rationality

2.3.2. Agent Orientation

2.3.3. "Just-In-Time"

2.3.4. Visual Pattern Recognition

2. Bounded Rationality Vs Chaoplexity: Best Is Not Always Better

2.4. APPROACH

2.4.1. Applying the Start Vector, Adapting the Criteria

2.4.2. Anthropocentrism

2.4.3. Transdisciplinarity

2.4.4. Microcontinuity. Successive Prototyping

3. Bounded Rationality in Humans and Agents. State of the Art

3.1. ADAPTING THE "STATE OF THE ART"

    3.1.1. Fine-Tuning the Guidelines

    3.1.2. The Sieve. Thesis Non-Objectives

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

3.2. TRANSDISCIPLINARY BRIDGES

    3.2.1. From Myths, Through Metaphors to Memes

    3.2.2. Cognitive Psychology, the Protecting Pillar

        3.2.2.1. Cognition. Where Does It Stems From?

        3.2.2.2. Holism vs. Reductionism in CSIT

    3.2.3. Semiotics, From RUNES to Emoticons in Communication

        3.2.3.1. Computing with Words, Sounds, or Gestures

        3.2.3.2. Nonverbal communication

    3.2.4. Memetics. An Engineering Perspective

        3.2.4.1. Scientific Status (CSITAO Level)

        3.2.4.2. Memetic Engineering as Antidote to Vicious Memes (Thesis Level)

3. Bounded Rationality in Humans and Agents. State of the Art

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

    3.3.1. Bounded Rationality Instead of Optimization

    3.3.2. Necessary Condition (to Fight Cognitive Complexity in Architecture)

    3.3.3. Sufficient Condition (to Fight Structural Complexity in Implementation)

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

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

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

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

3.5. EXPERIMENTAL MODEL DOMAIN

    3.5.1. Compression and Benchmark

    3.5.2. Lena as "Information Age Madonna"

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

4.1. PRE-SIMONIAN ERA. BEST VERSUS SIMPLE

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

    4.1.2. Some Lessons from the Prehistory of Optimization

    4.1.3. Simple Is Looked For

4.2. TERMINOLOGICAL ERA. IS PROPER DECISION MAKING ACHIEVABLE?

    4.2.1. Bounded Rationality and Decision Making

    4.2.2. Bounded Rationality and Behavioural Economics

    4.3.3. Bounded Rationality and Approximation

    4.3.4. Bounded Rationality and Uncertainty

4.3. THE POST-INDUSTRIAL ERA? FIGHTING CHAOPLEXITY

    4.3.1. Unavoidable (Cognitive) Complexity

    4.3.2. Avoidable (Black Box) Complexity

5. Transdisciplinary Communication Needs a Lingua Franca: GST

5.1. RATIONALE AND METHOD

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

5.1.2. Semantic Web and General Culture

5.2. HOLISTIC COGNITION IN GST TERMINOLOGY

5.2.1. Cybernetic Systems

5.2.2. Automatic Systems

5.2.3. Intentional Systems

5.2.4. Bounded Rationality and Dennett Stances

5.3. STABILITY VS CREATIVITY: BOUNDED RATIONALITY AS TWOFOLD FEEDBACK

5.3.1. Enthymems and "Intentio Auctoris": Positive Connotations of "Negative"

5.3.2. From Barkhausen to Wiener: The Huge Positive Role of Negative Feedback

5.3.3. Preserving Stability: Bounded Rationality as Negative Feedback

5.3.4. Boosting Creativity: Bounded Rationality as Positive Feedback

5. Transdisciplinary Communication Needs a Lingua Franca: GST

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

5.4.1. Synergy. Where Does it Stem From?

5.4.2. From Aristotle to Haken

5.4.3. Back to Lao Tzu: Synergy, Symbols, *Semiotics*

5.4.4. Back to Modelling: Synergy, Software, *Sigmoids*

6. Non-Algorithmic Mechanisms for Word-Based Modelling

6.1. CONCEPTUAL OUTLINE

6.1.1. Requirements for Post-Industrial Decision Support Systems

6.1.2. Requirements for Agent-Oriented Mechanisms

6.1.3. Resource Limitations

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

6.2.1. Requirements for Boundedly Rational Interfaces

6.2.2. First Prototype: Pseudo-Linear Dependence (Linear Function)

6.2.3. Second Prototype: Logarithmic Dependence (Logarithmic Function)

6.3. ABDUCTION-BASED SERVICE-ORIENTED DECISION-MAKING SIMULATOR

6.3.1. Detaching "Manual" from "Automatic" in Post-Industrial Service Providing

6.3.2. Reconciling CWA with Uncertainty in Decision Support Systems

6.3.3. Simulating Abduction-Based Reasoning in "Service-Outlining Dialog"

7. Boundedly Rational Experimental model(s) for E2020 Targets

7.1. POST-MODERN EDUCATIONAL CHAOPLEXITY. BOUNDEDLY RATIONAL MODEL

   7.1.1. Why *Post-Modern*?

   7.1.2. Why *Chaoplexity?*

   7.1.3. First Boundedly Rational Approach in Modelling *E-Teaching*

   7.1.4. Bounded rationality as Antidote to Educational Chaoplexity

7.2. E-TEACHING AS BOUNDEDLY RATIONAL SYSTEM

   7.2.1. The Epistemology of a Prefix

   7.2.2. Abridging the current state of the Europe2020 Theses Cluster

   7.2.3. Anthropocentrism entails "User Mode"

   7.2.4. Heutagogy as Decision Making

7. Boundedly Rational Experimental model(s) for E2020 Targets

7.3. EXTRAPOLATING LASTING TOPICS. THE *GOLDEN RATIO*

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

7.3.2. Memetic Stability

7.3.3. Boundedly Rational Extrapolation in E-Teaching

7.4. EXTRAPOLATING ANCIENT BEHAVIOURS. THE *DAMASCUS BLADE*

7.4.1. In (Pre)History Scoring Was Easier

7.4.2. The Innumeracy Memeplex

7.4.3. Extrapolating Comparisons and Ratios, Not Numerical Mathematics

8. Implementing the Experimental Model for Visual Patterns

8.1. SERVICE VALIDATION REQUIRES A LESS COMPLEX APPLICATION DOMAIN

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

    8.1.2. Why *Visual Patterns* Instead of *Visual Patterns Recognition?*

    8.1.3. Inexorability and Basic Requirements of *Qualitative Validation*

    8.1.4. Validation *in Embryo* (Mechanisms) and *in Ovo* (Toy Real-World Problems)

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

    8.2.1. Defining a Child-Care Toy Problem

    8.2.2. Design Space

    8.2.3. Scope of First Prototype

    8.2.4. Interface

    8.2.5. Outline of the Second Prototype

8. Implementing the Experimental Model for Visual Patterns

8.3. APPLYING DECISION-MAKING SIMULATOR TO SERVICE-ORIENTED DIALOG

    8.3.1. Defining a Toy Problem about "Outlining Service-Requirements"

    8.3.2. Design Space

    8.3.3. Scope of First Prototype

    8.3.4. Interface

    8.3.5. Outline of the Second Prototype

8.4. MERGING THE MECHANISMS IN VISUAL PATTERN RECOGNITION PROBLEMS

    8.4.1. Choosing the Toy Problem Depending on Affordable Benchmarks

    8.4.2. General Architectonic Framework

    8.4.3. Components and Technology: IDE, Code Samples

    8.4.4. Validating the experimental model

9. Evaluating The Good, the Bad, and the Future Contingent

9.1. THESIS OBJECTIVES

    9.1.1. Evaluation Framework and Criteria

    9.1.2. Achievements

    9.1.3. Expectations for Sustainable Development

9.2. ORIGINAL CONTRIBUTIONS

    9.2.1. Concepts

    9.2.2. Mechanisms

    9.3.3. Approaches

    9.3.4. Effects of Serendipity

9.3. OPEN PROBLEMS

    9.3.1. Proposed for Eu2020

    9.3.2. Proposed for CSITAO

    9.3.3. Proposed for other CSIT Domains

Objectives

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

    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.*

Extensions in **2011**

Objectives

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).**

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.*

Extensions in **2011**

Objectives

3. **Instantiating this approach for permanent 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*.**

    a) *Investigating post-modern "educational chaoplexity".*

    b) *Exploring e-teaching as boundedly rational system.*

    c) *Boosting e-teaching via extrapolating lasting topics and behaviours.*

Extensions in **2011**

Objectives

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".**

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

Context

e-World

Intense positive feedback

Moor's Law
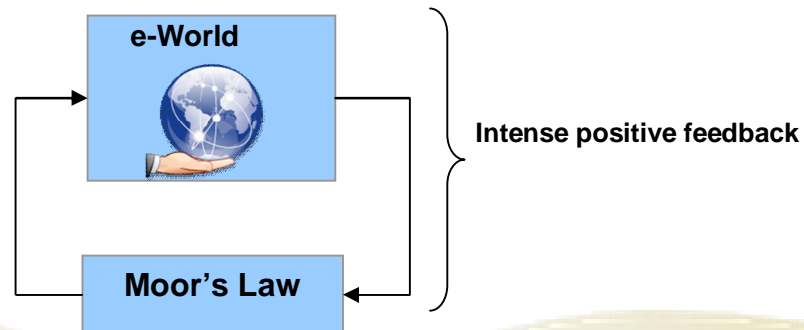
"**Kelvin-*Number*-Oriented**"

Deterministic **Environment**
(closed, static, known)

Well-Defined *Problem*
(quantity, precision, certainty)

Optimal Lasting *Solution*
(algorithmic, apodictic, general)

Solving **accurately Problems**
(imperative, firm, reliable)

Client-Server **Paradigm**
(object-oriented, sequential)

**Mental
Rubicon**

"**Zadeh-*Word*-Oriented**"

Nondeterministic **Environment**
(open, dynamic, uncertain)

Fuzzy-Defined *Situation*
(quality, imprecision, uncertainty)

Suboptimal Temporary *Answer*
(non-algorithmic, revisable, local)

Managing **"Just In Time" situations**
(descriptive, flexible, robust)

"*Computing as Interaction*" **Paradigm**
(process-oriented, parallel)

Premises

- **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).

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

- **Pr3:** *Negative feedback* tends to keep parameter values, is corrective, conservative and promotes symmetry, stationariness, stability, reversibility. *Positive feedback* tends to increase parameter values, is evolutive, innovative and promotes chain reactions, ontogenesis, system increase (perhaps catastrophic, leading to system annihilation), instability, irreversibility.

- **Pr4:** Both *decision making* and *learning* are cognition-based, non-deterministic, *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. **Pr6:** Precision is costly (Zadeh).

Working Assumptions

- **Wa1:** The very concept of Bounded Rationality involves suboptimality in nontrivial applications.

- **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).

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

- **Wa4:** Cognition is (regarded as) holistic and boundedly rational. (The parenthesis is necessary because an apodictic assertion about the very nature of human cognition is outside the competence of computer scientists and hence unacceptable in a CSITAO thesis). As a result, here only the relationship between cognition and decisional or educational systems seen as *cybernetic* and *intentional* is dealt with.

- **Wa5:** Precision is useless.

- **Wa6:** Precision could be harmful when decision is urgent ("Just-in-Time" decision mak-ing).

Thesis kernel. The main paradigmatic shifts

- **Chapter 4** – the new role of bounded rationality in the post-industrial era, focusing on the evolution "From Kelvin to Zadeh"

- **Chapter 5** – choosing General System Theory (GST) as "Lingua Franca" for transdisciplinary communication, focusing on bounded rationality as twofold feedback.

- **Chapter 6** – illustrates the new paradigms by two non-algorithmic mechanisms for word-based modelling: a multifunctional bar for decision input and an abduction-based decision-making simulator.

Bounded Rationality from Hindrance to Excuse, to Mechanism, to Strategy

- ■ "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"

- - a) *bounded rationality* has a long-standing and significant pre-Simonian use;

- - b) it was organically related to another unborn concept: "*Just in Time*" (there is not enough time to *optimise*);

- - c) it was not a purpose for itself, but an ingredient of a *holistic* endeavour.

Pre-Simonian Era. Best Versus Simple

- BR sufficed to finding "Just in Time" solution whiteout having an accurate mathematical proof is the isoperimetric problem ("Dido Problem") according to Virgil's Aeneid, the first optimisation problem.

- the pre-terminological life of BR shows the intrinsic anthropogenetic / psychological nature of BR due the vital need to manage situations "Just in time".

Terminological Era. In Search For Time

During its half a century long terminological life, the concept acquired several new connotations including the ambivalence of BR in holistic approaches.
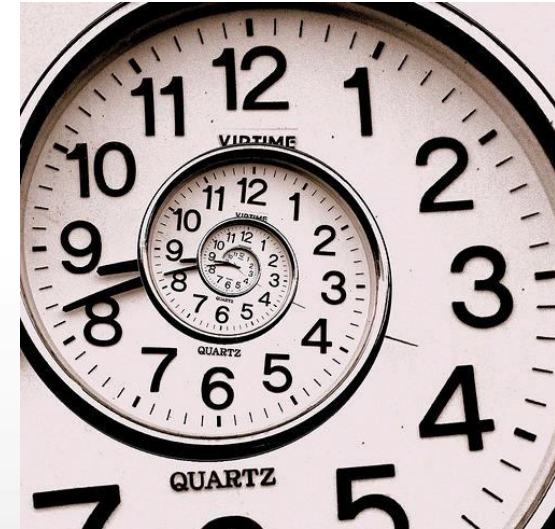
- *Herbert Simon* proposed in 1982 the concept of BR as valuable tool for decision making in economy

- *Ariel Rubinstein* describes "models in which procedural aspects of decision making are explicitly included"

- *Daniel Kahneman* received his Nobel Prize for seeing bounded rationality as a means to improve economic modelling.

- *Gerd Gigerenzer* proposed alternatives for decision making, based on simple heuristics; for instance, priority heuristics

Cognitive Psychology vs. Educational Chaoplexity

- explaining the concept of "educational chaoplexity" via a lingua franca

- focus on BR as mechanism of permanent education, showing how it can alleviate the temporal hiatus intrinsic to permanent education, proposing to teach a *lasting subject matter* as well as a *lasting behaviour*.

GST as Lingua Franca for Holistic Approaches

- educational systems are teaching systems and learning systems

  a) such systems are open, nondeterministic, and operate in dynamic and uncertain environments;

  b) without claiming "the end of reductionism", cognition can be studied only macroscopically, i.e., holistic, within cybernetic intentional systems;

  c) long-term quasi-stability is preserved through BR acting as negative feedback;

  d) short interludes of creativity can be boosted through BR acting as positive feedback.

GST as Lingua Franca for Holistic Approaches

- Why is BR crucial?
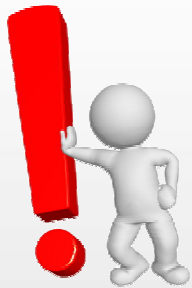
- *Because* it is a psychological – hence, lasting – feature.

Most Lasting Topics. The Golden Ratio

- has inspired thinkers of all disciplines like no other number in the history of mathematics

- 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 subjects and real-life applications"
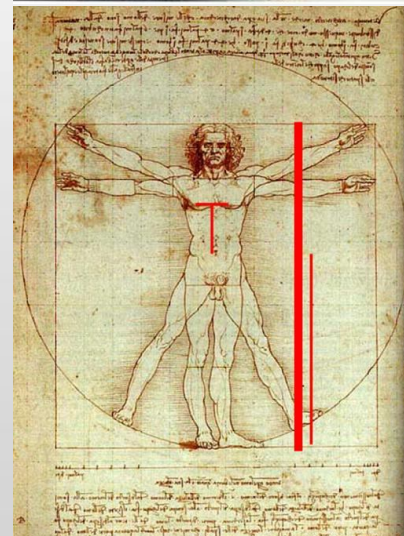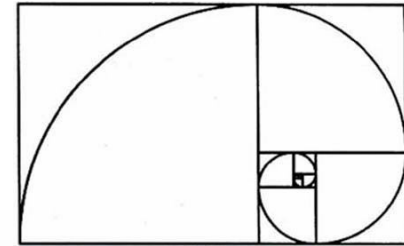
Most Lasting Behaviours. The Damascus Blade

Five reasons why it is relevant for BR as mechanism

1. an informal experiment showed that even **bright** students have cognitive problems as regards the relationships between "scoring", comparing", "measuring" etc.

2. it is independent on technology: both the ancient blacksmith and the present-day oncologist just compare colours;

3. moreover, both use their eyes as precision equipment in evaluating hue after transducing;

4. corollary: is it another example of shifting from myth to meme?

5. it opens significant transdisciplinary niches towards semiotics in at least two directions: nonverbal communication and psycholinguistics

Toy problem – relevant as regards

Toy problem
Managing Body
temperature
situations
Fevercheck

Bounded rationality

Just-in-Time

Holistic, non-algorithmic, decision making

Semiotics-based

Genuine Zadehian Fuzziness

Psycholinguistics

Multifunctionality

Successive prototyping
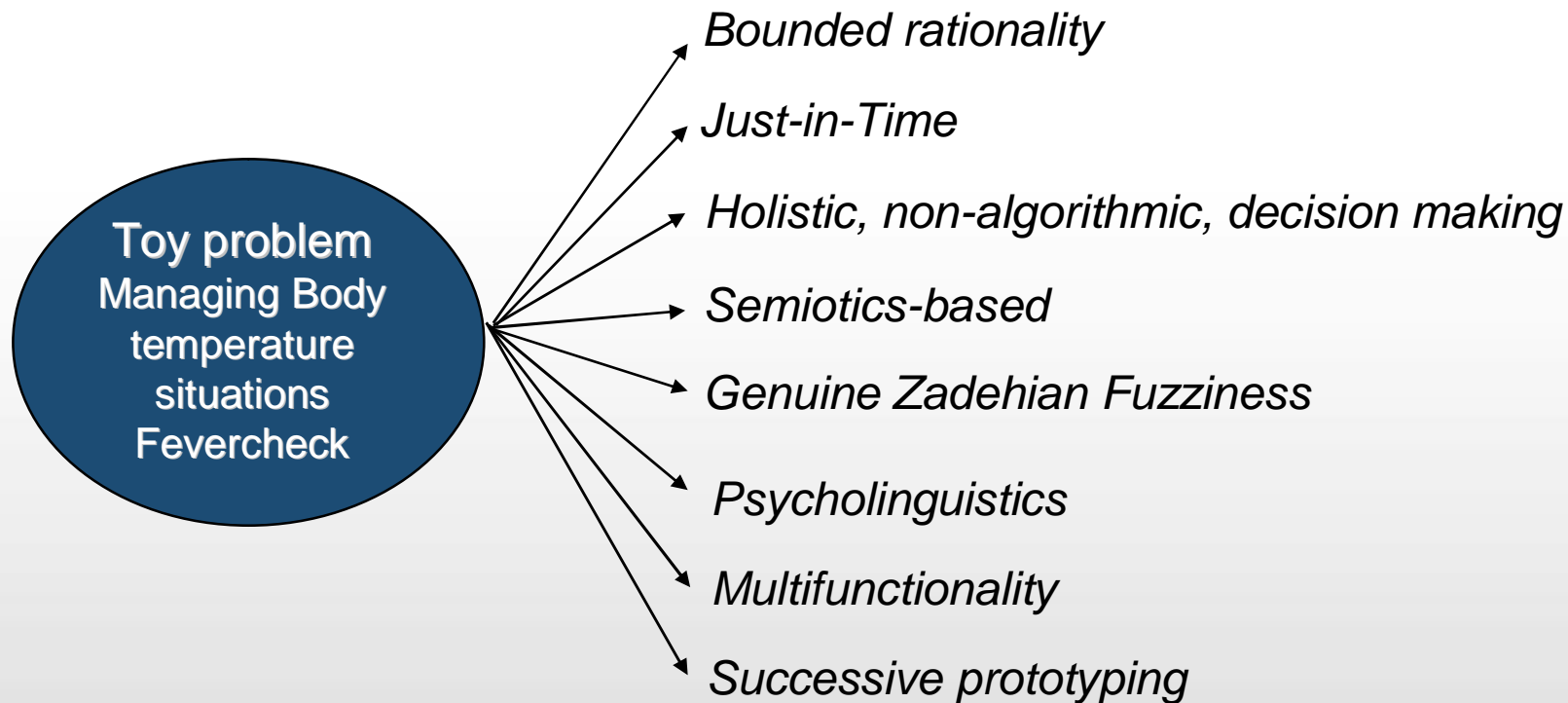
Other (possible) DIB instances
- **Logarithmic**
- **Exponential**
- **Sigmoidal**

Decision-Input Bar

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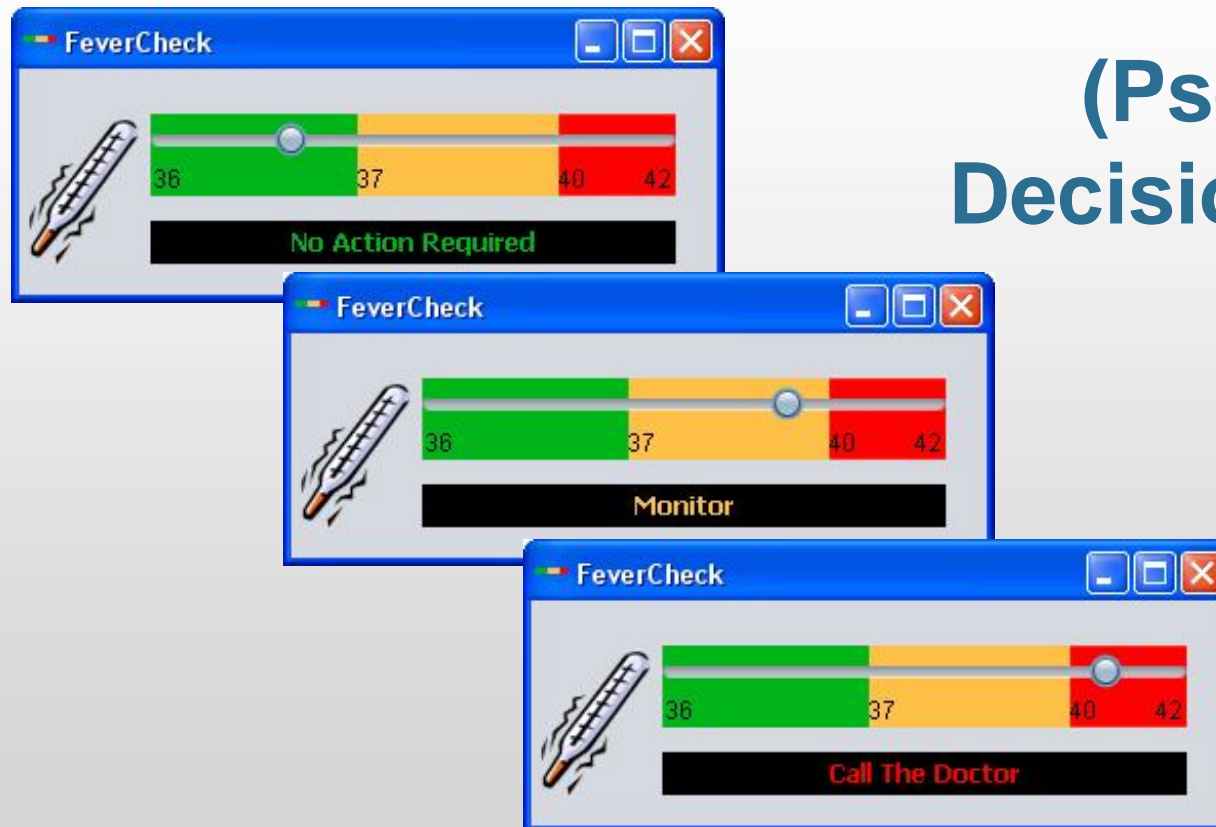
(Pseudo)Linear Decision Input Bar

Decision-Input Bar

```java
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();
}
```

Paradigm shift in decision making

- **The old 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.

- **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 agent-oriented IT.

Decision making. Toy problem: Fevercheck

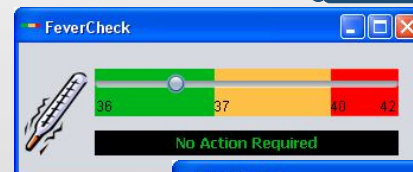**DECISION DOMAINS WHERE DECISIONS ARE FOR *SIMPLE SITUATIONS***
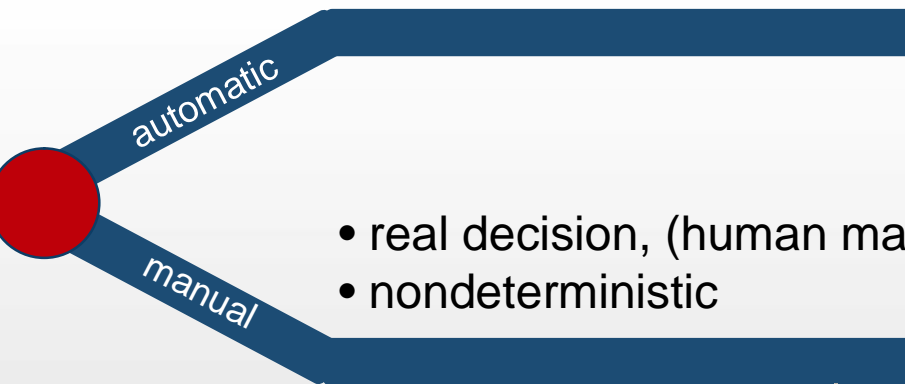
Simple situations

Managing Situations

Decisions that can be made by human decision makers as well as by automatic decision maker

automatic

- automatic decision (if allowed),
- deterministic

manual
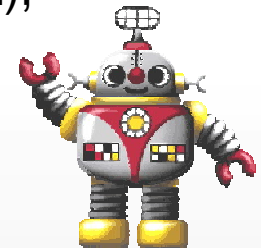
- real decision, (human made, free will)
- nondeterministic

FeverCheck
36 37 40 42
No Action Required

FeverCheck
36 37 40 42
Monitor

FeverCheck
36 37 40 42
Call The Doctor
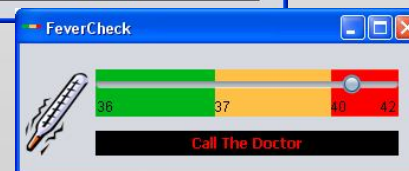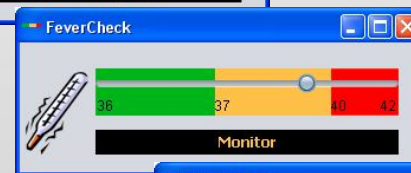
Simulating Abduction-Based Reasoning in "Service-Outlining Dialog"

```
67
68          int client=getCurrentClient();
69          boolean dialogResult;
70
71          switch (client) {
72          case 1:{
73              dialogResult=doDialogClient_1(client);
74              if(dialogResult==false)
75                  return -1;
76              else{
77                  processing(client, currentServiceSpecs);
78                  sendToClient(client);
79                  return 0;
80              }
81          }
82          case 2:{
83              dialogResult=doDialogClient_2(client);
84              if(dialogResult==false)
85                  return -1;
86              else{
87                  processing(client, currentServiceSpecs);
88                  sendToClient(client);
89                  return 0;
90              }
91          }
92
93          default:{
94              doSomething();
95              break;
```

Simulating Abduction-Based Reasoning in "Service-Outlining Dialog"

```
BOOL Dlg_OnInitDialog (HWND hwnd, HWND hwndFocus, LPARAM lParam) {

    HWND hwndSB;
    SetClassLong(hwnd, GCL_HICON, (LONG) LoadIcon((HINSTANCE)
    GetWindowLong(hwnd, GWL_HINSTANCE), __TEXT("ExAplicTR")));
    g_hwndLB = GetDlgItem(hwnd, ID_APPLICATIONEVENTS);

    …
    hwndSB = GetDlg
    ScrollBar_SetRan
    FORWARD_WM_HSCR
            72, SendMe

    return(TRUE);
}
```

```
DWORD WINAPI ThreadSubgoal (LPVOID lpvParam) {
    int nSubgoalNum = (int) lpvParam;
    DWORD dwResult;
    DWORD dwStartTime, dwLoopStartTime, dwCalcDuration;
    …
    if (fGuard)    {
        g_nThreadDuration[nSubgoalNum - 1] = GetTickCount() - dwStartTime;
        SetEvent(g_hEventSubgoalEnd[nSubgoalNum - 1]);
        return(g_nThreadDuration[nSubgoalNum - 1]);
    }
    …
    dwLoopStartTime = GetTickCount();
    …
    g_nThreadDuration[nSubgoalNum - 1] = GetTickCount() - dwStartTime;
    SetEvent(g_hEventSubgoalEnd[nSubgoalNum - 1]);
    …
    return(g_nThreadDuration[nSubgoalNum - 1]);
}
```

Experimental model – Visual Pattern

- Here BR is *not related to a product* – deliver "Lena" at pixel level precision – but rather to providing information about Lena for everyone who needs them.

- Every service is performed by a live entity,
  - if biological – human
  - if virtual – agent

- Apply BR to simplify visual complexity to be able to transmit only what's needed

- Focus on user, level of granularity, feature – relevance to the target

Experimental model – Visual Pattern

Dialog

Features of the interest area (technical variables)

- location of the interest area
- precision for the interest area
- imprecision for the complementary area

```
switch(client){

    case of: client_1


    case of: client_2

        .
        .
        .
    case of: client_n



    default:


}
```
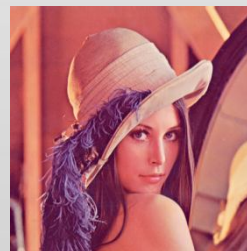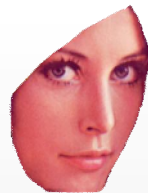
```
switch(CLIENT)

    case: CLIENT_1
        call(CLIENT_1)

    if (dlg_result == 0) then
        call_PROCESSING (Specifications)

            if (processing_result == 0) then
                send_to(CLIENT_1)
            else
                notify_service_provider()
    else
        complain_about_failure()
    ...
    case: CLIENT_N
        call(CLIENT_N)

    if (dlg_result == 0) then
        call_PROCESSING (Specifications)

            if (processing_result == 0) then
                send_to(CLIENT_N)
            else
                notify_service_provider()
    else
        complain_about_failure()
    case: OTHERWISE

        do_defaults()
```
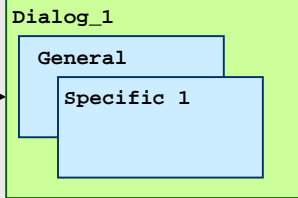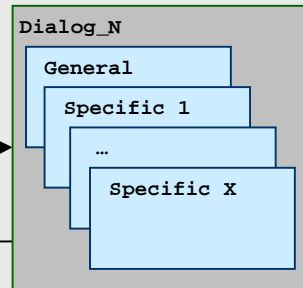
Dialog_1
General
Specific 1

Service specifications

foreach(requirement from Specifications)
    do_number_crunching(image, requirement)

Dialog_N
General
Specific 1
…
Specific X

Service Specifications

foreach(requirement from Specifications)
    do_number_crunching(image, requirement)

Conclusions

- By extending to several accomplished subobjectives, the thesis objectives have been more than fulfilled.

- Precision is against nature and the opposite of precision is fuzziness.

- Ever more services have to be provided in line with the "just in time" (JIT) paradigm;

- Developing applications for JIT services implies both bounded rationality as fact of life and artificial intelligence as powerful IT instrument.

- BR was systematically revisited from psychologic feature to subconscious approach and from conscious hindrance to legitimate excuse for incoherent decision-making

- BR was linked organically to "Just-in-Time" setting up its main role in a post-industrial society: *fighting cognitive chaoplexity*

Conclusions

- In the challenging environment of post-modern educational chaoplexity, BR was substantiated as both cognitive limitation and IT guiding principle.

- History and psychology show that "simple" was always paramount, whereas "best" became arguable when mathematics became (too) complicated

- The role of BR as "psychological stabiliser" was proved in three steps: b1) choosing an interesting topic or a pervasive habit; b2) investigating memetic stability that assure their usability; b3) proposing a boundedly rational way to exploit simplicity in e-teaching via extrapolating similar topics and behaviours.

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

Conclusions

- The framework able to manage Educational Chaoplexity (EDCHA) based on BR as common denominator of, mechanism for, and connection between the two facets of permanent education was carried out only for e-teaching since no research started yet as regards service-oriented e-learning.

- It was shown that BR can tackle EDCHA and that it is able to alleviate the temporal hiatus intrinsic to permanent education.

- Exploring the possibility to build Computer Science rather on Semiotics than on Mathematics seems to be more than a single paradigmatic shift.

- Certain openings to be substantiated within the EU2020 research strand came out clearly at least in two directions: *transdisciplinarity* and *osmotic interference*. Thus, shifting the transdisciplinary focus from psychology to semiotics, endorses the claim about the deep relationship between BR and all kind of signs other than numbers. In both directions using GST as Lingua Franca was very useful.

Conclusions

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

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

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

- Helplessness in managing situations too chaoplex for our BR can be lessened investigating the real world according to the huge potential of BR itself.

Open problems – EU2020

Question – Supposition

- *Q1: Linguistics (as part of Semiotics).*

- *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 metamodels should find out the methods mothers use and should focus on.

Open problems – EU2020

Question – Supposition

- ***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).*

- Hence, teaching metamodels should shift the focus from conventional mathematics to modern, human-centred (non-numeric and even non-verbal) mathematics.

Open problems – EU2020

Question – Supposition

- *Q3*: *Bounded rationality as positive feedback.*

- *S3*: *Since BR is a – maybe THE – main cognitive mechanism and cognition involves inventiveness (e.g., "Eureka"-like effects) it is likely that BR could boost creativity (via positive feedback).*

- Hence, a GST based and cybernetic-oriented investigation should be carried out starting from the idea of local feedback loops within simulated discernable educational subsystems.

Open problems – CSITAO

- 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 and psycholinguistics?

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

- Why is "Innumeracy" a much newer concept than "Illiteracy" and what is their rela-tionship to BR?

Thank You!