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Natural Emotions as Evidence of Continuous Assessment of Values, Threats and Opportunities in Humans, and Implementation of These Processes in Robots and Other Machines

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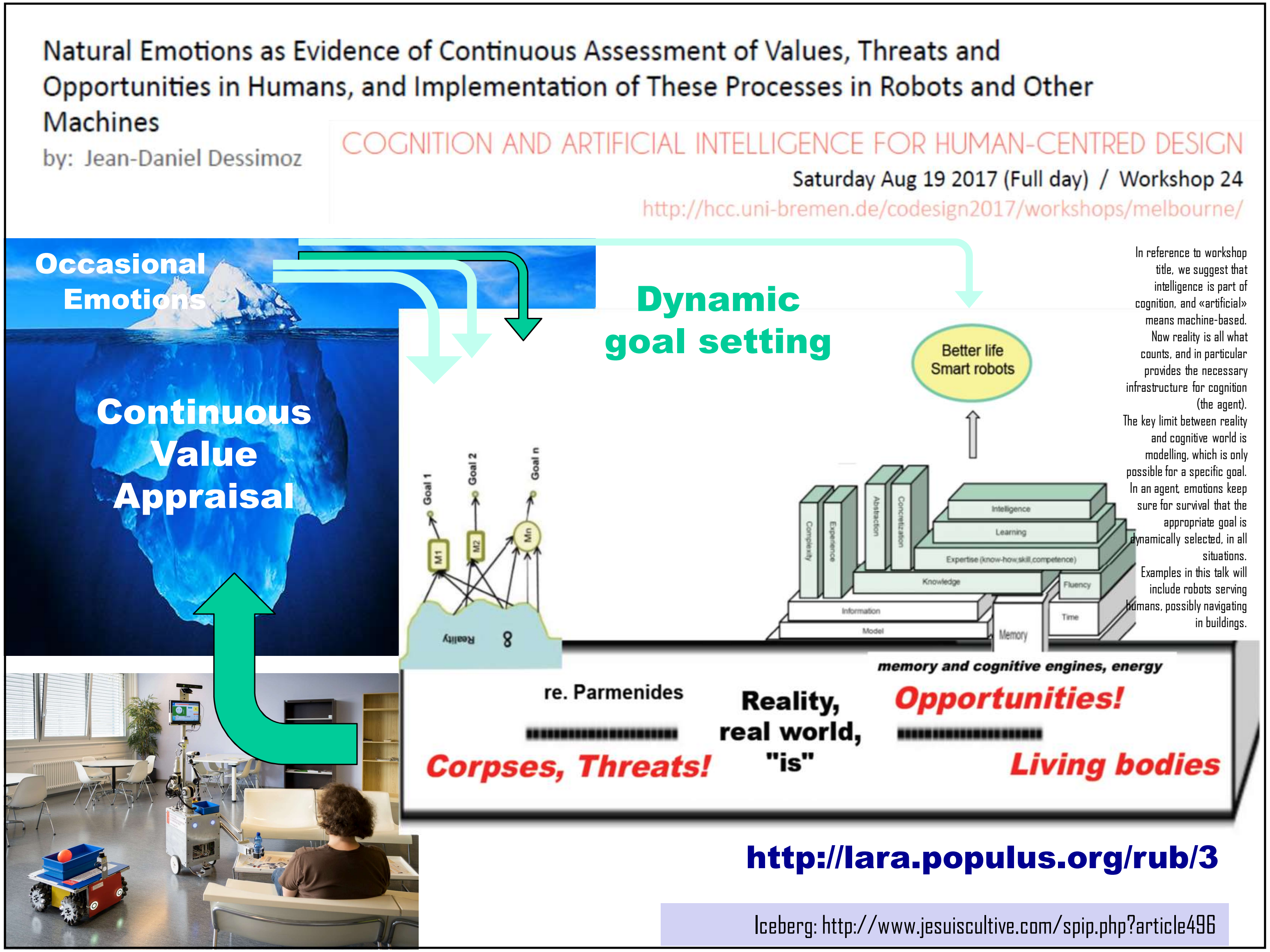

Natural Emotions as Evidence of Continuous Assessment of Values, Threats and Opportunities in Humans, and Implementation of These Processes in Robots and Other Machines
by: Jean-Daniel Dessimoz
COGNITION AND ARTIFICIAL INTELLIGENCE FOR HUMAN-CENTRED DESIGN
Saturday Aug 19 2017 (Full day) / Workshop 24
http://hcc.uni-bremen.de/codesign2017/workshops/melbourne/
Occasional Emotions
Continuous Value Appraisal
Dynamic goal setting
Better life
Smart robots
Goal 1
Goal 2
Goal n
M1
M2
Mn
Reality
Intelligence
Learning
Expertise (know-how,skill,competence)
Knowledge
Fluency
Information
Model
Memory
Time
Complexity
Experience
Abstraction
Concretization
In reference to workshop title, we suggest that intelligence is part of cognition, and «artificial» means machine-based. Now reality is all what counts, and in particular provides the necessary infrastructure for cognition (the agent). The key limit between reality and cognitive world is modelling, which is only possible for a specific goal. In an agent, emotions keep sure for survival that the appropriate goal is dynamically selected, in all situations. Examples in this talk will include robots serving humans, possibly navigating in buildings.
memory and cognitive engines, energy
re. Parmenides
Reality, real world, "is"
Opportunities!
Corpses, Threats!
Living bodies
http://lara.populus.org/rub/3
Iceberg: http://www.jesuiscultive.com/spip.php?article496

1. Introduction

- Good solutions for physical systems, and lots of progress in cognitive systems have occurred;
- now we recognize the primary **need to process the laws of values**, to permanently and synchronously appraise threats and opportunities that keep happening in real world.
- **Occasionnally, major changes in instant value do occur, launching emotions in humans**.
- Actually, **this is also a technical requirement for machine-based systems** in artificial cognition.
- The plan of the talk follows…

Content

Content

2 Emotions and associated laws of values

2 Emotions and associated laws of values 2 of 12

2.1 Emotions? Why?

- **First**, as a tribute to **on-going research in international community.** To improve H-R communication.

- **Now, and more fundamentally: Necessity of assessing values** (which is implicit in emotions) in order to set goals and “consequently” for updating modelling approaches and other cognitive processes

2 Emotions and associated laws of values 3 of 12
2.2 Artificial Emotions – The first wave

- In robotics, subject of research already in the 70's
- **Give robots a more attractive look** than traditional machines, in order to improve acceptance and empathy
- Then communication aspects: concrete goal for machines to recognize human emotions
- In our case, in early times:
  - Robocup@Home participation – with new head? No, with a robot group including **NAO as a H-R mediator**.
  - Priority in setting **foundations of cognition theory, MCS**.

2 Emotions and associated laws of values 4 of 12

2.3 Real Emotional Iceberg – Synchronously coping with threats and opportunities - 1

- Revisited, the concept of emtions opens a world, of utmost importance
- **Evident as the tip of an iceberg, emotions in humans** (i.e. natural emotions) appear as certain types of sudden changes in behavior and activity, events or episodes
- **And under the water?** :

  2.3.1. Keep synchronous with real world circumstances

  2.3.2. Assess values, convergence between status and goals.

  2.3.3. **Appropriately set new current goals, thereby steering new cognitive efforts and corresponding actions**.

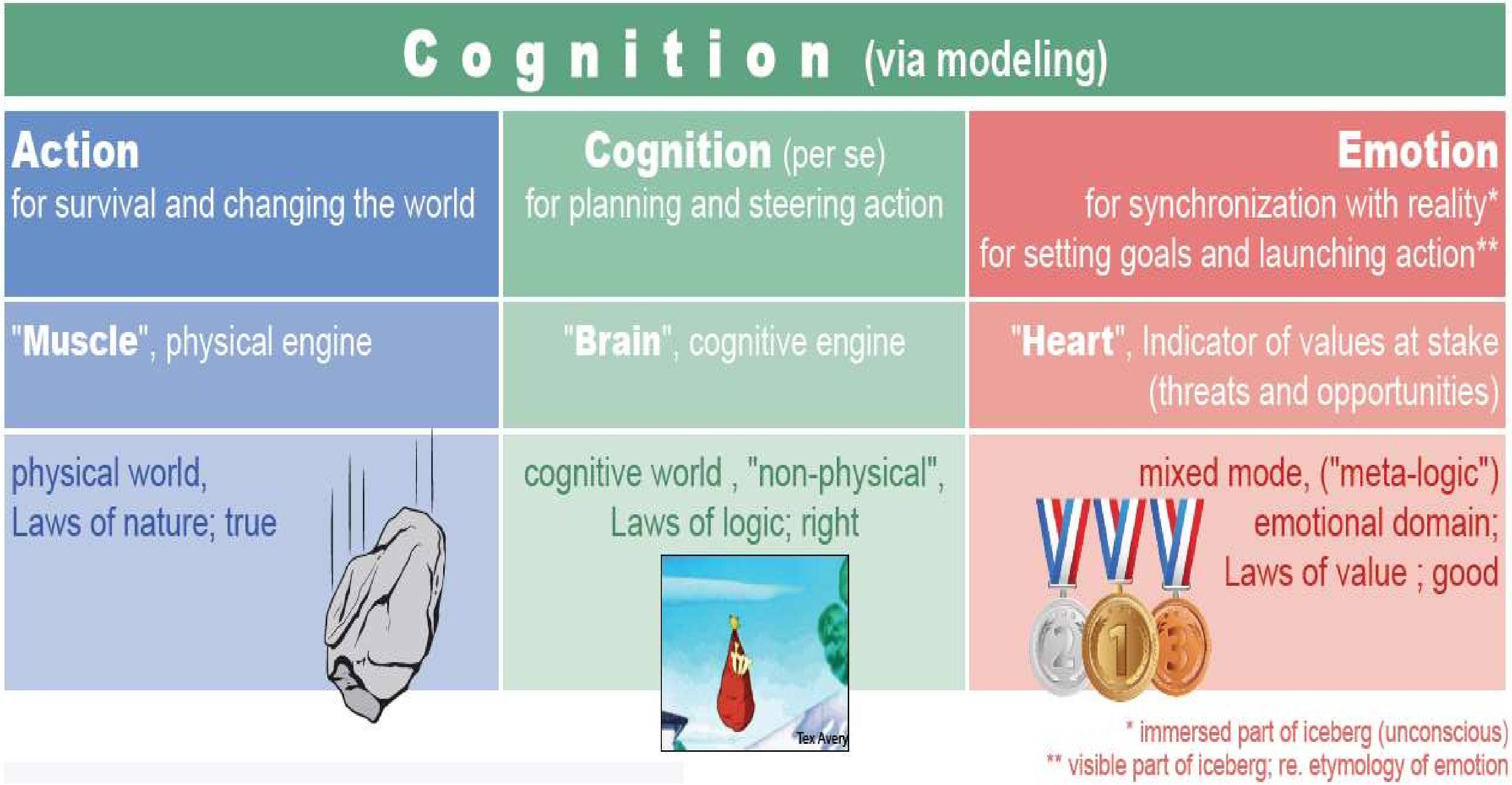


Fig. 1. Emotions set new goals for cognition, which steers action accordingly [updated from 2015 & 2016a]**.**

2 Emotions and associated laws of values 6 of 12

2.3.1. Keep synchronous with real world circumstances - 1

- Cognition can extend into the infinite reaches of the imagination in humans' cognitive universe:
  - generous of **unlimited virtual possibilities**,
  - even if memories turn out to be mirages of the "**past**",
  - and visions of "**future**" prove more or less illusory,
  - all this does not necessarily matter!
- On the contrary, as shown in Appendix (§ A.1 and § A.3), **the present moment is critical, hosting all realities**.
- And even **cognition requires a real infrastructure**;

2 Emotions and associated laws of values

2.3.1. Keep synchronous with real world circumstances - 2

- Therefore **reality constantly requires top priority of cognitive agent's attention** for latter's further survival. When changes occur, those changes should be detected without delay, and this should trigger new processes as presented in next point.
- By the way notice that time showing devices are precious crutches for our emotions; these devices are safety tethers that connect us, synchronous, with reality, where everything is played in the moment, where **it is vital, immediately, to slalom between instant threats and to gather current opportunities.**

2 Emotions and associated laws of values 8 of 12

2.3.2. Assess values, convergence between status and goals - 1 of 3

- In MCS theory of cognition, **good** (and symmetrically, bad):
  - defined as true (versus false),
  - for logic laws relating to the **ability of moving towards a corresponding goal**.
- This is the **axiomatic foundation for values** in MCS theory (what is good-true-positive value, what is bad-false-negative value)
  - In this sense **opportunities can be associated to factors tilting results on the "good" side, i.e. tending to help the agent reach his/her goal** –true - positive value,
  - while threats tend to let him/her deviate from it -negative value.

2 Emotions and associated laws of values 9 of 12

2.3.2. Assess values, convergence between status and goals - 2 of 3

- So in case of significant **changes in current, perceived circumstances**
  - **->the laws of values must be processed again** and
  - in case current goal gets out of reach or could be surpassed by others in optimality,
  - **-> adaptation should proceed**, as described in next subsection.
- **In humans,**
  - it might be argued that no cognitive analysis would be required for value assessment, values being directly perceived, as **immediate pains or pleasures?**
  - (TBC)

2 Emotions and associated laws of values 10 of 12

2.3.2. Assess values, convergence between status and goals - 3 of 3

- In humans (cont.):
  - Nevertheless **numerous examples show that such a direct connection is questionable**.
  - Obviously it is not applicable to highly abstract situations, like winning lottery or hearing about the risks of smoking tobacco.
  - Thus if this direct perception were sometimes true, it would at most be restricted to low-level phenomena, like tasting salt or burning fingers.
  - But even in such cases, experience shows a gap as well: soldiers keeping shooting undisturbed, while having suddenly lost their own legs; or physicians practicing hypnosis, apparently decisively modulating pain in patients by shifting their focus of attention.

2 Emotions and associated laws of values 11 of 12

2.3.3. Appropriately set new current goals, thereby steering new cognitive efforts and actions - 1 of 2

- When new current goals are assigned, **a cascade of increasingly uncertain processes may develop**, depending on circumstances.
  - The simpler cases may simply call for immediately switching to **another routine goal** in a usual manner.
  - More elaborate cases may require some **new cognitive efforts,** further exploration of reality, and possibly calling for collective and external help.
  - But reality does not wait; so searching for more elaborate goal definitions also possibly requires meanwhile **getting back to basic, traditionally safe situations** (TBC)

2 Emotions and associated laws of values 12 of 12

2.3.3. Appropriately set new current goals, thereby steering new cognitive efforts and actions - 2 of 2

- (cont.) Basic, traditionally safe goals : sustainable at least in immediate and short terms (fight, flee, lapse into a coma, etc.); this is of topmost importance for survival.

- **Changes in goal setting have dynamic consequences for cognition**:
  - first in terms of requirements for modelling, and
  - second as adapted processes for planning and launching appropriate actions.

Content

3. H-R Dialogue - Translation and cultural mediation

- 3.1 **Emotions in humans and (bio-inspired) machines** – the communication and translation issues.
- 3.2 **Emotions in groups (RR, HR)** – the common culture issue.
- 3.3 General approach for **managing** complexity and application in **the case of emotions**.

3. H-R Dialogue - Translation and cultural mediation 2 of 4

3.1 Emotions in machines – the translation issue

- Natural emotions are evident in humans
- Theoretical definition 1 in MCS: **Emotion is a particular kind of "expertise"** (specific domain); "universal" definition – for H &R & M.
- **Yet sensitive connotations** – here close to core, specific (?) human nature e.g. agitation, audaciousness, courage, enthusiasm, passion
- **Emotions relate to values > exclusively human??**

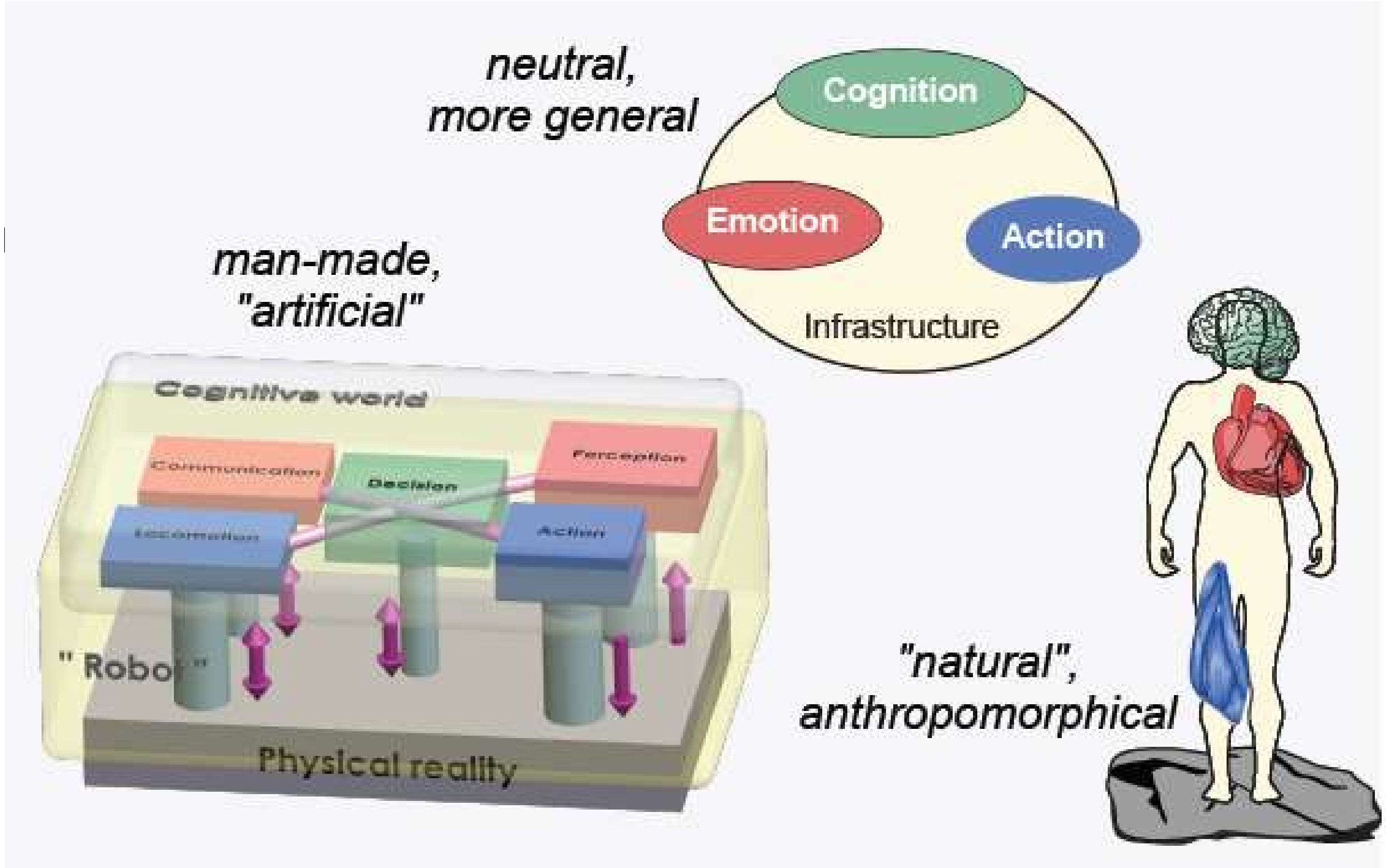
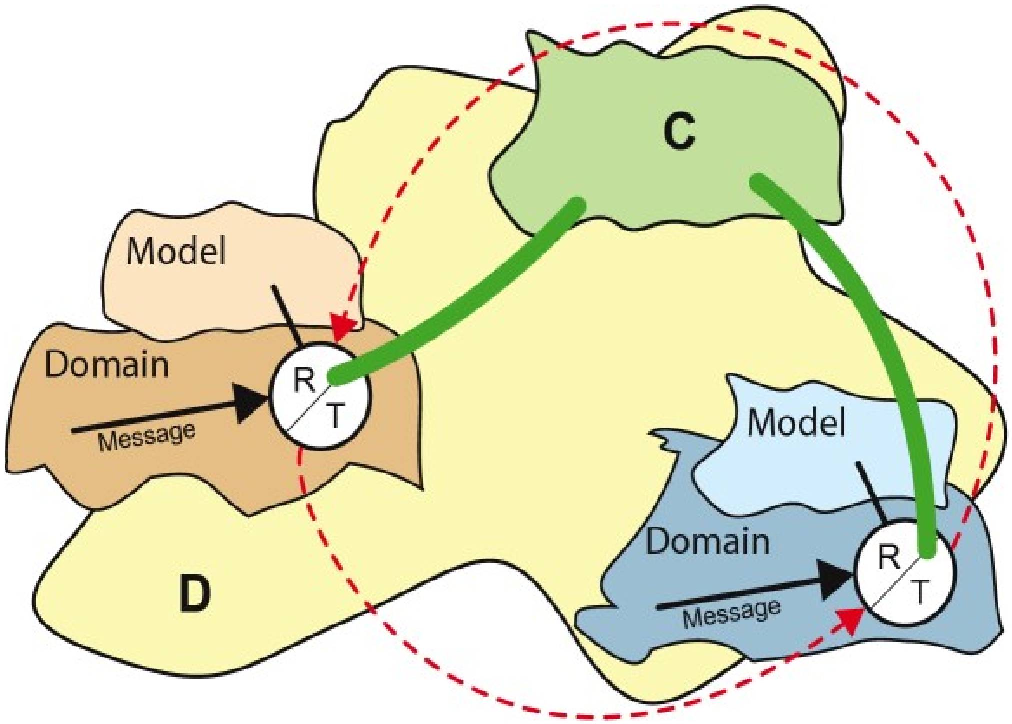


Figure 2. Examples of cognitive systems, operational in the real world. Standardization should avoid misleading connotations.

3. H-R Dialogue - Translation and cultural mediation 3 of 4

3.2 Emotions in groups –common culture issue

- Cognitive perspective: **groups need communication channel and common culture**.
- For mutually understanding emotions, a lot can also be done without explicit agreement, just by observation of behavior-operation.
- In all cases, when available, some **cultural mediation may help**.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D
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Domain
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Message

3. H-R Dialogue - Translation and cultural mediation 4 of 4

3.3 General approach for managing complexity and application in the case of emotions

- Complexity : **approach it gradually** (re. modelling, focus, hic et nunc, ad hoc, case-base reasoning, etc.)
- For practice of emotions in H-R groups, some **standardization, connotation-free**, is the most promising approach (re. road traffic signs; letters; cognitive "agent" in Fig. 2).
- Waiting for a standardization, rely on a **dedicated translation scheme**, as between natural languages: imagine a choice between **human view and machine view** (e.g. Fig. 2).
- From human perspective, emotion is usual, somehow traditionally understood. Moreover, it has been defined **in MCS**, in **a selection of concepts directly applicable both to machines and robots**.

Content

4. Application in real world

- 4.1. Basic systems.
- 4.2. Robot group for domestic help.
- 4.3. Value-based navigation strategies and suggestions for architectural design.
- 4.4. Temporary conclusion in CAID workshop context.

4 Application in real world

4.1. Basic systems – 1 of 3

- First examples: **simple yet with essential notions in emotions and laws of values**.
- Most basic technological support for emotion-related processes : the **alarm clock** - ensures synchronicity with real-world. Law of value consists here in a single predicate: if current time “lays” before wake-up target, stand still, otherwise ring! It then switches goals and launches a noisy action- Think of value.

4 Application in real world

4.1. Basic systems – 2 of 3

- Another key crutch for human emotions : the **smoke detector** - the device keeps tirelessly monitoring particle density in air, and when a significant level is detected, synchronously, an alarm is launched. Value: life or death issue.
- Getting back to the time-base issue, an example involving robots may be quoted in the context of **Eurobot robot competitions**: round duration have always been set to 90 seconds. (TBC)

4 Application in real world

4.1. Basic systems – 3 of 3

- (cont.) Previously, humans had to manually stop the machines with ad hoc red buttons, at the specified moment. Then this operation has been transferred as a task to be autonomously done by robots, and an explicit rule of the game was introduced: **failing to spontaneously stop after 90 second, a robot would loose the game**.
- In summary, these simple cases illustrate the essential elements of emotions: **synchronicity with real world, assessment of value, and adaptation of current goals and launched actions**.

4 Application in real world

4.2. Robot group for domestic help – 1 of 4

- At world level, to develop AI and robots > **Robocup** initiative: first focus on soccer; later on, notably on **domestic services**
- Our robots have participated to the five first R@H editions, sometimes also involving a Nao humanoid robot as mediator between human and machines, e.g.
  - **communicating vocally** with humans,
  - **synchronizing and following** them without contact,
  - **locating and recognizing** objects **visually**,
  - "**copycating**" human **motions**,
  - all, in tasks involving kitchen goods, and generally domestic services (re. Fig. 3).

Figure 3. Original RH-Y and OP-Y robots, many times engaged in Robocup@Home competitions, shown here in a domestic task. The system is modular, featuring various configurations, all driven in Piaget environment

4 Application in real world

4.2. Robot group for domestic help – 3 of 4

- Emotions implemented in this robot group,
  - Case 1 - in the consensual sense of § 2.2,
  - Case 2 - in the deeper sense involving laws of values, as defined in § 2.3.
- For **example**, in case 1 :
  - graphic display for **usual facial codes** (with displays similar to animated emoticons), displaying part of the internal status and intentions of RH-Y robot;
  - both robots feature **colour headlights** that may vary in a variety of manners according to internal conditions and circumstances.
- For **example**, in case 2, several safety measures are enforced:
  - **obstacle detection and avoidance**
  - additionally, a constant, low-level **monitoring of torques on wheels** is performed; consequently, some laws of values ensure that possible collisions are detected fast, at low force levels, that motion strategies are adapted, and that power gets selectively restricted in order **to prevent casualties to humans**.

4 Application in real world

4.2. Robot group for domestic help – 4 of 4

- In summary, **laws of values can be established and autonomously processed to ensure emotion-driven, smart behavior in real world**.
- In fact, emotion-related processes, when actually implemented in robots, can not only simulate human behaviors but can also even effectively replicate them.
- In practice, this notably means that beyond formal analysis, simulation may validate assumptions and theories. And the capability to implement emotion-related cognitive processes in machines opens the **possibility to create a wealth of new resources helping humans**.
- Implication of **domestic concerns in architectural design** is an obvious necessity.

4 Application in real world

4.3. Value-based navigation strategies and suggestions for architectural design – 1 of 6

- The **third class of examples** most closely relates to CAID 2017 theme
- A robot freely moves with two joint constraints (Fig.4):
  - avoidance of physical collision in real world
  - **avoidance of virtual obstacles**, as defined by humans in order **to restrict access to some a priori defined areas**.
- The way the system works points at measures to be recommended in architectural design phase.

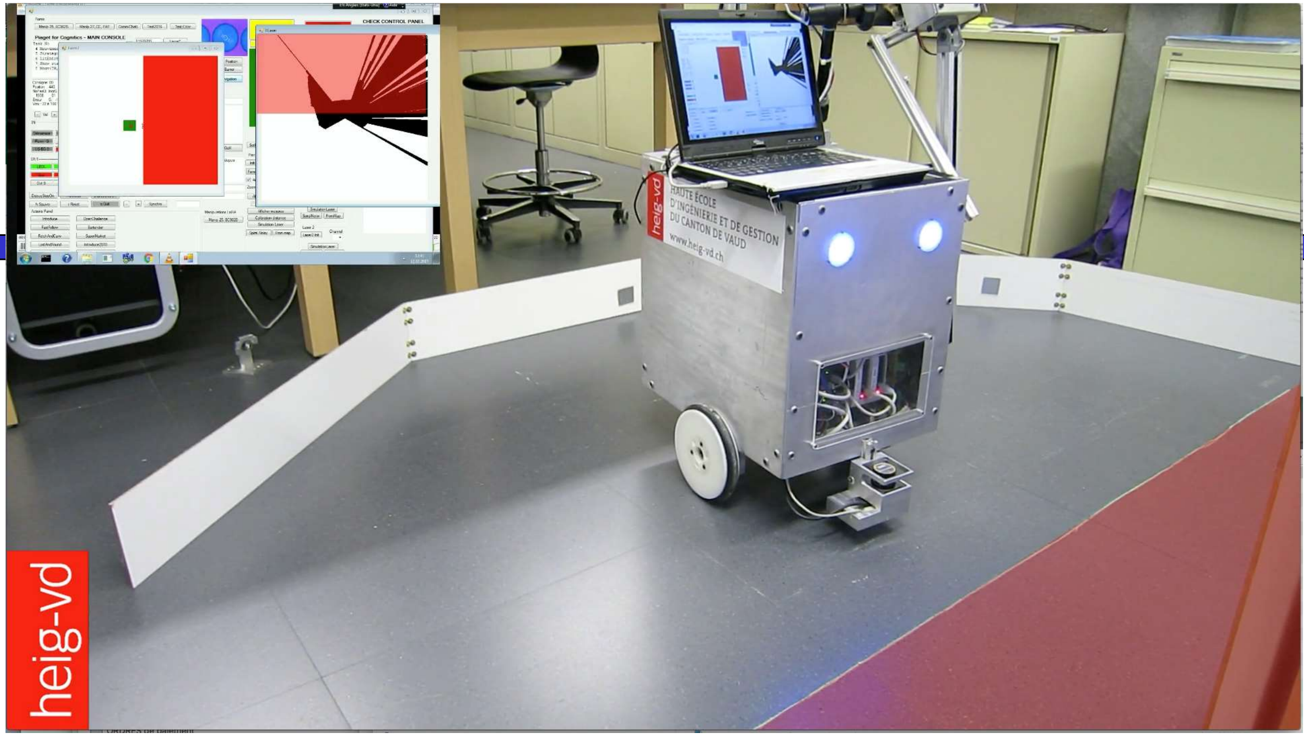

Figure 4. RH-Y robot navigates freely, assessing continuously threats, such as obstacles, to be perceived by LiDAR, or as forbidden areas (e.g. downwards staircases, pools) virtually and a priori defined by humans (shown here in red, graphically superimposed on original screens for reader's convenience). Notice also the gray squares on low walls – mirrors- conveniently made for calibration purpose.

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Free navigation using LiDAR, virtual barriers and forbidden regions

Rishabh Madan
GitHub: @madan96
Summer Intern, LaRA, HEIG-VD

4 Application in real world

4.3. Value-based navigation strategies and suggestions for architectural design – 3 of 6

- A key difference between physical and virtual worlds : **location estimation**.
  - **In physical world: accumulation of inaccuracies**, reflecting the complexity of reality,
  - **solutions may be local**, relative to close environment;
  - In virtual world, typically no “noise”.
  - **When virtual worlds are added, location estimation must be absolute,** coherent with a priori definitions (re. maps – e.g. in CAD, or as in Fig.5).

Figure 5. Example of a **2D map** created using LiDAR data. The red blob represents the region where a robot is currently located in the map (ref. agv-iit-kgp.github,io, IIT Kharagpur, in [Madan and Gauthey, 2017|).

4 Application in real world

4.3. Value-based navigation strategies and suggestions for architectural design – 5 of 6

- Thus **for simulation purpose: artificial noise generation** should not be neglected!
  - for meaningful prediction of mobile behavior,
  - hopefully leading to appropriate corrective measures.
- **In real world: some calibration means should** always **be provided**.
- Many approaches have been explored for indoor location. (TBC)

4 Application in real world

4.3. Value-based navigation strategies and suggestions for architectural design – 6 of 6

- (cont.) In particular, also visible in Fig. 4,
  - a pragmatic approach, for cm range accuracy, consists in defining some calibration planes (e.g. 1m x 0.1m flat surface)
  - with a 2D LiDAR, this retrieves two coordinates in the plane (e.g. x and phi), or even the third coordinate (y) with additional mirrors (thereby discontinuity in LiDAR signal, without discontinuity of surfaces).
- Thus, most of **common architectural items (walls, doors, furniture) naturally provide potential calibration planes**; yet in some cases, design additional ad hoc calibration structures for machine-based systems.

4 Application in real world

4.4. Temporary conclusion in CAID workshop context - 1 of 3

- **Discussions are still welcome, yet some** of the main **points** are **already clear** today **in** reference to **CAID context,** including the following ones:
  - AI is part of cognition (in general, i.e. human or machine-based);
  - design implies concretization processes, which typically are cognitively much less demanding than symmetric abstraction processes;
  - similarly to humans, who are primarily made out of DNA, the mere *replication* of best practices should not be overlooked;
  - (TBC)

4 Application in real world

4.4. Temporary conclusion in CAID workshop context - 2 of 3

- (cont.):
  - modelling cannot be complete (at best, models can infinitesimally represent reality, i.e. be true)
  - yet models are made to be good (goal-oriented, tractable);
  - a quantitative approach in cognition allows to track improvements and to expertly optimize known solutions;
  - only chance has the potential, sometimes, of yielding disruptive novelty (i.e. of successfully challenging the infinite complexity of reality);
  - Emotion supporting, value-related process is of vital importance: (TBC)

4 Application in real world

4.4. Temporary conclusion in CAID workshop context - 3 of 3

- (cont.) emotion supporting, value-related process:
  - permanent synchronization with real world (monitoring)
  - assessment of instant human-related values (possibly critical threats and opportunities in current situation?),
  - thus possibly and dynamically adapting immediate goals and related modelling and cognitive processes.
  - **Beware of an essential property of information, inherited here** : its quantity vanishes upon reception (re. « idem »). By this token, **simplicity is a typical quality of problems already solved**. In fact, even devices as « simple » as alarm clocks have appeared rather recently in human evolution.

Content

5. Conclusion 1 of 4

- **Emotions** :
  - occasional events,
  - but **require a permanent monitoring of circumstances in real world**,
  - along with appraisal of situation
  - **and**, when appropriate, **immediate and drastic updates in strategic goals**,
- Goals **->** **modeling** & other cognitive operations (e.g. planning) **-> actions in real world**

5. Conclusion 2 of 4

- After briefly referring to a cognitive framework, this paper has proposed a more comprehensive view of **emotions** than it is usually done. Instead of event-driven or episodic phenomena, the latter **imply a permanent, recurring assessment of threats and opportunities**, critical for ultimately ensuring survival.
- **The value assessment process** must actually set targets, and ***drives* cognition** accordingly, which notably often calls for specific, dynamical, changes in modelling strategies.

5. Conclusion 3 of 4

- Appraisal implies an assessment of values, and ultimately **values can only be defined in human-centered approach**.
- Many practical difficulties appear; in human-centered approaches, **even for essentially identical core cognitive concepts**, different words are usually chosen, depending on the specific nature of cases, human or machine-related; thus **unwanted differences in connotations may undermine the message**.

5. Conclusion 4 of 4

- In fact, **emotion-related processes, when actually implemented in robots, can effectively replicate human behaviors**.
- This is also true for many more automated processes in our current, machine-based, automated world.
- **Finally, this contribution has described some representative applications in real world** and has closed with a call for further discussions in CAID context.

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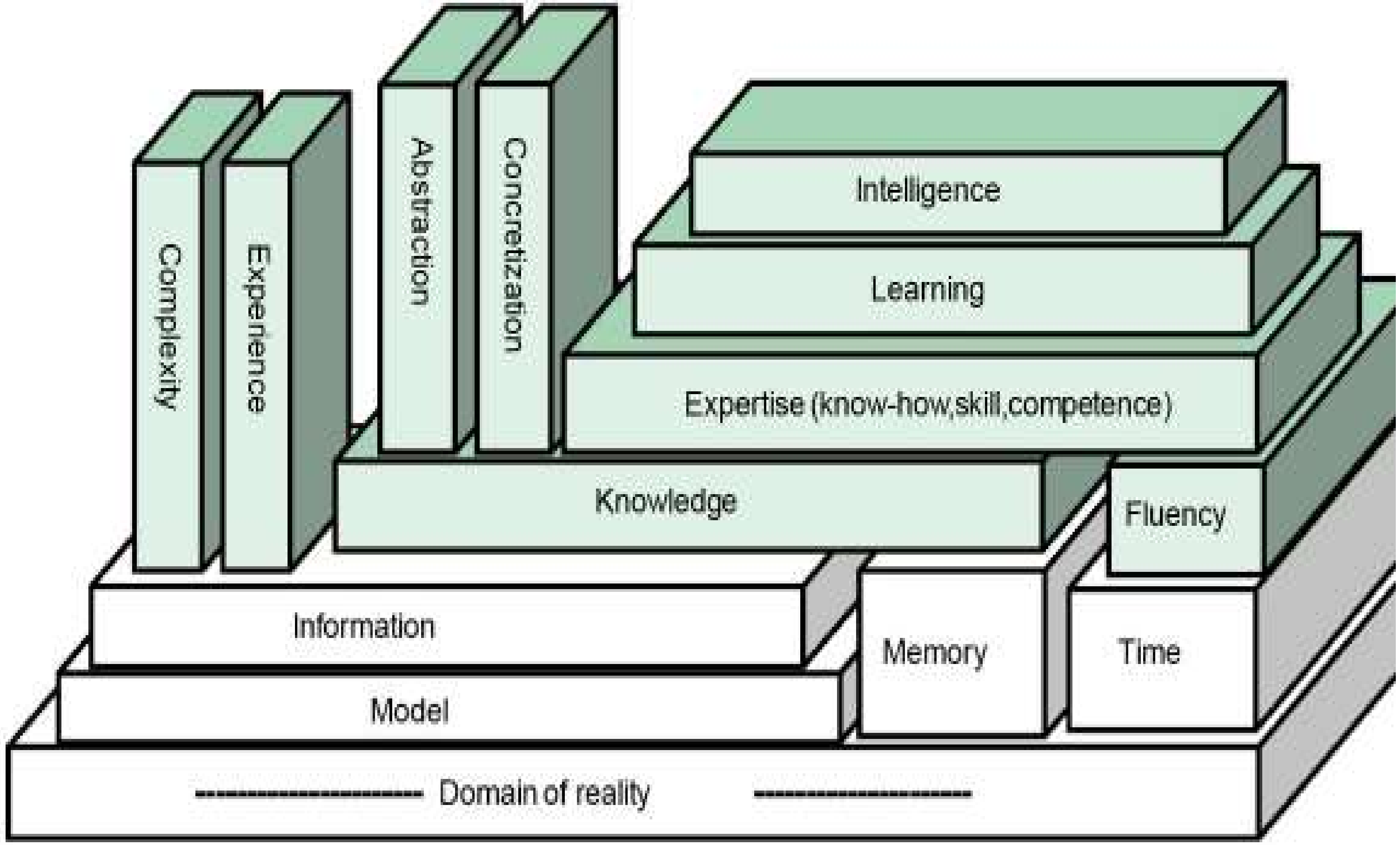

Complexity
Experience
Abstraction
Concretization
Intelligence
Learning
Expertise (know-how,skill,competence)
Knowledge
Fluency
Information
Memory
Time
Model
---------------------- Domain of reality ---------------------

Content

Appendix A - Revisiting Basics

- **Foundations**
  - reality
  - imagination and **models**,
  - time and speed,
  - probability and information
  - expected potential, and known limits

Appendix A - Revisiting Basics 2 of 8

A.1 Reality

- The first basic concept to address is reality. Unfortunately, reality itself is quite out of reach for our discussion**. Any words and representations could only fail to describe, but a biased, infinitesimal part of reality.**
- The only and definitely pertinent statement that can be made about reality is the following one, due to the Ancient Greek Parmenides: “What is, it is”.

Appendix A - Revisiting Basics 3 of 8

A.2 Modelling, imagination and representations

- The second basic concept to address is modelling. **Modelling implies the infinite reaches of imagination, as in humans' cognitive universe**.
- Imagination allows for modelling. The word "modelling" is retained here to assert the imaginary nature of things, **possibly somehow related to certain elements of reality; or not**. In this sense, modelling provides the most essential, core part of a large number of other concepts, such as notably representation, word, image, idea, theory, type, example, signal, variable, qualia and "concept" itself.

Appendix A - Revisiting Basics 4 of 8

A.3 Time and speed - 1 of 2

- The third basic concept to introduce, time, pragmatically attempts an "impossible", yet extremely important link across reality and imagination.
- **Time is but a dimension in a model**, which **denotes permanence**, up to eternity. Its inverse, speed, characterizes change, up to discontinuity

Appendix A - Revisiting Basics 5 of 8

A.3 Time and speed - 2 of 2

- As seen in paragraph 2.1, **the real "is,"** it is right there, it is physical; **time, on the other hand, is but an idea** expressing the permanence and change of things. According to this idea, reality is wholly in the present moment, whereas our imagination can freely slide time's cursor "backwards," towards our memories, and "forwards," towards visions of the future. Appropriate real-world machines - timekeepers, clocks, watches - can surprisingly calibrate with superhuman precision in the real that conceptual time that is ever passing.

Appendix A - Revisiting Basics 6 of 8

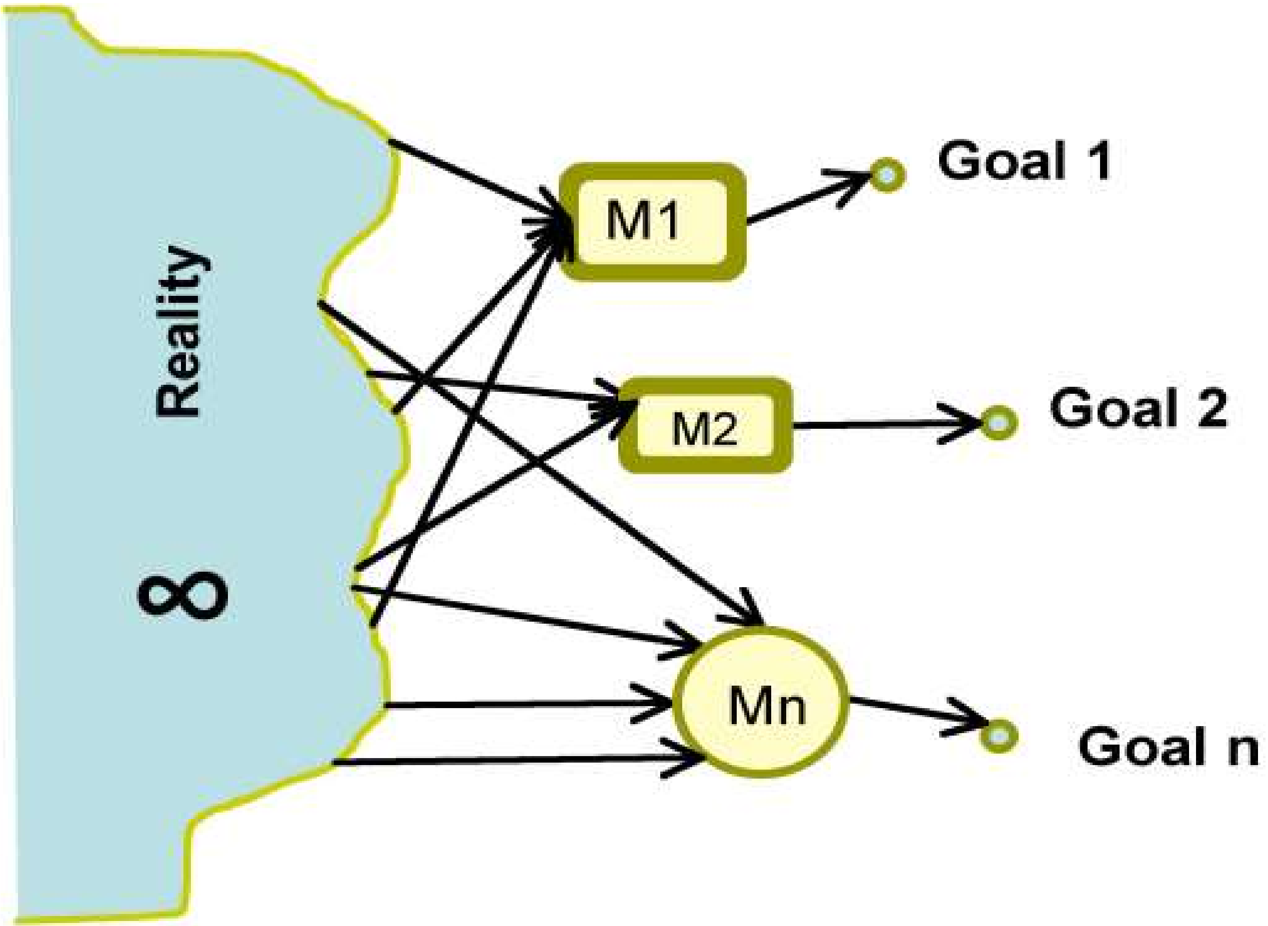
A.4 Information, uncertainty and probabilities

- Probability is one of the primary dimensions to consider when modelling reality. Uncertainty is essentially its inverse; **information is an antidote to uncertainty** and both concepts are similarly estimated, in terms of quantity.
- Probability is a measure of likelihood, the property of things that are expected to happen.
- For our purpose, probabilities, and therefore, consequently, information must be estimated in priority from receiver’s perspective.

Appendix A - Revisiting Basics 7 of 8

A.5 Potential and limits of basic notions – 1 of 2

- Let us quickly state what are the best potential and main limits relating to the basic concepts sketched in above four subsections.
- Reality is all what counts; but it remains impossible to be *fully* perceived and described in cognitive world.
- **Modelling** in principle allows for an unlimited imaginary universe, and, even crude, **may often help in reaching specific goals; but** in practice it **always remains infinitesimal in power of representation of reality**, and may “loose ground”, i.e. reflect a wrong rendering of the real world.


Reality
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M2
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Goal 1
Goal 2
Goal n

Appendix A - Revisiting Basics 8 of 8

A.5 Potential and limits of basic notions – 2 of 2

- The **notion of time** supports the massive (imaginary) representations of past and future worlds but **connects to reality** at best only for a thin, instantaneous present.
- **Information** allows for a quantitative estimation of uncertainties and can compensate for them; but it **cannot address reality itself**, approaching the latter only via models. Moreover, we must keep in mind that by definition, information **is subjective and quantitatively vanishes upon delivery**.

Content

App. B - Model for Cognitive Sciences (MCS)

- Conceptual pyramid supporting emotions : requires new layers, core entities in cognitive realm, above classical foundations presented in App.A.

  – B.1 MCS and cognitive framework
  – B.2 Emblematic cognitive notions

- re. [Dessimoz, 2016b] for a more detailed presentation on MCS

App. B - Model for Cognitive Sciences (MCS) 1 of 7
B.1 MCS and cognitive framework – 1 of 2

- Robotics really started in the 60's of 20th century, with maturity in mechatronics.
- In the 90's, **time has come to implement cognition in machines**.
- No proper definitions, nor measuring units were available. We had to elaborate axiomatic definitions and provide a metric system for cognitive realm; MCS was initiated.
- Essentially, **cognition** has been defined in MCS context, as **the ability to generate and deliver pertinent information**. It **requires a cognitive engine**, an agent (re. Fig. 6); in real world.

App. B - Model for Cognitive Sciences (MCS) 2 of 7

B.1 MCS and cognitive framework – 2 of 2

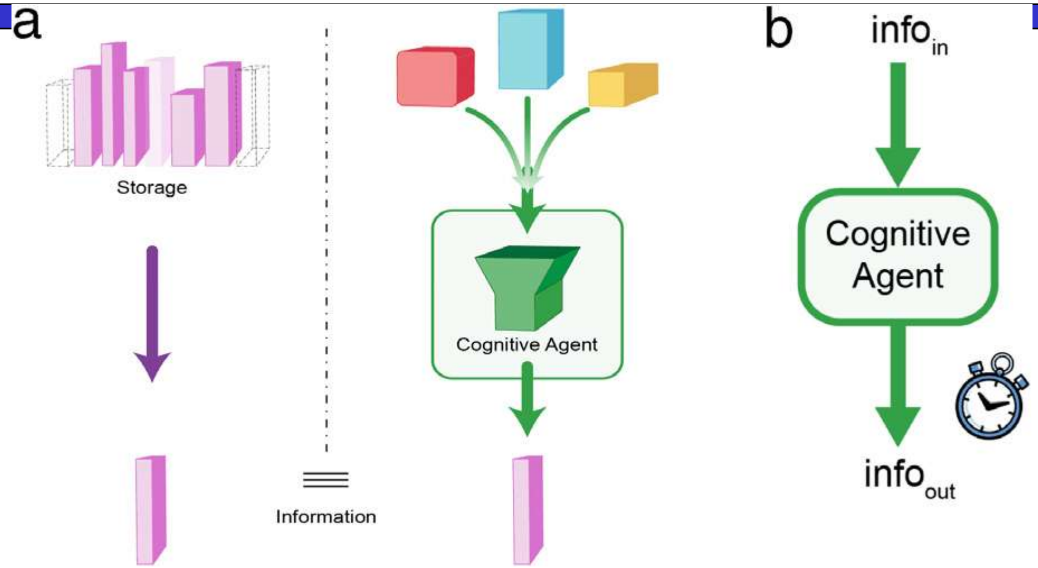

Figure 6. Cognition generates and delivers pertinent information (a). Main elements for quantitative estimation of cognition include incoming and outgoing information amounts, and processing time or speed (b).

App. B - Model for Cognitive Sciences (MCS) 3 of 7
B.2 Emblematic cognitive notions – 1 of 4

- **MCS theory for cognition provides formal definitions** for many cognitive concepts. **Here are** some of **the most emblematic ones**:
  - Knowledge
  - Expertise
  - Learning – re. machine learning
  - Experience
  - Intelligence - re. artificial intelligence
  - Complexity

App. B - Model for Cognitive Sciences (MCS) 4 of 7

B.2 Emblematic cognitive notions – 2 of 4

- **Knowledge, K** : feature of a cognitive system capable of delivering the relevant information in a given cognitive domain; **"to do right".** Quantitatively, K relates to system input and output information quantities, and is measured in **"lin" units**.
- **Expertise** : main notion in cognition; has numerous informal synonyms in natural languages, including know-how, competences and skills; characterizes the mix knowledge - speed; **"to do right and fast"**. Quantified in **"lin/s" units;** appears as **cognitive speed**.

App. B - Model for Cognitive Sciences (MCS) 5 of 7
B.2 Emblematic cognitive notions – 3 of 4

- MCS defines **learning** as an **increase in expertise**, and therefore features the same measuring units, **"lin/s".**
- **Experience** is defined, and measured, in MCS theory in two different ways, depending on current goals, on applications:
  - one simpler : **time to visit the cognitive domain, unit: second , "s"**), and **{OR}** ,
  - the other one, more elaborate : **amount of system input and output information witnessed, in the cognitive domain, "bit"**.

App. B - Model for Cognitive Sciences (MCS) 6 of 7
B.2 Emblematic cognitive notions – 4 of 4

- **Intelligence** is the **capability** of a cognitive system **to learn**. Quantitatively, it is estimated as the **derivative of expertise with respect to experience**;

  it may consequently appear as the property **of cognitive acceleration; "lin/s^2"**. (**{OR} "lin/s/bit) - c**f. experience).
- **Complexity** is defined in MCS theory of cognition as the quality of **requiring a lot of information to be described**. The metric unit is the same as for information, **"bit".**

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^{-1} and communication delays

τ: Reaction time of target system, to be controlled

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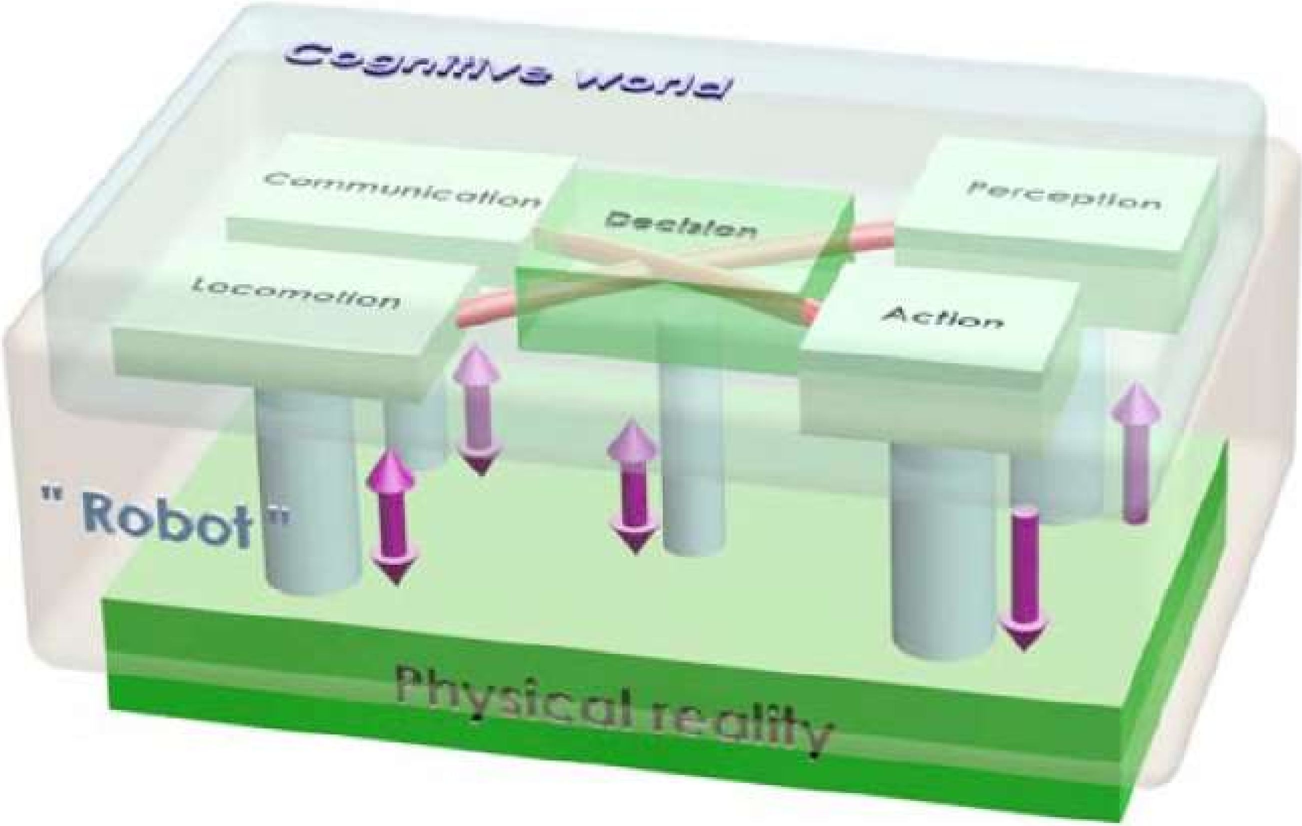
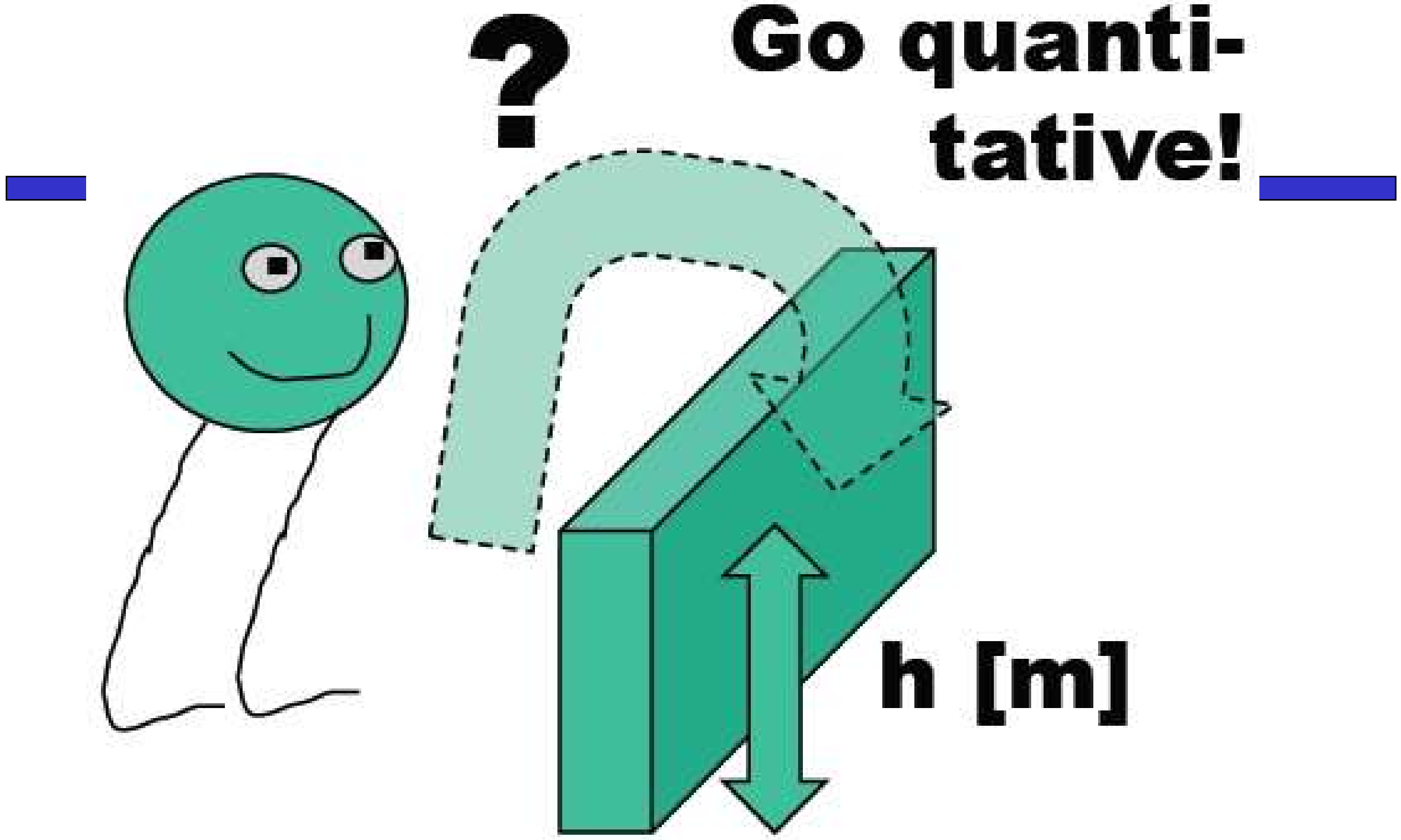
Robotics – Core property

Grounding and deploying cognition in the real world



… grounding and deployment … Internal information flows are shown in red, and energy in purple color


?
Go quanti-
tative!
h [m]

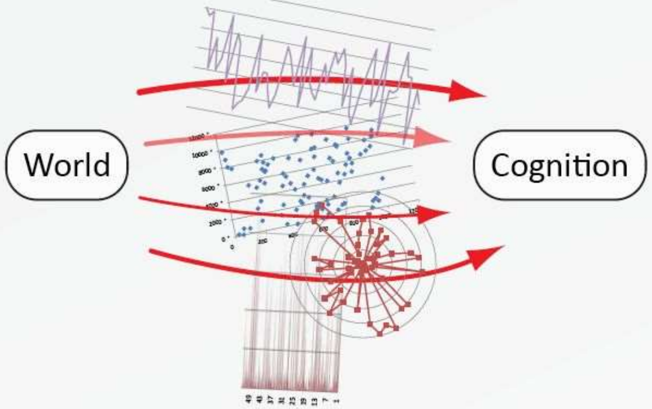
4th International Conference on Cognitive Systems
CogSys 2010
January 27 & 28, 2010, ETH Zurich, Switzerland

University of Zurich
ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

Institut d' Automatisation industrielle
LaRA
Laboratoire de Robotique et Automatisation

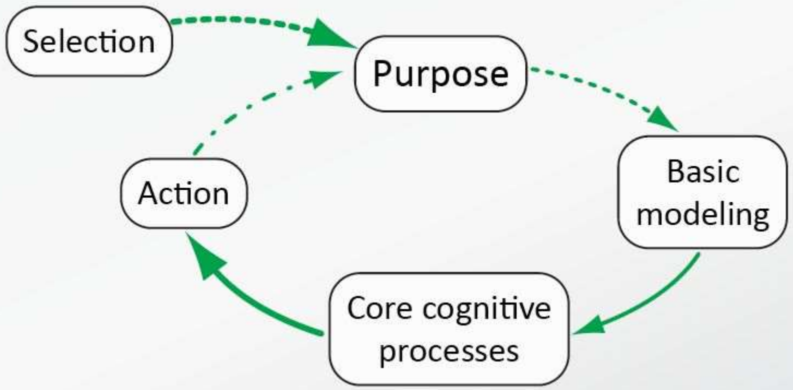
Cognition for a Purpose

Cognition without purpose is impossible and useless



Common errors: belief in the possibility of absolute truth, in finite, apprehendable size of real world complexity, and in the value of understanding per se.

Cognition prerequires modeling, i.e. purpose-oriented, simplified representation of reality



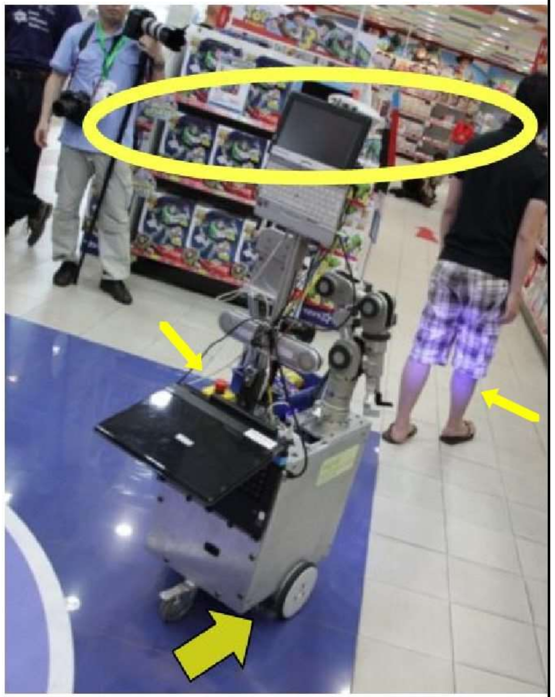
«Focus»: precisely selecting purposes implies multiple constraints to be considered as chances rather than drawbacks.

Key Factors for Success

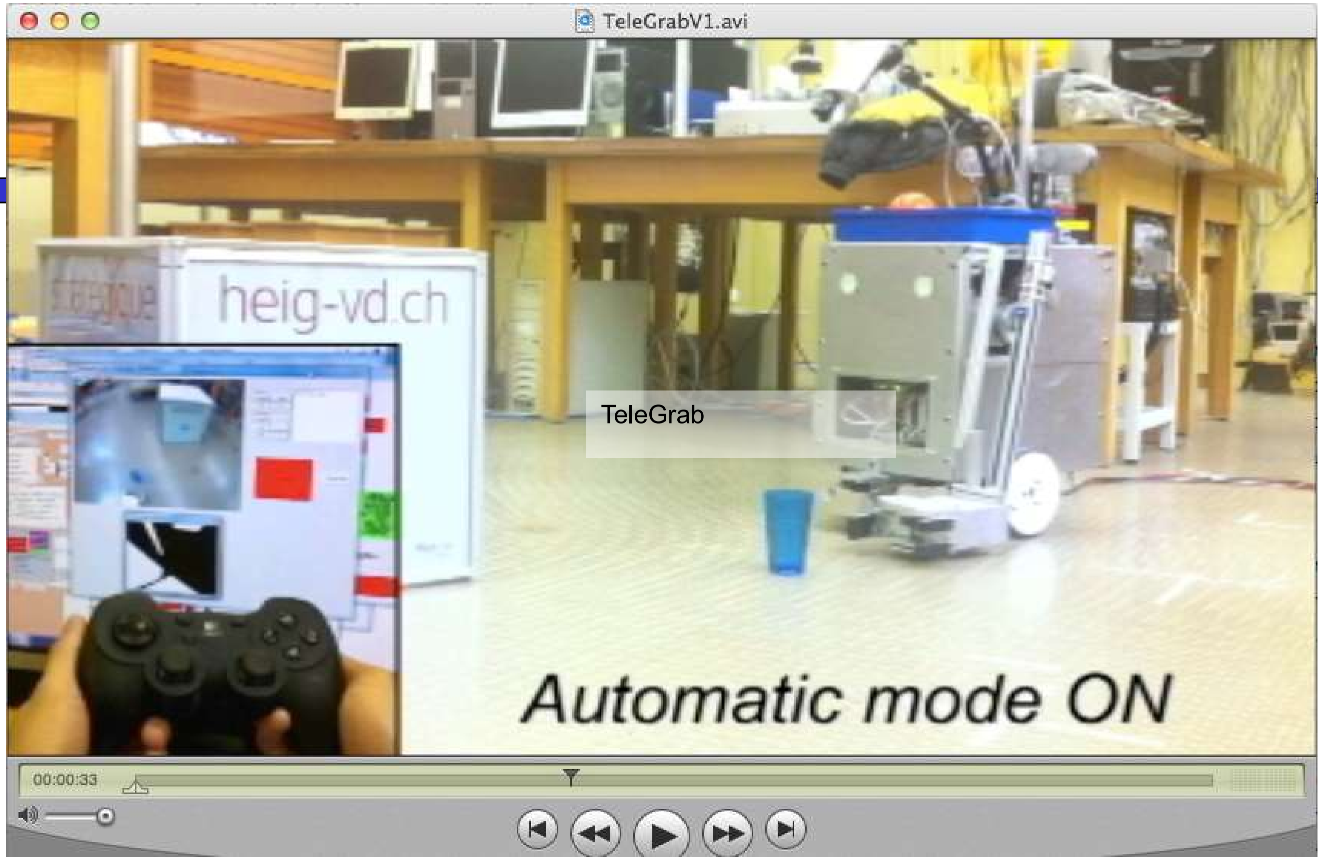
- e.g. about security 2 of 2,

Overview of some security measures for mobile robots in public places :

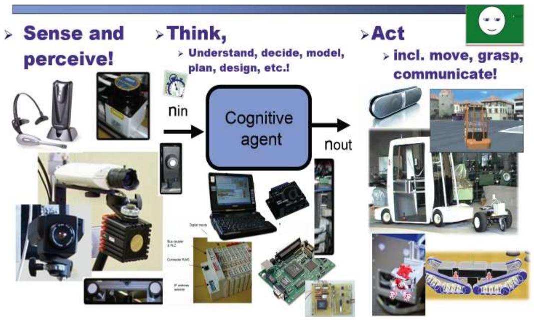
1. **The blue warning blinking light reflected on the legs of the guide (arrow on the right).**
2. **If a wheel is blocked, the other wheel gets stopped in a properly coordinated way (lower arrow).**
3. **The unidirectional blocking capability is also active (same lower arrow).**
4. **In principle, the top circle illustrates the concept of the maximal radius of influence; in fact, the effective circle at that very moment is larger than drawn. It must encompass the guide, otherwise all motion would stop.**
5. **Emergency stop mechanism (left arrow).**



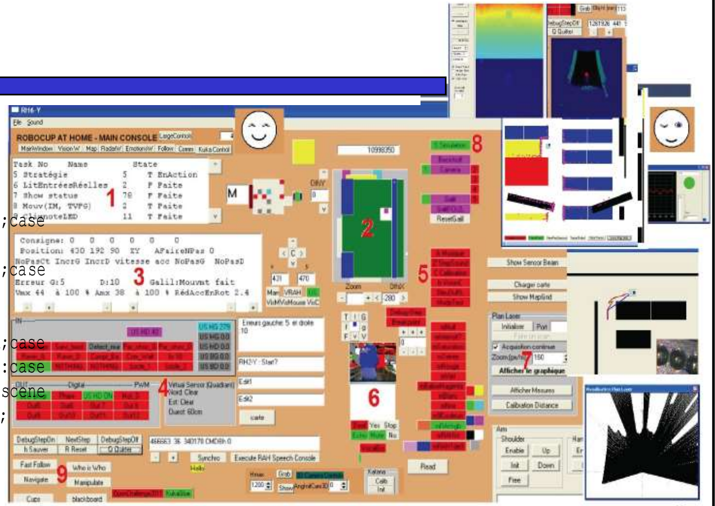
J.-D. Dessimoz, HESSO.HEIG-VD, Fachtagung kollaborative Robotik, ETH Zürich


TeleGrabV1.avi
heig-vd.ch
TeleGrab
Automatic mode ON
00:00:33

Example - Piaget




```
12: if(!SignalIn(NSIStart))
      GoState(6);
        else
      GoState(20);        break;case
20: ApproAGN(Table,30);   break;case
//Switch light on
21: SignalOutAGN(NSOLamp,true)
                          break;case
22: SleepAGN(0.05);       break;case
//Visual analysis of a row in scene
23: WatchRowAGN(R,CStart,Cstop);
```

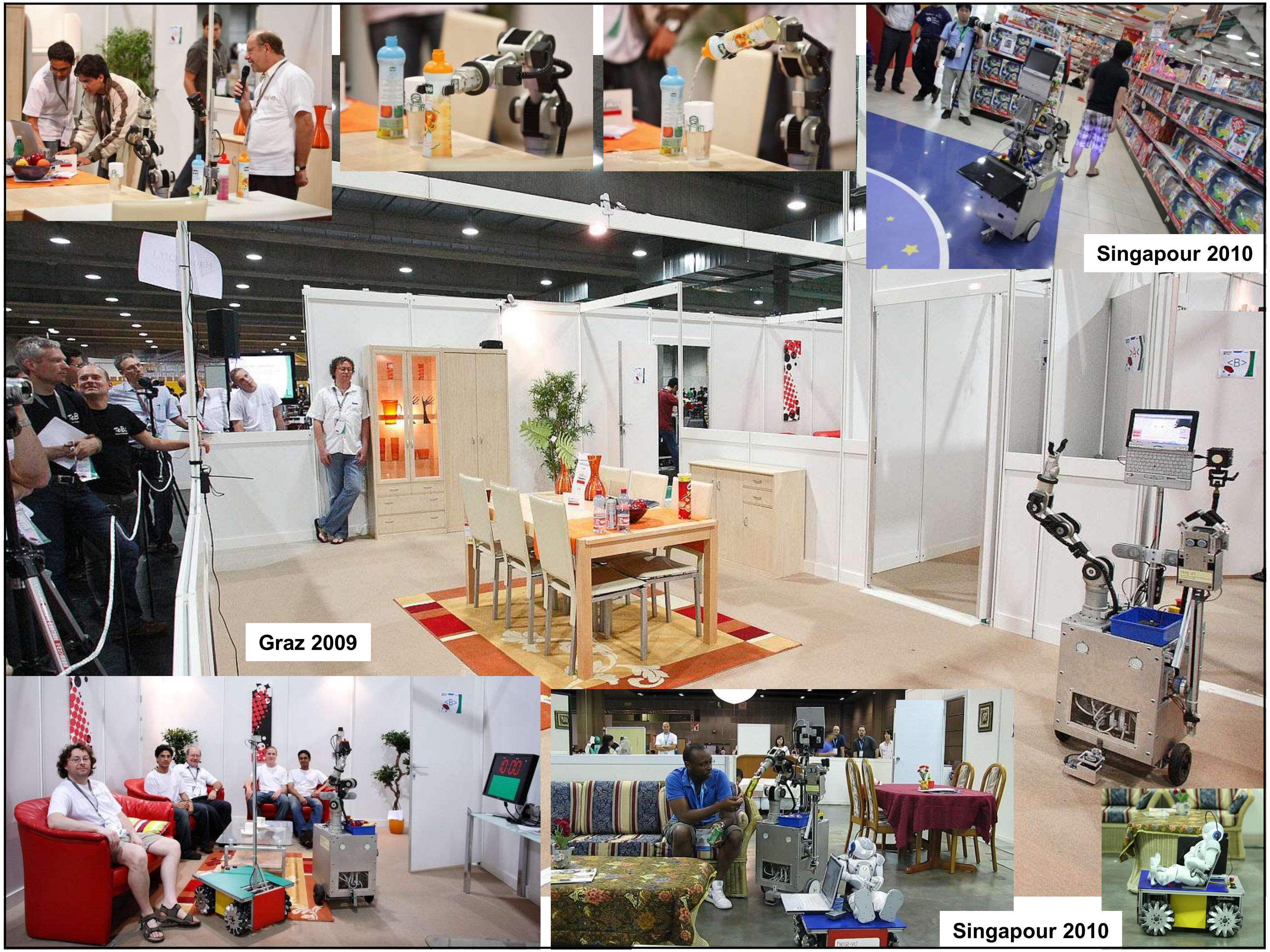


Smart Systems in the Real World; and Piaget (*center and right*)

Applications

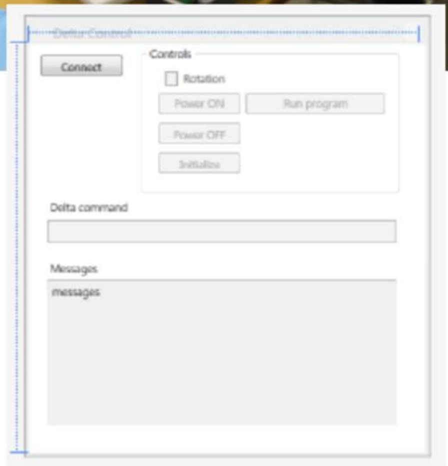
HAUTE ÉCOLE D'INGÉNIERIE ET DE GESTION DU CANTON DE VAUD
www.heig-vd.ch

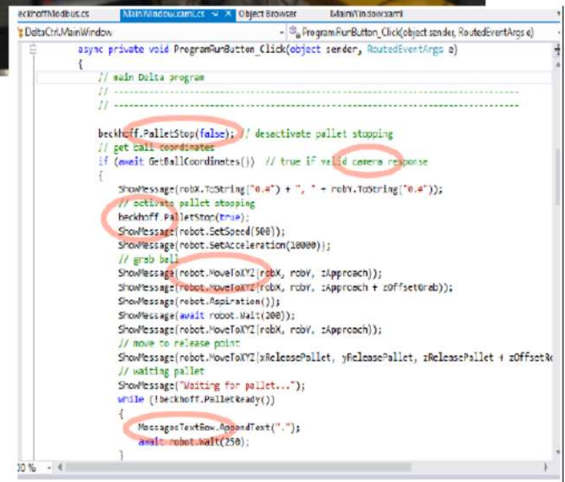
Hes·so Haute Ecole Spécialisée de Suisse occidentale

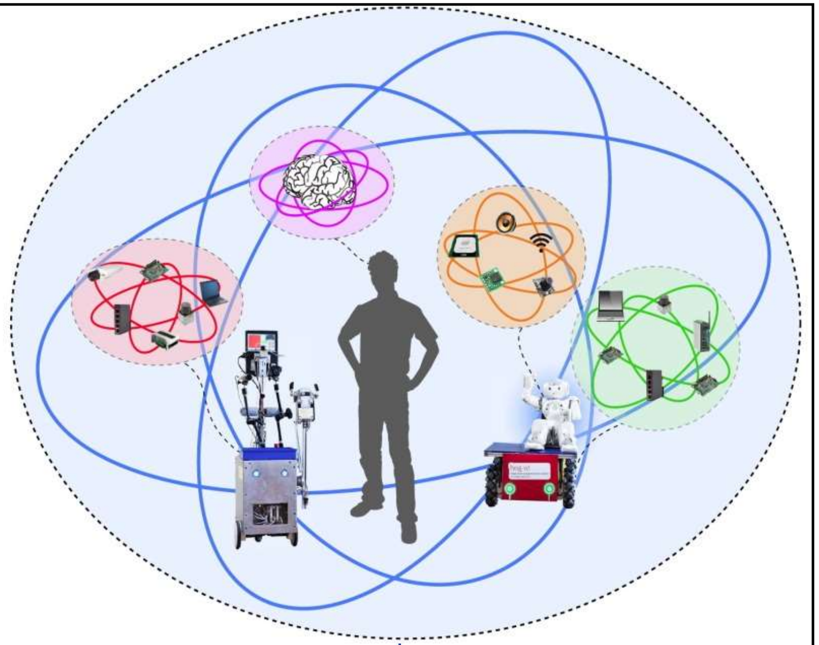

Singapour 2010
Graz 2009
Singapour 2010

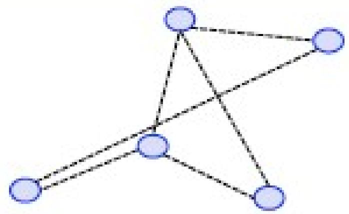
Cooperative Task with Vision and Industrial Robots

3. Advantages of the intelligent systems applied in robots

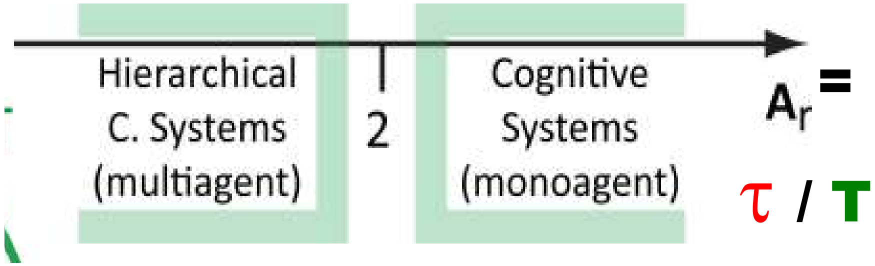


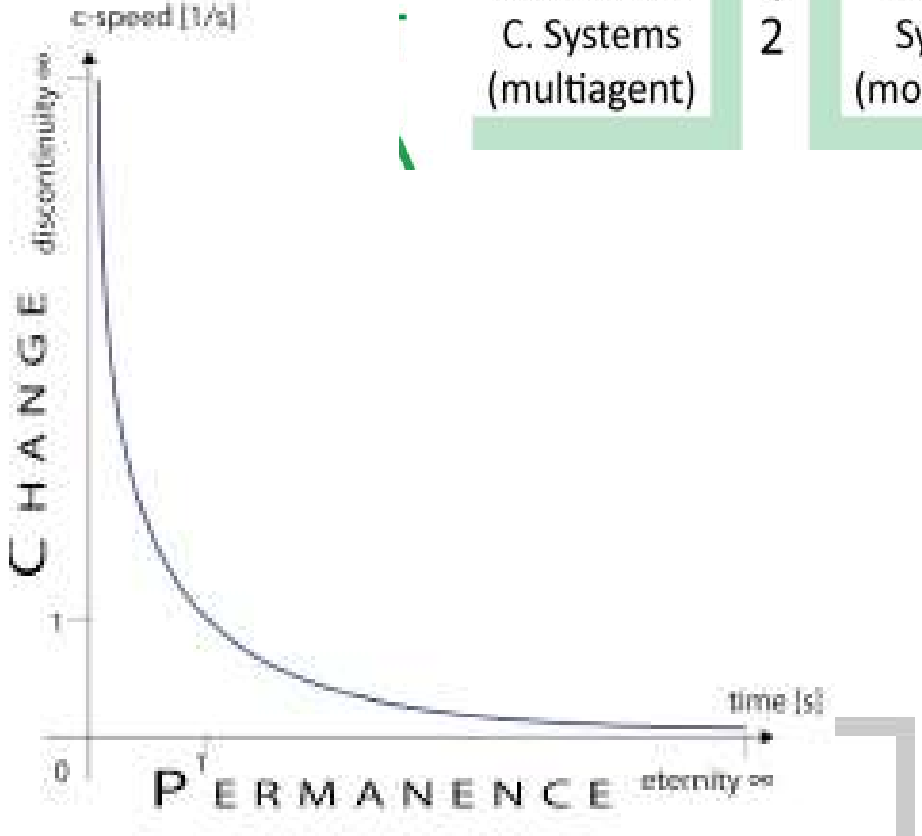


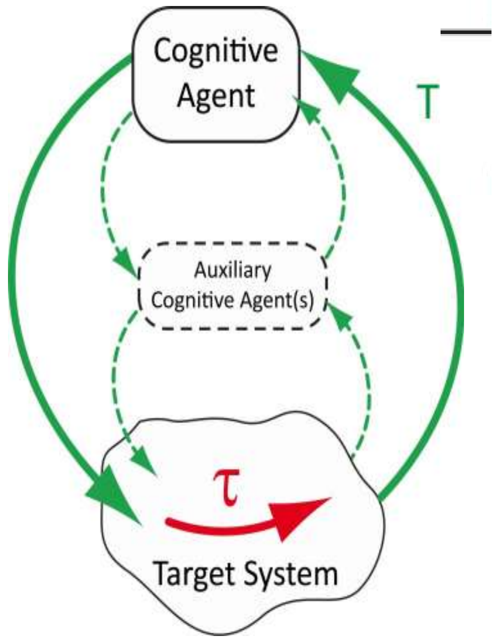


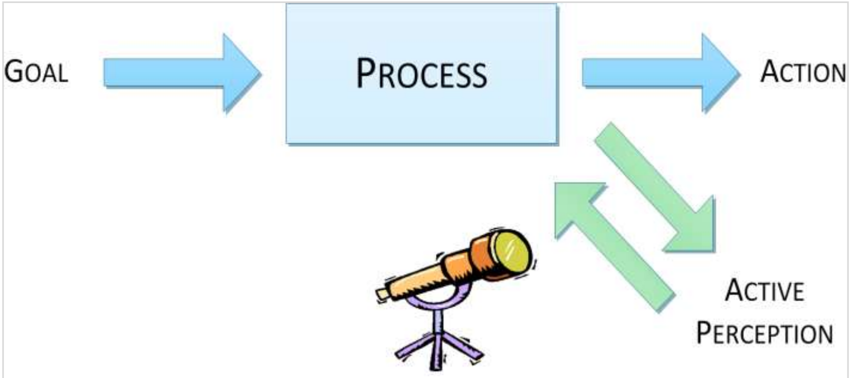


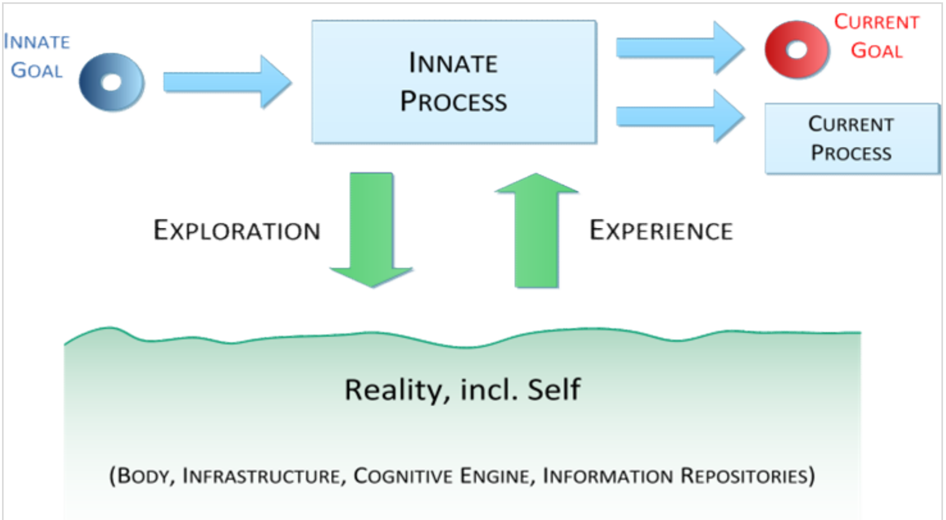
1. **group** (collective agent)
2. **members** (individual agents)
3. **"glue"** (communication channels and common culture; re. e.g. team spirit, constitution, charter, flag, hymn, bondage, relations, commons, etc.)


Hierarchical
C. Systems
(multiagent)
2
Cognitive
Systems
(monoagent)
A_r =
τ / T


c-speed [1/s]
discontinuity ∞
CHANGE
1
0
time [s]
PERMANENCE
eternity ∞


Cognitive
Agent
T
Auxiliary
Cognitive Agent(s)
τ
Target System


GOAL
PROCESS
ACTION
ACTIVE
PERCEPTION


INNATE
GOAL
INNATE
PROCESS
CURRENT
GOAL
CURRENT
PROCESS
EXPLORATION
EXPERIENCE
Reality, incl. Self
(BODY, INFRASTRUCTURE, COGNITIVE ENGINE, INFORMATION REPOSITORIES)