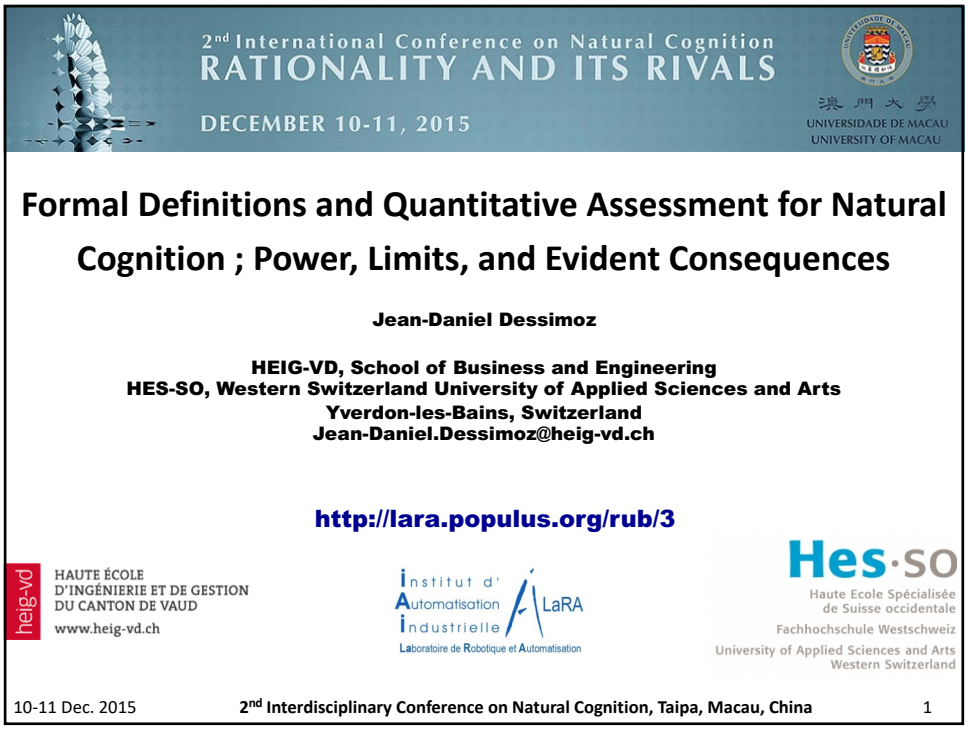
2nd International Conference on Natural Cognition
RATIONALITY AND ITS RIVALS
DECEMBER 10-11, 2015
UNIVERSIDADE DE MACAU
UNIVERSITY OF MACAU
Formal Definitions and Quantitative Assessment for Natural Cognition ; Power, Limits, and Evident Consequences
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10-11 Dec. 2015
2nd Interdisciplinary Conference on Natural Cognition, Taipa, Macau, China
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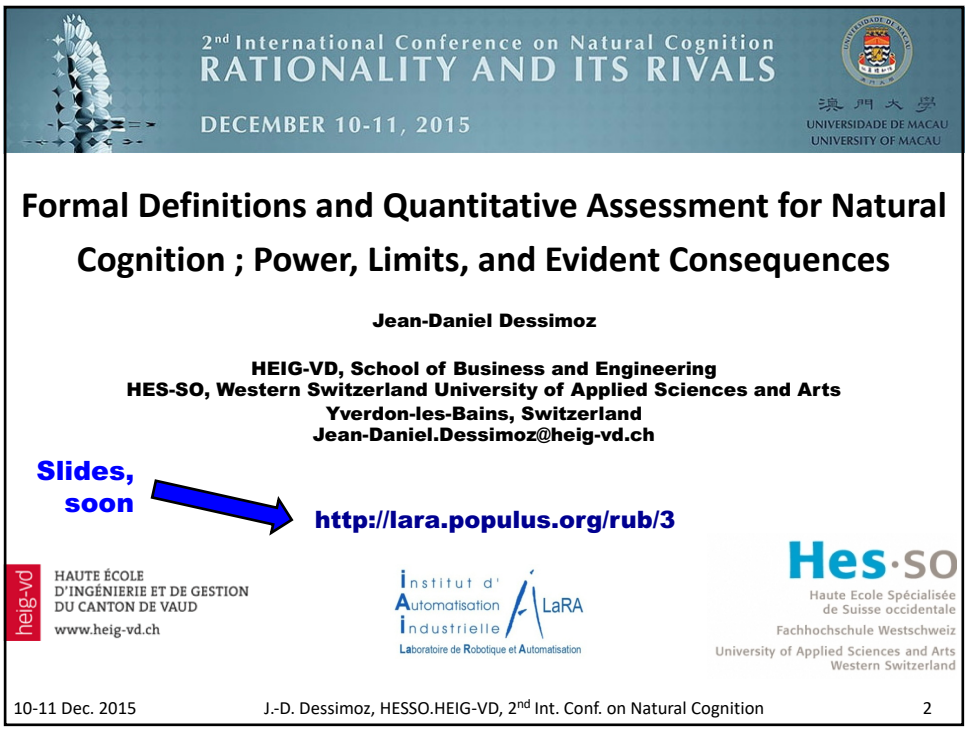
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2

Introduction 1 of 2

- It is evident that cognition is the key factor for the privileged ecological niche humans have crafted for themselves in the known universe.
- Cognition-related issues such as logic and sillogism, rationality, knowledge or memory have been studied for long, especially in psychology, and more general extensions have been pervasive for ages in human sciences, including philosophy, sociology or political sciences.
- Yet in view of the importance it has proved in the evolution of mankind, from the early times a million years ago to the recent boost of our highly developed societies in terms of information processing and communication, it appears that cognition per se did not receive yet the scientific and technical attention it should.

Introduction 2 of 2

- Traditionally, cognition has been mostly ensured in humans by neural resources located in the brain. This relates to the implementation material however, the "hardware", in reference to computer infrastructures.
- The MCS theory of cognition [1] has been made for the purpose of carrying cognition over to machine-based infrastructures, in particular, robots; thus to implement automated cognition, a scientific and technical field named as "cognitics".
- Now this MCS theory of cognition is however very general, thus it is notably also applicable to humans and human societies, with similar benefits, e.g. in terms of quantitative assessment of core properties.
- We discuss cognition here in the context of nature, philosophy, rationality, and more broadly, possible alternatives as well as social aspects.
- The presentation is organized as follows.

Content

1. Introduction
2. Cognition: why engineers bother; first theoretical and experimental results
3. Major conclusions – infinitesimality and c-goodness
4. Scope and implementation media for cognition
5. Cognition and cognitive endeavors
6. MCS cognition theory for natural cognition, for balancing rationality versus rivals
7. Cognition in the context of action and emotion, humans and societies, agents and groups
8. Conclusion

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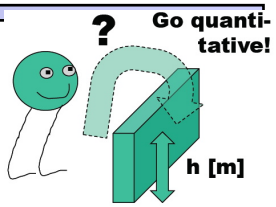
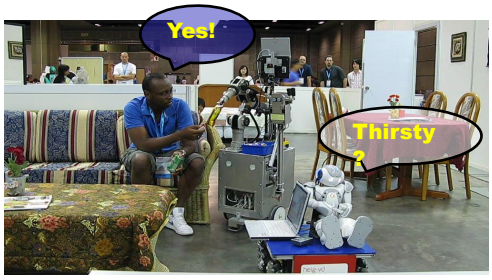
2. Cognition: why engineers bother? first theoretical and experimental results 1 of 4

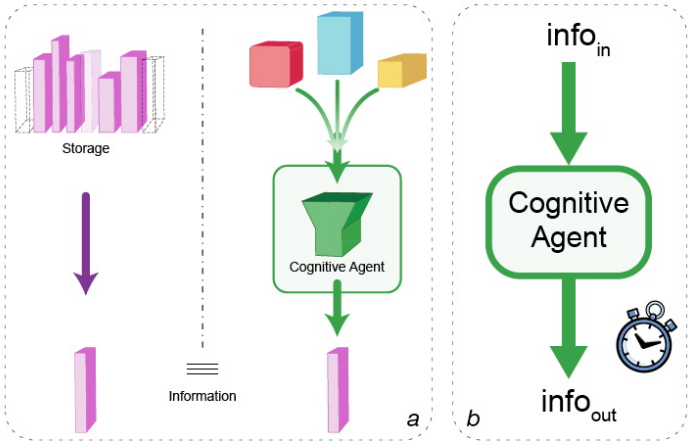


- **First (when the goal was considered to possibly implement cognition in robots), the necessity appeared to formally define and quantitatively assess cognition.**
- **After some research, this condition could effectively be met, and in particular:**
  - **several scientific publications have been made [e.g. 1,2],**
  - **several of our prototypes have been successfully engaged, at international level, in autonomous and cooperative robot competitions (re. Eurobot and Robocup @ Home).**



2. Cognition: why engineers bother? first theoretical and experimental results 2 of 4

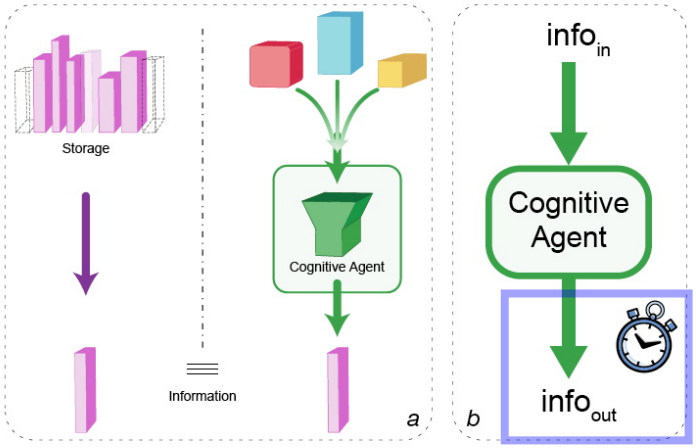
- **Information is a mature concept?**
- **And time?**
- **Let's first assume it is the case.**
- **Cognition can then be defined on this basis.**



- **Cognition is the faculty to generate the right information**

2. Cognition: why engineers bother? first theoretical and experimental results 2b of 4

- **Information is a mature concept?**
- **And time?**
- **Let's first assume it is the case.**
- **Cognition can then be defined on this basis; behavioral.**



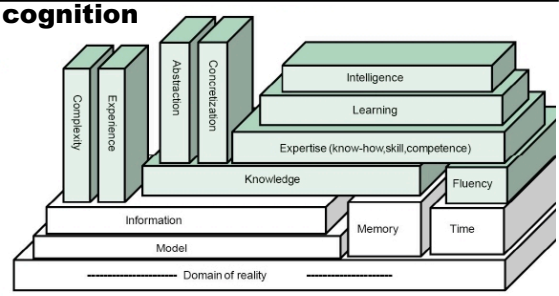
- **Cognition is the faculty to generate the right information**

2. Cognition: why engineers bother? first theoretical and experimental results 3 of 4

- **Core concepts in MCS cognition theory**

Information:	$n = \sum p_i \log_2(1/p_i)$ [bit]
Knowledge:	$K = \log_2(n_{out}\, 2^{n_{in}}+1)$ [lin]
Fluency:	$F = 1/\Delta t$ [s^{-1}]
Expertise:	$E = K \cdot F$ [lin/s]
Learning:	$\Delta E = E(t_1)-E(t_0)$; >0 [lin/s]
Experience:	$R = r(n_{in}+n_{out})$ [bit]
Intelligence:	$I = \Delta E/\Delta R$ [lin/s/bit]
relative Agility:	$A_r = \tau/T$

T: Fluency and communication delays
τ: Reaction time of target system, to be controlled

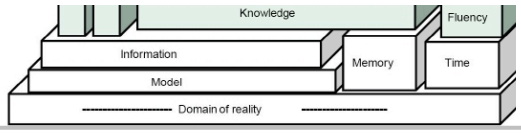


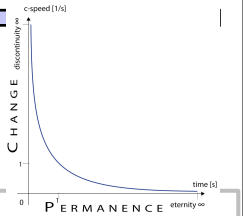
- **Complexity: amount of information required for description (inverse of simplicity)**
- **Experience : amount of operational information witnessed; (or observation time)**
- **Knowledge: "to do right" (re. cognition)**
- **Expertise: "to do right and fast"; cognitive speed ***
- **Learning: increasing expertise level**
- **Intelligence: ability to learn; ratio of learning to experience; (or cognitive acceleration)**
- **Abstraction: ratio of input to output information quantities**
- **Concretization: ratio of output to input information quantities**
- **Fluency: c-speed, in cognition context**

*** worth a B-Prize**

2. Cognition: why engineers bother? first theoretical and experimental results 4 of 4

- **Revisiting MCS foundations**



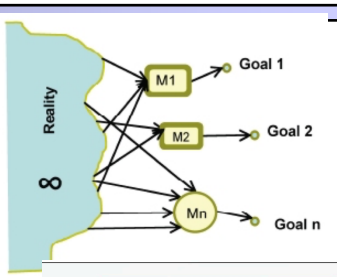


- **Reality: Parmenides [e.g. 3] has the definite word: *what is, it is.* My comment: to know more, go and explore. The complexity of reality is infinite and irreductible.**
- **Model: purpose-oriented, simple representation of some arbitrary aspects of reality, possibly including if-worlds. Re. § 3.**
- **Information: antidote to uncertainty (re. probabilities [4] and App. A.); allows for updating receiver's opinion (model). My comment: beware of lifetime (re. striking a match) and of subjectivity**
- **Memory: in MCS cognition theory, any ancillary structure essentially ensuring physical permanence of support for information (e.g. stored signal, gravestone, knot in a handkerchief).**
- **Time: dimension (i.e. element of a model) that denotes permanence; inverse of speed ("c-speed", to refer to MCS cognition theory), which measures change. Particular values:**
  - **∞, infinite value of permanence (eternity), and consequently no speed, no change.**
  - **0, no permanence at all, and consequently infinite speed of change (discontinuity)**

Content

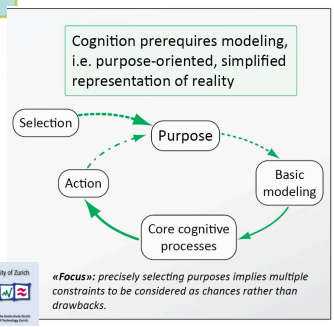
3. Major conclusions – infinitesimality and c-goodness of models 1 of 3

- **The first quantitative outcome is that cognition, and in particular rationality, only addresses infinitesimal aspects of reality, necessarily relying on more or less explicit, finite-sized models.**



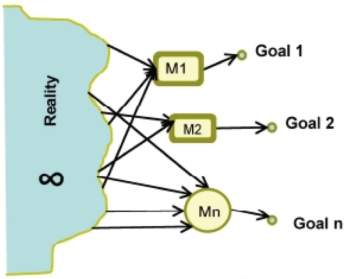
- **The second conclusion is that what definitely matters, for possible success, is less an impossible, exhaustive exploration of reality, than the careful selection of a specific goal.**

[5]



3. Major conclusions – infinitesimality and c-goodness of models 2 of 3

- **The crucial quality of a model?**
  - **it is *not,* essentially, to be true or complete versus reality ;**
  - **it is *rather* to be good, i.e. allowing to ultimately reach the selected goal (let's say here «c-good»).**



- **Many synonyms, more or less close, could also be used here, sharing the same essential notion of being a model, i.e. a simple, purpose-oriented representation of some domains of reality; e.g. a word in a language, a picture, a theory, a mathematical equation.**
- **In view of the strong limits of models, it is very challenging to deal with their closely linked notions like meaning, semantics or ontologies (re. App. B)**

3. Major conclusions – infinitesimality and c-goodness of models

3 of 3

Re. Google Earth

- **Specificity or universality of models? A choice must be made:**
  - **The specificity of a model fades away as complex exceptions and addenda are considered;**
  - **Reciprocally, if a domain is to be exhaustively explored, the initial model that helped starting does not matter much.**
- **E.g. the town of Yverdon-les-Bains and the city of Macau**
  - **are totally different if we strictly isolate them into their respective geographic and political boundaries ("amputation", schematic view)**
  - **are exactly the same if we compare their respective planets (Earth)**
- **Recommended choice: models should be evolutive**
  - **in early stages, the most useful models are kept specific, thus very simple and happily incomplete**
  - **then if required, complexity may incrementally grow, and the specificity of early phases happily looses relevance**
  - **finally always (re-)focus on circumstances – case based reasoning**

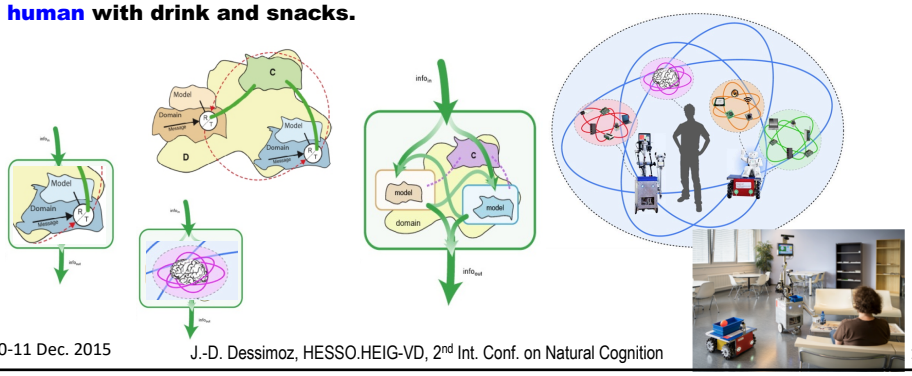
Content

4. Scope and implementation media for cognition 1 of 2

- The model for cognitive sciences that we have proposed («MCS » cognition theory) introduces a « cognitive agent » regardless of scale and nature of implementation medium.
- In MCS cognition theory, cognitive properties can be defined and quantitatively estimated as well for the typical case of a singular agent, as eventually also for cases of different scope: any subunit, elementary component of the latter singular agent; or reciprocally, any possible (« macro/meta »,) integral structure of multiple such agents.
- This also means that MSC can be applied in just the same way for an electronic gate, a digital circuit, a computer or a network, as for neurons, brains, humans, or a group (re. family, society, association, H-R team, etc.). Idem for cognitive processes : e.g. thinking, group deliberation, digital computation, or network-based operation (e.g. search)

4. Scope and implementation media for cognition 2 of 2

- As cognitive systems gain in scope, multiple agents appear and patterns of sociology must develop. Communication channels and shared cultural references support novel coordinated, collective behaviors, as if ensured by a single, overall meta-agent. From a cognitive perspective, individual thinking and meditation then evolve towards group discussions and deliberation, with the perspective of defining appropriate subsequent actions.
- For example in the Robocup@Home case demonstrated in Singapore, our RG-Y robot group consisted in three major agents (robots) cooperating to serve a human with drink and snacks.



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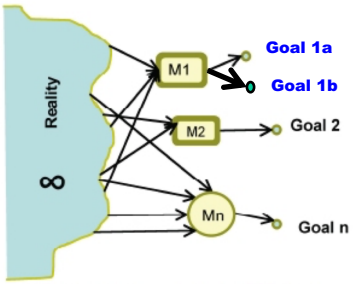
5. Cognition and cognitive endeavors

- Applying our conclusions about cognition to our own cognitive endeavors, we are led to clearly state two of our selected goals, which may be shared by many (e.g. Goal 1a & 1b):
  - to develop robots capable of cooperating with humans at home ; and, much more generally (Goal 1a),
  - to contribute to the well-being of mankind (Goal 1b).
- In the perspective of the goals just mentionned, we have found the MCS cognition theory to be the best model; at least, it is the best synthesis of what is known today, from our perspective and contexts.



Content

6. MCS cognition theory for natural cognition, for balancing rationality versus rivals 1 of 7

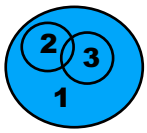
Establishing a common ("interdisciplinary") culture

- **6.1 About nature – 3 definitions**
- **6.2 Comments on some other concepts: rationality, belief, deception, imagination, consciousness, ethics, allegories, faith, trust, adhesion, etc.**
- **6.3 Rationality versus rivals**

6. MCS cognition theory for natural cognition, for balancing rationality versus rivals 2 of 7

6.1 About nature – 3 definitions

Nature; definitions #1, 2, and 3 overlap



- **About "nature" 1 – something "true", "real", "raw" versus "artificial 1", analog, resulting from random circumstances or from some more or less rough technical, man-driven processes; e.g. approximate (re. "ersatz") or refined. (Definition similar to e.g. [6]).**
  - **Natural length, "real" length, is length**
  - **Natural weight, "real" weight, is weight**
  - **Natural cognition, "real" cognition, is cognition**
- **About "nature" 2 –*physical* aspects of reality (re. natural sciences), versus intangible ones (re. human sciences) (Definition similar to e.g. Merriam Webster dictionary)**
  - **Here, natural cognition would be an empty set.**

6. MCS cognition theory for natural cognition, for balancing rationality versus rivals 3 of 7

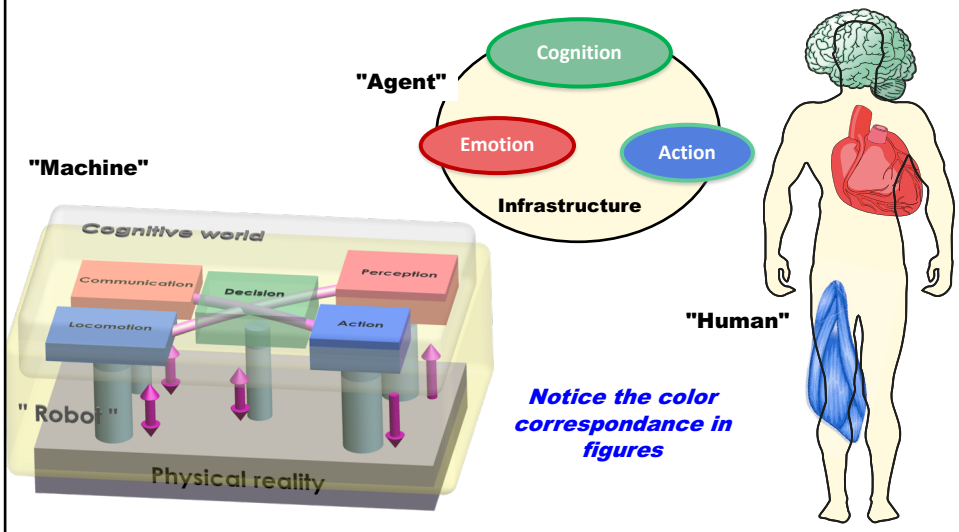
- **About "nature" 3 – biological/human, versus man-made/machine-based. Examples of domain-related synonyms, in current context:**

Man-made, "artificial 2" *	Neutral, "universal"	"Natural", anthropomorphical
machine	agent	human; re. life
gripper, end-effector, net, magnet	grasping agent	hand; re. prehension
camera, Hubble, MRI	perceptive agent	eye; re. visual sense
kinematic chain	kinematic agent	arm, leg, limb; re. motion
motor/engine	effector	muscle; re. action
computer, electronics, networks	cognitive engine	brain; re. cognition
status interface, alarm center, monitoring systems	emotive/emotional agent (re arousal, valence, stance)	heart; re. emotions
systems	group	society, corporation, holding, federation, family
components, subunits	subsystems	brain regions; neurons; shareholders, members
cathedral, skyscraper	shelter	cave, tree

** "Artificial 1" implies not real (e.g. "sugar" may be flour); "artificial 2" means man-made, yet real (sugar, is sugar)*

6. MCS cognition theory for natural cognition, for balancing rationality versus rivals 4 of 7

Man-made, "artificial"	Neutral, more general	"Natural", anthropomorphical



Notice the color correspondance in figures

6. MCS cognition theory for natural cognition, for balancing rationality versus rivals 5 of 7

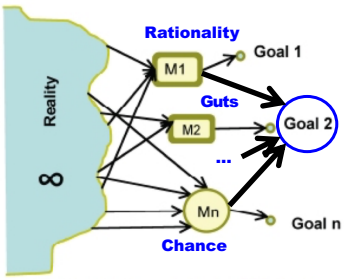
6.2 Comments on some other concepts

- **rationality: typical property in cognition (C)**
  - **strong coherence of involved elements, in any (arbitrary) model.**
  - **weak coherence with reality (necessary incompleteness of models)**
  - **comparable to coherence in a caricature?**
- **belief: typical property in emotion (E) (re. App. A)**
  - **from a cognitive point of view, this is a domain-related feature**
  - **possibly an attribute of probabilistic nature,**
  - **possibly an aspect of membership to a group (indirect certainty)**
  - **often (like faith, trust, adhesion), it is the support for a certain goal**
- **deception: typical property in emotion; driving cognition and action via false information (in MCS, false: wrong wrt reality) (re. App. C)**
- **imagination: cognitive property; faculty of modeling, often differently from evident reality (**physical laws are just an option; re. e.g. past, future, if-worlds **)**
- **consciousness & conscience: mixed property; 1. cognitive: awareness, of the environement, of oneself (Re. App. D); 2. emotional: assessment of value (re. ethics, empathy, responsability, guilt, dignity, etc.).**
- **allegories (E): kind of models useful for communication purpose**

6. MCS cognition theory for natural cognition, for balancing rationality versus rivals 6 of 7

6.3 How good is MCS theory, when focusing on the case of 2nd International Conference on Natural Cognition, and specifically, possibly choosing rationality versus its rivals ?

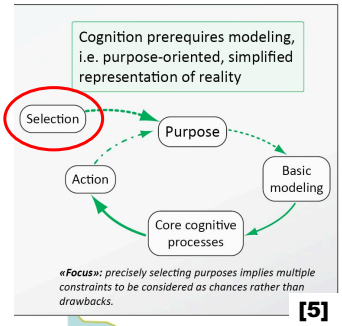
- **What is clear from MCS perspective :**
  - **rationality develops on infinitesimal aspects of reality ;**
  - **in that sense, it is weak and can hardly claim for exclusivity in a decision process.**
- **The ultimate quality for a model, according to MCS, is the ability to support in reaching the goal (e.g. Goal 2):**
  - **in this sense rationality very often proves «c-good» ;**
  - **but, again, rationality must also modestly accept that some of its rivals (e.g. «guts», or «chance») sometimes perform better**



- **Giving due attention to "nature" and better observing humans may lead to increased acknowledgement of the role of emotions; even though engineers can handle the latter (re. e.g. safety, ergonomy, or energy management; in general, values) as effectively as cognition and action.**

6. MCS cognition theory for natural cognition, for balancing rationality versus rivals 7 of 7

- **Emotion : in MCS theory, defined as a particular kind of cognition, which involves a specific domain.**
- **Here, emotion can be viewed more precisely, as :**
  - **a (non/meta-physical, non/meta-logical) faculty to dynamically assess values, in real-time, in the real-world; and to select the appropriate, current, purpose/goal to focus on / aim at;**
  - **logic may seem to keep changing; the behavior may seem irrational.**



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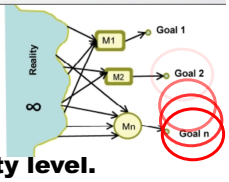

- **Specialists often represent emotions in 3D :**
  - **valence : more or less un/happy; current balance, as subjectively perceived, of overall benefits and costs.**
  - **arousal : more or less awaken or asleep; activity level.**
  - **stance : attitude that may vary between open (open to dialogue or empathy) and closed (barring exchanges and cooperation) [7].**

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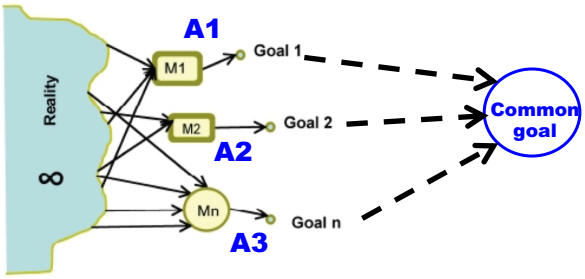
7. Cognition in the context of action and emotion, humans and societies, agents and groups 1 of 3

- **Establishing a common culture**
  - **Respective aspects of a (possibly collective) agent, with some of the most typical associated concepts (schematic views)**

Action to survive and change the world	Cognition to plan and guide action	Emotion, to synchronize with the world, to trigger action
"**muscle**", physical engine	"**brain**", cognitive engine; (mind)	"**heart**", indicator of values at stake
physical world, laws of nature, true	cognitive world,"non-physical", laws of logic, right	mixed/mode, emotional realm ("meta-logic"), laws of value, good
support operations, logistics	follows & optimizes rules, guidelines, standards; computes; evolution; syntax	changes rules and paradigms; irrationality, deception; changes price, gives and takes; revolution; peace or war
Motor and brake operation	cruise control (re. gear, throttle targets)	tempomat adjustment and braking control; starts-stops
force, energy; fight or flee; control power,	truth, notion of c-good, imagination, if-worlds, modeling, prediction	internal monitoring, communication, wisdom, consciousness, empathy, solidarity, dignity, mercy
shepherd's dog, horse	shepherd, shepherdess	lamb, flock of sheep, Romulus's & Remus's lupa
executive power (Cesar, MT)	Legislative power, science	People initiatives, fashion, strikes, mobs
lion, bear, bull	think tank, re. Martians in "Mars attacks"	flock of birds; « federative » imperial dragon (camel head, etc.)
technology, engineering	**philosophy,** "analytic" philosophy	**religion,** "continental" philosophy
work, operation	rational thinking, meditation, function, administration	strategy, art (value-laden, symbolic communication), dreams and nightmares, relaxation, mindfulness
Mars; permanence (constancy, determination, time)	mixed/mode	Venus; change (synchronicity with circumstances and instant values, speed)(re. App. E)
soldier, police, fire squad, farmer, entrepreneur, sports - individual	school, research institute, science, admin., games of strategy (logic), chess	ambassador, mediator, court system, social services, insurance, banking, sports-team

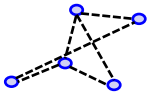
7. Cognition in the context of action and emotion, humans and societies, agents and groups 2 of 3

- Another **cognition-related challenge** worth mentioning is **coordination in a group**.
  - a group requires, in particular, a common culture
  - a common culture is hard to establish as (like for all models)
    - it necessarily relies on infinitesimal aspects of reality
    - **a common goal must be selected, understandable, and coherent with acceptable respective goals of member agents A_i**



7. Cognition in the context of action and emotion, humans and societies, agents and groups 3 of 3

- Contributions to a common culture
  - **Physical reality exists only in the most integral form of an (operational) agent (the whole, which is more than the parts); thus members and other subunits are just (cognitive) elements in immaterial models.**



1. **group** (collective agent)
2. **members** (individual agents)
3. **"glue"** (communication channels and common culture; re. e.g. team spirit, constitution, charter, flag, hymn, bondage, relations, commons, etc.)

- According to some authors (re. [8]), requirements in cognitive terms become very demanding when **social implications** are considered; **a possible cause for the evolutive development of human brain size,** to the current capacity to effectively deal with up to 150 people.

Content

8. Conclusion 1 of 2

- **Cognition should receive more scientific and technical attention. First for multiplication in machines; second for a better life in human context. Re. publications and practice / competitions.**
- **Models are necessary for cognition,**
  - **infinitesimal in relative complexity wrt reality,**
  - **yet most often good in leading to goals**
- **MCS theory of cognition applies**
  - **to all scales (integral and analytic),**
  - **all implementation mediums/media (man-made or natural);**
  - **re. e.g. thinking, deliberation, information processing.**
- **Useful for cognitics, domestic robots; as well as for human development.**

8. Conclusion 2 of 2

- Focusing on the current theme of this Conference:
  - Rationality is essentially bound to cognitive world;
    - thus it is powerful, as biological evolution proves,
    - and yet, by far, cannot claim exclusivity in matter of truth or goodness, versus rivals (e.g. "guts" , chance, "irrationality").
  - Emotions may call for value-based, dynamic CHANGES in models, including currently applicable laws of logic, which often appears as irrationality (e.g. vomiting, expressing a white lie, or forgiving)
- For collective agents, cognition requires in particular a common culture, which may be hard to keep 1. good for all, 2. coordinated, and 3. well understood by group members.
- Cognitive requirements in social life are high and may have caused evolutionary brain growth.
- In conclusion, Yverdon-les-Bains, Macau, rationality and rivals are but color spots in some models, while our unique, common, physical, hearty reality keeps cruising, global, Parmenidian, as Spaceship Earth, through our practically limitless universe.

Thanks for your attention!

Slides, soon → http://lara.heig-vd.ch

http://lara.populus.org/rub/3

… a glance at what follows?

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Appendices

- A. Probability, Logarithm and Information
- B. The challenge of meaning, semantics and ontologies
- C. Example of appropriate "cheating" and "manipulation" for a human-robot application
- D. Conscience & Consciousness
- E. Critical condition for recursive control

A. Probability, Logarithm & Information

~~1 of 2~~

- **Logarithm**: counting zeroes in a number; left or right.

N	Log
1'000'000	6
10	1
1	0
0.1	-1
0.000'000'1	-6

- **Probability**: ratio of success to trial; "chance"

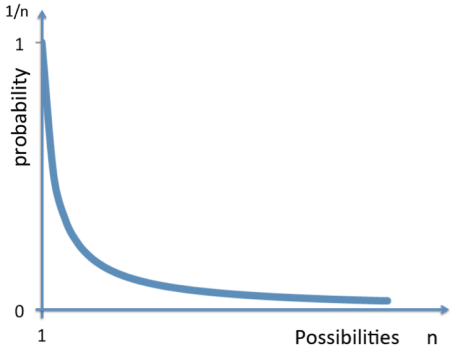
Possibilities	%; 0..100	Probability, P; 0..1	1/P ; 1..∞
1 in 1'000'000	0.000'01%	0.000'000'1	1'000'000
1 in 20	5%	0.05	20
1 in 10	10%	0.1	10
900 in 1000	90%	0.9	1.11
1000 in 1000	100%	1	1

- **Information** quantity: logarithm of inverse of probability [4]

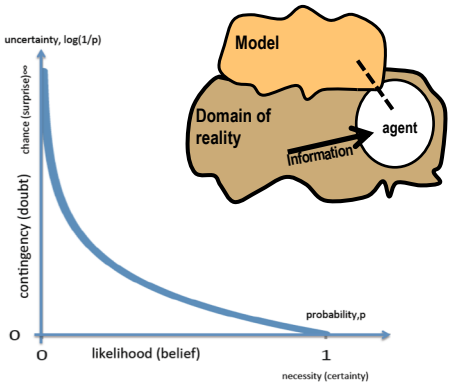
A. Probability, Logarithm & Information

2 of 2

- **Information updates agent's model; information quantity is a measure of uncertainty**

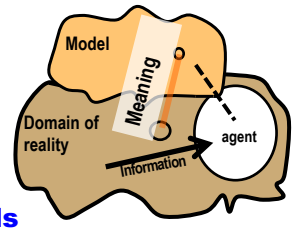


The probability of occurence of a specific message decreases with the number of all possible messages; case of equiprobability.



Probability, uncertainty and related concepts : likelihood, belief, necessity, certainty, contingency, doubt, chance and surprise.

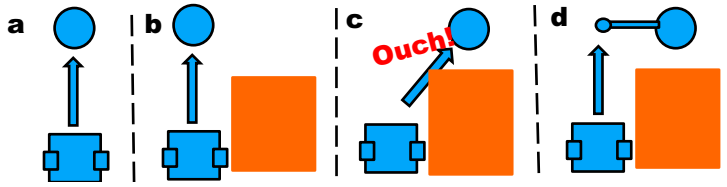
B. The challenge of meaning, semantics, and ontologies

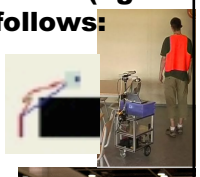


- **Meaning is the link that binds an element of a model, in a cognitive agent, and the corresponding element of reality**
- **Main consequences:**
  - **It inherits the key qualities of models**
    - **infinitesimal complexity wrt reality, incompleteness**
    - **often, possibility to help reaching goals (re."c-good")**
  - **It overflows logic and rationality fields, which are confined to cognitive models**
- **Associated notions, such as e.g. semantics or ontology, share the same properties**
- **Example: the senses/sensors of an agent gets a tactile stimulus; this may mean that an obstacle is to be avoided.**

C. Example of appropriate "cheating" and manipulation for a human-robot case

- In general, what may be considered as right in a context (re. cognition; laws of logic 1), may be wrong in another one (laws of logic 2); and changing the set of logic laws may be appropriate in some circumstances (re. emotions; laws of values)
- Example: Consider a human (agent 1, G) guiding a robot (agent 2, e.g. RH-Y). Typical cases can be considered as follows:
  - a: RH-Y tracks G's body, modeled by its torso part;
  - b: same, also successful, in the vicinity of an obstacle;
  - c: here, a regular, "honest" torso guiding would collide;
  - d: extending one arm allows G's hand to "manipulate" RH-Y, to "cheat" it about current G's torso location.





Note. Alternatives exist, whereby e.g. the robot has additional, ultrasonic, proximity sensors (top, tight); or the robot has a map to avoid obstacles (top "left").

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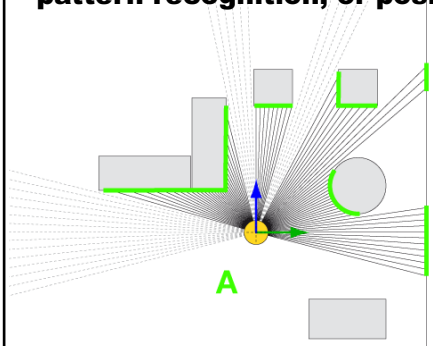
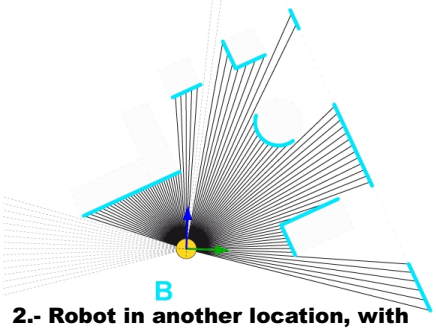
D. Conscience & Consciousness

1 of 2

Evident case of consciousness in our robots (re. SLAM, pattern recognition, or positional calibration) [1, 7]



1.- Real egocentric distances, perceived with a scanning laser range finder; world elements (green), learned as persistent model of the world.

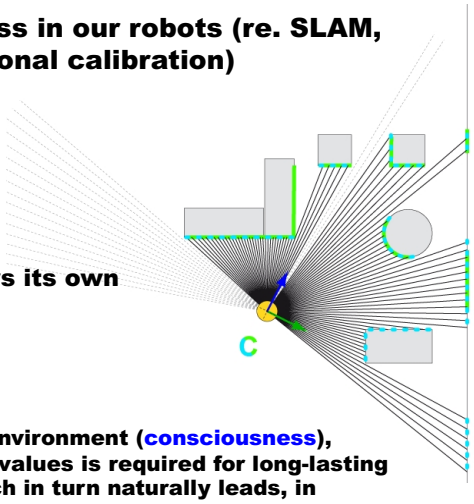


2.- Robot in another location, with unknown orientation, along with the corresponding range data. A correlative process matches B data with A elements.

D. Conscience & Consciousness

2 of 2

Evident case of consciousness in our robots (re. SLAM, pattern recognition, or positional calibration)

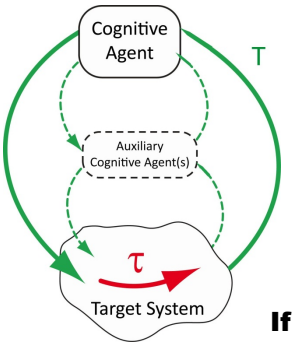


3.- Consequently, the robot knows its own location in the world.

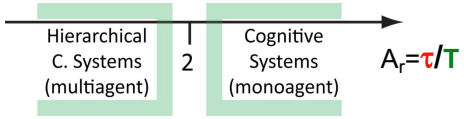
Note.
Awareness of oneself, in one's own environment (consciousness), naturally teaches that an account of values is required for long-lasting operation/survival (conscience), which in turn naturally leads, in particular, to the notions of ethics and ecology.

E. Critical condition for recursive control

- **Dynamic behavior - compensation for disturbances and stability; hierarchies and autonomy**



For successive control, the agility (control speed) of a cognitive agent must be large, relatively to the one of the target system [2]



If an agent is too slow, a hierarchy must be devised; part of the control must be outsourced; autonomy must be granted to auxiliary agent(s), in matters of high speed [2]

Thanks for your attention!

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Slides, soon

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