EUROBOT
CONFERENCE 2010

International Conference
on Research and Education
in Robotics

May 27–30, 2010
Rapperswil, Switzerland

Venue
HSR Hochschule für Technik Rapperswil
Oberseestrasse 10
Rapperswil

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Do Cognition and Robotics Share Common Ground? Some Answers from the MCS Perspective and an RH-Y Case Study

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Eurobot 2010 – Internat. Conf. on Robotics Research and Education,
Rapperswil-Jona, Switzerland, 28-30 May 2010

http://www.heig-vd.ch, http://lara.heig-vd.ch

Keywords: Cognition, cooperating robot, Robocup-at-home, domestic help, cognitics, MCS theory, consciousness, conscience, life

Content

1. Introduction
2. Main elements of the "MCS" model for cognitive sciences
3. Potential role and essential limits of cognition from MCS perspective
4. Specific boundaries between robots and humans
5. Case of RH-Y, OP-Y and other robots
6. Conclusion

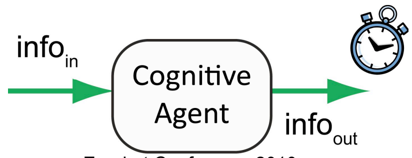
1. Introduction

- **History of humans extending natural capabilities. Recently: dreams of artificial servants**
- **Now cognition: "Think", (process and) generate information**
- **Convergence of robots and humans :**
  - **Ideas/Gods; spiritual versus material, physical world**
  - **Constructivism**
  - **Emergence**
  - **Manufacturing, information related devices, computers**
- **Now what is similar, and what is distinctive? Re. this paper. Including Examples.**

Content

2. Main elements of the "MCS" model for cognitive sciences 1 of 3

- **MCS theory (Model for Cognitive Sciences) : formal definition of essential entities in cognitive domain. Goals:**
  - **better understanding of cognition in general,**
  - **facilitating progress in the invention and design of novel, artificial (i.e., man-made) cognitive systems.**
- **Behavioral representation of cognitive agents: information flows incoming to and outgoing from cognitive agents; and time**



2. Main elements of the "MCS" model for cognitive sciences 2 of 3

- **Information : conveyed by messages, with a metric system based on probability calculus (Shannon); current context much broader : receiver more active and interesting cognitive agent**
- **Most essential properties : knowledge, i.e., the ability to deliver the right information, and fluency, which is related to the agent's processing time.**
- **Broader view: experience, complexity, expertise.**
- **Still broader view: learning, intelligence, etc.**

2. Main elements of the "MCS" model for cognitive sciences 3 of 3

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

Content

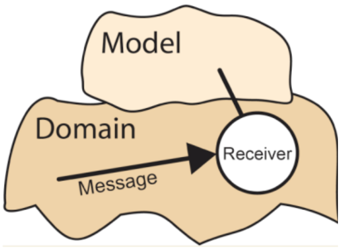
3. Essential limits and potential role of cognition from MCS perspective

3.1 Limits of humans and machines in the cognition domain

3.2 System dynamics and cognition

3.1 Limits of humans and machines in the cognition domain

- **MCS theory based on Shannon's information theory, and thus inherits serious limitations:**
  - time variance (non-stationarity)
  - subjectivity of information,
  - even more fundamentally, a severe necessity of modeling

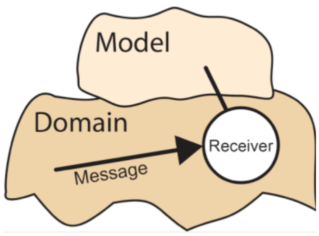


3.1 Limits of humans and machines in the cognition domain

***Time variability*. The essential property of information: to update the receiver's model, and in particular to reduce a priori uncertainties.**

***p*, the probability of occurrence of a possible incoming message, is de facto changed to 0 or 1 upon receipt of a message. C**

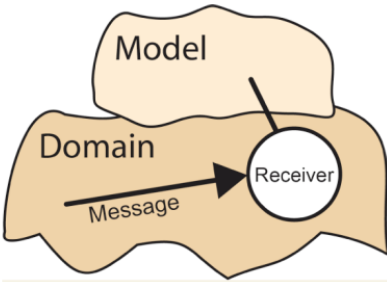
Consequently, the amount of information conveyed by the incoming message immediately drops to zero.



3.1 Limits of humans and machines in the cognition domain

***Subjectivity*. In Shannon's fundamental equation, *p*, is the prior message occurrence probability, as perceived by the receiver.**

Different receivers => different models and a priori probabilities; thus, different information quantities !

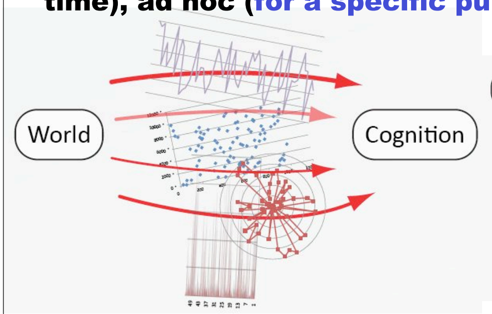


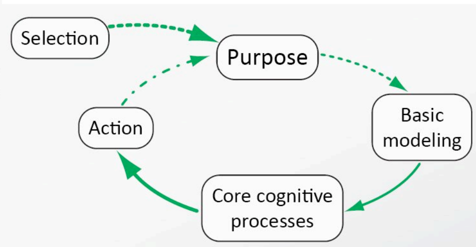
3.1 Limits of humans and machines in the cognition domain

***Modeling*.**

Quantitative approach: usually infinite amounts of complexity met, even for very focused domains of reality.

Consequence: specific models must be devised that closely adhere to circumstances: hic et nunc (focus in space and time), ad hoc (for a specific purpose), ignoring exhaustivity.





3.2 System dynamics and cognition

Cognition impossible in a strictly static world: cognitive agents always need to elaborate the right (outgoing) information.

Time, although qualitatively necessary, usually not quantitatively critical; in such quasi-static views, cognition already obviously useful, providing right (outgoing) information.

When dynamics (change, inverse of time) also considered, new aspects appear: cognition can help in a variety of ways.

The case of control: 1. in direct action and 2. in closed-loop systems.

3.2 System dynamics and cognition

- ***Direct action*.**

Cognitive agents generate (outgoing) information and trigger action; dynamics show that controlled systems always require some time to react.

If result desired at a precise point in time, a cognitive approach allows to select the right moment in the future, and to anticipate all delays.

Example: Participants of an international conference reach the venue on the D day.

3.2 System dynamics and cognition

***Closed-loop control*.**

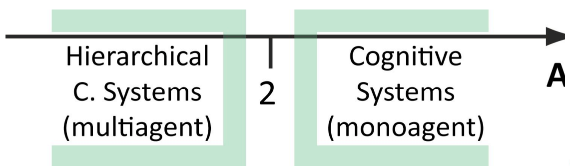
Sometimes unknown factors, possibly random, disturb the state of controlled systems.

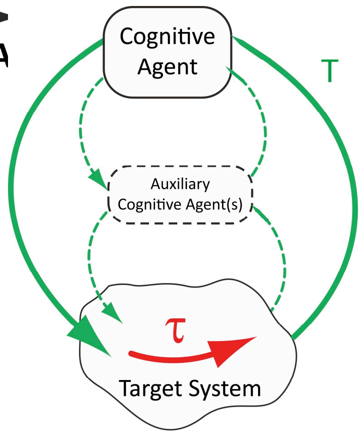
To achieve success, the cognitive agent controlling the disturbed system must perceive the changes and adapt its actions.

Schematically, two situations appear:

1. **cognitive agents agile enough, and communication delays short enough, to allow for a single agent.**
2. **control tasks to be distributed among several agents, each subject to the same constraint.**

3.2 System dynamics and cognition





An agent can successfully control a system in closed-loop mode only if its relative agility is better than 2.

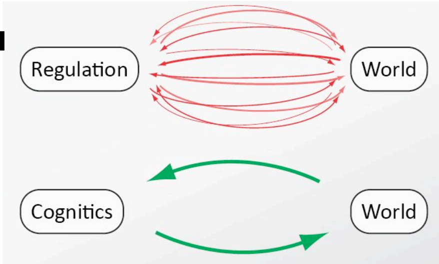
If not, a hierarchy of agents must be considered

3.2 System dynamics and cognition 5 of 5

In all cases, situation possibly improved as cognition allows forecasting phenomena and anticipating actions, compensating for potentially disturbing delays.

Cognitics help in control:

- **identifying relevant factors and processes,**
- **determining critical values,**
- **sparing measurements,**
- **reducing or sometimes even eliminating critical delays,**
- **anticipating effects and**
- **compensating for disturbances**



Content

4. Specific boundaries between robots and humans

4.1 Boundary in cognition domain

4.2 Expanding MCS theory for robotics

4.3 Should the ultimate robot be a human?

4.1 Boundary in cognition domain 1 of 2

- **The definitions of the MCS theory are strictly confined to cognitive abilities: the MCS model applies without distinctions to humans and machines.**
- **In this context robots already have the possibility to do better than humans in quantitative terms: more bits of information perceived, more knowledge, more expertise, learning, intelligence, generated information, and so on.**

4.1 Boundary in cognition domain 2 of 2

- **Differences remain in various *domains*, which relate specifically to those domains:**
  - **physical perception (e.g., infrared is only perceived by some robots)**
  - **action channels (e.g., 10-fingered hands, with skin, are currently only the features of humans),**
  - **language,**
  - **exposure to news,**
  - **repeatability,**
  - **and so on.**

4.2 Expanding MCS theory for robotics

Quest for robots in domains traditionally reserved to humans going on.

Contribution: 3 notions newly defined in MCS theory; first intuitively, then formally.

- ***Consciousness***
- ***Conscience***
- ***Life***

Consciousness

Property of cognitive systems, which can be estimated to different degrees. Etymology : root referring to cognition, to the ability of knowing, and prefix referring to the subjective nature of this knowing.

-Very least degree of consciousness : awareness, the ability to know and thus to cognitively accompany what is going on in the world around the cognitive agent. The ability to react may be a sufficient indicator of consciousness according to this minimal definition

- More demanding degree of consciousness : additional, explicit, and regularly updated representation of what is going on around the agent

- Still higher degree of consciousness : some aspects of the agent itself are explicitly present in agent's representations; self-contemplation is performed. The scope of self-contemplation may vary, from some elementary self-aspects to more extensive ones, and even to the inclusion of "external" components, representing the environment in which the agent develops its activities.

Consciousness

For the MCS theory: consciousness is the ability of a system to perform its ordinary cognitive operations.
Value: essentially Boolean, corresponding to the presence or absence of consciousness.
If required, the various degrees of consciousness discussed above should be addressed, in the MCS theory, as different, specific domains, for which the same definition of consciousness is applicable.
In quantitative terms, this simple view can be complemented by a finer attribute, a *consciousness index*: the ratio of the current level of operation to the ordinary level of operation.
Here in practice an exclusive choice must be made, which is application dependent: either the Boolean view is sufficient, or the finer estimation approach is required instead

Conscience

***Conscience*. May be used as a synonym of consciousness, especially in most demanding, self-oriented interpretation. In English, it includes a capability to judge the right or wrong character, in ethical terms, of an agent's decided actions.**
Conscience implicitly requires not only that cognitive agents include in their cognitive domain representations of themselves and of their own behavior, but also that the agents include representations of their environment, with its associated operational modes. Only at this point can the possibility emerge for cognitive agents to compare their own behavior to the customary norms of the environment, and consequently, to estimate the right or wrong character of their operations (note that this description remains closely connected to the etymological meanings of the words ethics-environment and moral-customs).

Conscience

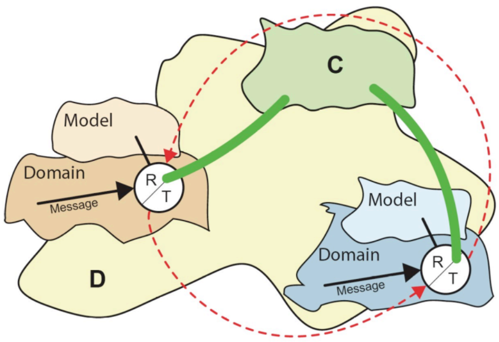
In laymen opinions, ethics may not look relevant for robots; how robots would ever attempt to break ethical laws? However, to make a right decision, the ethical question must first be addressed.
Moreover, even in an environment of very moderate complexity, choices must be made in the face of conflicting ethical values, depending on the level of attention (e.g., a lower priority law is broken for the sake of a more general one). Of course, environments may be of various complexities, and may include, for example, groups of agents to which the agent with a conscience may relate in diverse ways. Notice that in the MCS models, as well as in reality, what is immediately apparent of agents is their behaviors. Consciousness, and its derived benefits, can still improve if agents express themselves and so share some of their internal representations; communication develops, e.g., flowers bloom, and animals develop a common culture.

Conscience

- In summary, for the MCS theory, conscience is the property of a cognitive agent whereby it includes in its cognitive domain some aspects of itself, of its own behavior, as well as of the environment and related customs; finally adapting its own actions as a consequence. The value that can be given to conscience is essentially Boolean, corresponding to the presence or absence of conscience.
- For finer quantization, all the core MCS notions essentially also apply here (e.g., information, complexity, knowledge and expertise); the possible specific differences in quantities relate to the respective, specific cognitive domains considered.

Conscience

Consciousness implies, in individual agents, some knowledge of themselves and of their environment. In a group, the degree of consciousness may be improved with appropriate communication among agents, and a common culture



Life 1 of 2

Life: **Property of agents to perform their ordinary operations.**
- can be defined in different grades of increasing requirements, which can also be viewed as related to the time duration of ordinary operation (functional activity), without discontinuity. Thus, a key unit seems here to be the time unit.
- In its most basic form, life refers to the operational continuity of agents themselves.
- A more demanding definition for life requires the ability of agents to actively sustain their own operations, and possibly recover from failures, thus possibly extending the duration of functional activity.
- A still more demanding requirement refers to the ability to persist across generations: life thus allows agents to replicate themselves, having children capable of taking over ordinary operations for longer periods.
- Time span of functionality can still increase, life being considered beyond the scale of a species, over evolutionary phases, and even, ultimately, at the scale of development of a whole life tree such as ours on planet Earth, from its very beginning, billions of years ago, to a yet undefined future.

Life 2 of 2

- **First basic definition given above, adequate.**
- **Variations in requirements equivalent to variant definitions for the cognitive agents under discussion (individuals, generations and species).**
- **Quantization may be useful in terms of life intensity, finer than just a Boolean value, namely life or death: ratio (life intensity index) of current level of operation with respect to the ordinary level of operations.**
- **In summary, for MCS theory, life is the property of agents able to perform their ordinary operations. Its value is essentially Boolean, corresponding to life or death. In quantitative terms, this simple view can be complemented by two finer attributes, a *life intensity index*, defined as the ratio of current level of operation with respect to ordinary level of operation, and a *life time,* a duration measured in time units.**

4.3 Should the ultimate robot be a human? 1/5

From the very beginning, there has been ambiguity in the definition of robots:

1- Some observers have understood Rossum's creatures primarily as "machines", providing flexible services to humans,

2- Other ones have been inspired by the idea of artificially replicating humans, creating "clones".

http://www.imdb.com/media/rm1525127424/tt0212720

4.3 Should the ultimate robot be a human? 2/5

1. ***Machines*. Clearly, this approach is easier to adopt; develop robots according to requirements that are rather task-oriented, functional.**
   - Engineers typically favor this approach, which offers benefits in terms of robustness and economy.
   - Depending on applications, the requirement of exact similarity between robots and humans is debatable:
      - practical solutions may be different from human solutions; for example, a robot might rely on wheels
      - yet as specific duties transferred from humans get more complex, there may be more advantages for robots to be more akin to humans: humanoids (limbs similar to humans) or androids (very similar look).
   - Here, some partial solutions are already welcome.
   - Here also, if robots do their jobs better than humans, this is perceived as an advantage

4.3 Should the ultimate robot be a human? 3/5

2. "*Clones*". The second definition puts humans in the center of the scene.
- Robots should not only be capable of performing duties similar to those of humans, but moreover, robots should ideally proceed in the same way.
- Ultimately, robots should be human in all respects.
- Obviously, this task is impossible to fulfill by non-biological means.
- Also in biological terms, if required, the most promising road would theoretically be to improve cloning techniques, and then to concentrate on education, but such a road is of course ethically completely unacceptable.

4.3 Should the ultimate robot be a human? 4/5

To advocate the first approach again (machines):
- Humans are not only the result of a well-defined, linear genetic legacy: in biology, some genes are acquired by lateral transfer, and some other genes are often randomly changed by external influences.
- Moreover, when living, humans are more and more complemented with artificial accessories: spectacles, auditory aids, pacemakers, wooden legs, artificial forearms and hands, infrared goggles or telescopes, cars, cellular phones, tools, pharmaceuticals and drugs, and so on.
- Bionics, cyborgs and avatars are examples of engineered extensions of the human body.

4.3 Should the ultimate robot be a human? 5/5

- The "clonic" approach may have some value in understanding better humans, but let us state here that it is *not* our goal to develop robots just as replicas of humans.

- Even if it were the case, we would have to face the fact that we are very far from reaching such a goal. No robot is in sight yet, so akin to humans that a risk of schizophrenia would threaten it: am I a human or a machine?

Content

5. The case of RH-Y, OP-Y and other robots

5.0 RH-Y service robot, designed for domestic assistance, and its fellow OP-Y, a counterpart with alternate locomotion properties

5.1 Do Cognition and Robotics Share Common Ground in the case of RH-Y?

5.2 Illustration of new human-like properties in the case of RH-Y

5.0 RH-Y and OP-Y

General view of RH4-Y robot in Graz during the "Introduce" test:
- the robot autonomously enters home,
- moves to the living room,
- talks,
- presents itself and team,
- then leaves

5.0 RH-Y and OP-Y

Consider RH-Y in the Robocup context, for example, as illustrated in the “Introduce” task, as well as in the “Follow me” and “Order by gestures” tasks.
- It appears that, in some sense, some tasks usually performed by humans and considered in the past as requiring cognitive capabilities can be taken over by robots;
- but it also appears that some gaps remain, which some observers will consider as requiring some other cognitive abilities that possibly in their views relate exclusively to human nature.

5.0 RH-Y and OP-Y

Cognition is an important capability of robots such as RH-Y. In the “Introduce” task, RH-Y can speak, move in space, and adapt its actions in order to compensate for disturbances and to progressively reach appropriate locations.
- There are always limits on what can a system do. However, the argument here is that, in principle, the solution usually lies in adding quantitative precision, and not necessarily in qualitatively adding new concepts, thus elaborating models of increasing complexity.
- For example, for a human attempting to jump over a wall, the height of the wall is critical for success, and it is therefore appropriate to take the height measurement into account.

5.1 Do Cognition and Robotics Share Common Ground in the case of RH-Y? 1/5

- For example RH-Y can virtually speak thousands of words in "English" and move with accuracy on the order of centimeters at speeds up to about 1 meter per second on flat ground.
- All this translates into specific quantities of information, knowledge, expertise, and so on. For example, one word among 10,000 (equiprobable) words may be estimated as conveying 10 bits of (word) information.

5.1 Do Cognition and Robotics Share Common Ground in the case of RH-Y? 2/5

Considering the elocution of a single word at a time, 10 bit are present at the speech synthesizer input side, and 2*20 kHz*7 bits of (sound wave) information per second are generated on the output side; considering that words are uttered at a rate of one per half a second on average, the amount of knowledge is of about 12+3 =15 lin of knowledge; and this yields an expertise of 30 lin/s

5.1 Do Cognition and Robotics Share Common Ground in the case of RH-Y? 3/5

Having entered home by following a human guide, OP-Y, on the right, moves according to gestures performed by its counterpart, the RH4-Y robot, in Graz, July 2010

5.1 Do Cognition and Robotics Share Common Ground in the case of RH-Y? 4/5

Or is cognition purely human? **Unfortunately, some observers consider cognition to be a capability exclusively associated with human nature; thus, they will consider that since RH-Y speech synthesis can be performed by (now very common) electronic and microtechnological means, this is de facto proof that the speech act requires no cognition. Moreover, as RH-Y features loudspeakers rather than vocal chords, a tongue and lips, it is even more obvious that such robots are just machines, and by no means human; actually for those observers, even the name of robot could be disputed here; for them, "machine" would be more fitting!**

5.1 Do Cognition and Robotics Share Common Ground in the case of RH-Y? 5/5

Synthesis. **Two opposite views are given:**
-the first one, compatible with the MCS model, confirms that machine-based cognition is possible, just accounts for one of many abilities of robots, including perception, action, locomotion and communication. Cognition is here totally integrated in robotics. Nevertheless, it can be accepted that cognition also develops in domains other than robotics, thus the question in the title can be answered affirmatively: there is a common ground shared by robotics and cognition.
-The second view appears intuitive, emotional, and scientifically unfounded from a behavioral perspective; yet, many people feel that way, and in such a context, implemented robotics and human cognition can only remain totally disconnected; for progress to be possible here, it would be necessary to clarify the concepts involved and, first of all, the goal being attempted.

5.2 Illustration of new human-like properties in the case of RH-Y

Even though the direct requirement for notions such as consciousness, conscience or life remains debatable, the following arguments do have some value for the good functioning of machines and robots:

- **potential for better human-robot communication,**
- **legacy of millennia of cultural developments in the human context, and**
- **better understanding of human nature.**

Consciousness
Conscience
Life

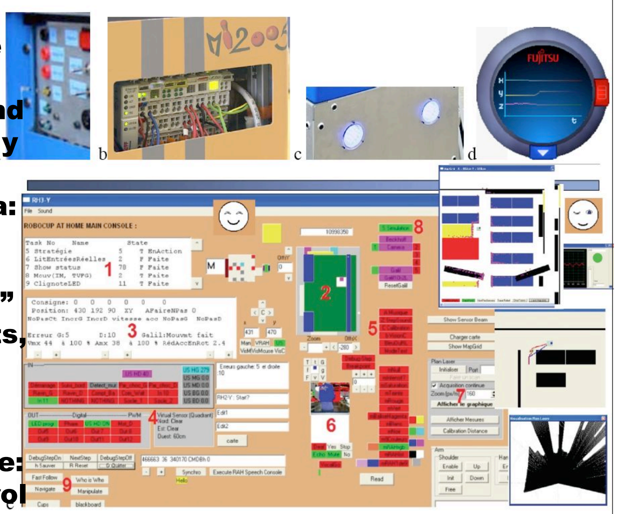
Consciousness

What degree of consciousness characterizes RH-Y?

1. **In the least demanding sense, awareness, consciousness is implicitly proven by proper, ordinary operation, which, in many ways, involves adequate instantaneous reactions (e.g., arm joint motor torques) to external stimuli (e.g., wheel motion).**
2. **At a higher degree of consciousness, awareness extends to what happens around the agent; done in several ways in RH-Y (e.g. microphone input, laser sensors, camera signals, and so on).**
3. **The next degree of consciousness involves, for RH-Y, the ability to explicitly represent internal and peripheral elements. RH-Y has such an advanced state of explicit representations, both of internal elements and of external elements, that most of its operations can even be performed in simulation mode.**

Consciousness

The consciousness of our robots [12] is made evident by the expression of status and intentions as classically described by panels, displays and screens (a: Hornuss, b: Dude, both developed for Eurobot, c: programmable "eyes" or modulated headlights, RH3-Y; d: 3-D acceleration components on supervising computer; e: set of interactive control screens for RH3-Y).



Consciousness 3 of 3

In quantitative terms, RH-Y in ordinary operative cognition can be said to have consciousness. The consciousness index introduces above could usefully refer to the completeness of its operational capability at a given point in time, e.g., in noting what percentage of its knowledge is available as a consequence of mounted, active perception, cognition, and action channels. The latter may greatly vary in time, and typically match specific tasks being benchmarked: such as autonomous navigation, 3D TOF ranger-based SLAM and human face recognition

Conscience 1 of 3

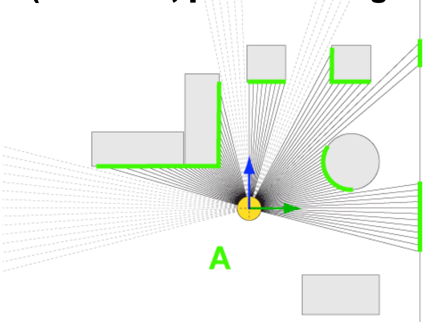
-As a synonym for consciousness, in its more demanding sense, conscience is demonstrated above for RH-Y.
- Furthermore, we can consider, as an example of choice between two conflicting goals, the “Follow me” task, as defined in Robocup at Home competition: At a particular checkpoint, robots are approached by two humans, and a decision must be made to follow the “right one”. The latter should be recognized as the guide introduced in a preceding phase.
- Other example of consciousness and self-reflection: the Kuipers sequence where robots gradually learn how range sensor data are sequenced, with egocentric perspective and assumption of stability and continuity of environment, subsequently taking a step, which leads to the persistence and stability of the environment, and to the explicit representation of self, as a mobile agent!

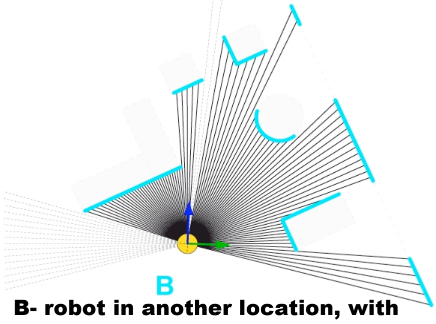
Conscience

2 of 3

Evident case of consciousness in our robots

(re. SLAM, pattern recognition, or positional calibration) :





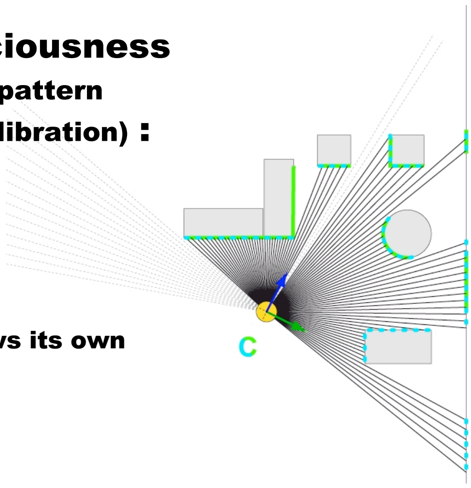
A- real egocentric distances, perceived with a scanning laser range finder; world elements (green), learned as persistent model of the world.

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

Conscience

3 of 3

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



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

Life

1 of 3

- RH-Y robots live according to the most basic definition: functional when appropriately prepared and relying on careful human-based maintenance for sustained operation.
- An interesting feature of our robots, continuously present since their first edition in Eurobot context (Diego3, 1998): display of a blinking signal, normally expressing correct operational status.
- For observers looking for analogies with humans, this can be considered in a way similar to a heartbeat, and facilitates checking whether the system is alive.

Life

2 of 3

- For our robots, when operational, the life intensity index should typically be equal to one.
- Interesting exception : our “Arthur” robot developed for Eurobot context (1999) had a selectable “turbo” mode, by which the current limits of the motors could be switched to higher values, yielding larger instantaneous torques but thereby also reducing the expected lifetime

Life

- Analogies with the human case could be carried further.
- For example, as relating to sustainability, in the same way as humans often need society and hospitals for some care, machines typically require maintenance.
- It is not clear, however, how extrapolating further analogies with the biological world might be useful or inspiring (e.g., calling for robot hospitals).

Content

6. Conclusion 1 of 3

In the historical development of human tools and techniques, of machines and robots, as well as of human philosophies, where the spiritual and material worlds progressively merge, the moment has arrived : cognition becomes a feature of man-made artifacts.

The "MCS" model for cognitive science provides a focused theory for core cognitive entities (incl. knowledge, expertise, learning, and intelligence). It is behavioral, independent of physical implementation nature, and provides a quantitative metric system based on information and time.

From MCS perspective, cognition has fundamental limitations:

- Modeling is necessary, yet always infinitesimally complete.
- Information has very short decay time and is subjective.
- Cognition may nevertheless have a potentially unique role in making both human-based and machine-based control effective, with single or multi-agent architectures, even when large delays are necessary for action, or circumstances change highly dynamically.

6. Conclusion 2 of 3

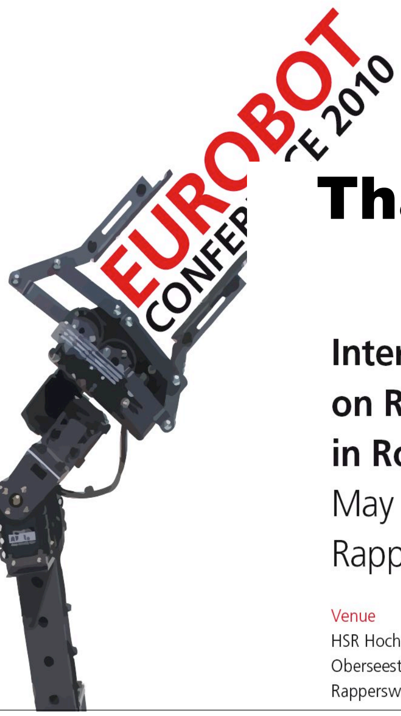
In cognition, the boundaries between humans and robots appear very differently, depending on one's point of view:

- from MCS perspective, no difference is made in the core definitions and metrics between humans and robots, the overlap is total;
- when perspective widens, considering properties typically defined for human context, such as consciousness, conscience, or life, a rather simple and direct analogous correspondence can also be given.
- Now on the contrary if, beyond full similarity in *behavioral* modeling and *functional* operation, a further attempt is made to create robots *identical* to humans in all respects, this attempt can only fail, both globally and for any significant part, such as for legs, eyes, skin, growing paradigms, self-sustenance and repair abilities;
- in particular here, the attempt to create a cognitive subsystem identical in all respects to the one of humans, i.e. much beyond the equality of (blackbox-type) behavior, and functionality, this attempt can only fail.

6. Conclusion

Examples taken from robots developed for Eurobot and Robocup at Home, e.g., speech synthesis, show that machine-based cognition is a common ground shared by robotics and cognition. Many instances show how these robots prove to operate with peripheral cognitive properties that were classically defined for human context, in particular consciousness, conscience and life. Nevertheless, the fact remains that many people feel on a visceral level that implemented robotics and human cognition can only remain totally disconnected; for any progress to be possible here, one must clarify the purposes and goals of such progress.

The author wishes to thank the anonymous reviewers for several helpful suggestions



Thanks for the attention!

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References

and

Acknowledgements

28/05/2010 J.-D. Dessimoz, HESSO.HEIG-VD, Eurobot Conference 2010

References 1 of 2

1 W. D. Ross: Plato's Theory of Ideas. Pp. 250. Oxford: Clarendon. Press, 1951

2 Jean Piaget, The Child's Construction of Reality. London: Routledge and Kegan Paul, (1955).

3 Francisco Varela, Humberto Maturana “Autopoiesis and Cognition: The Realization of the Living”. Boston: Reidel. 1980.

4 Karel Capek, - R.U.R. (Rossum's Universal Robots) (Rossumovi univerzální roboti), 1920

5 Jean-Daniel Dessimoz and Pierre-François Gauthey, "Quantitative Cognitics and Agility Requirements in the Design of Cooperating Autonomous Robots", Revised selected papers of Eurobot Conference 2008, Heidelberg, Germany, Communications in Computer and Information Science Series, A. Gottscheber and S. Enderle (Eds.): EUROBOT 2008, CCIS 33, ISBN: 978-3-642-03557-9 (Print) 978-3-642-03558-6 (Online), © Springer-Verlag Berlin Heidelberg, pp. 156–167, 2009

6 C. E. Shannon, A mathematical theory of communication. in: Bell System Technical Journal, Vol. 27, 1948, pp.379-423, 623-656.

7 Jean-Daniel Dessimoz, "Contributions to Standards and Common Platforms in Robotics; Prerequisites for Quantitative Cognitics", Internat. Conf. on Simulation, Modeling, and Programming for Autonomous Robots (SIMPAR) 2008. 1st Internat. Workshop on Standards and Common Platform for Robotics, Venice, Italy, 3-7 Oct. 2008

References 2 of 2

8 Jean-Daniel Dessimoz, *"Cognition Dynamics; Time and Change Aspects in Quantitative Cognitics"*, 2nd Internat. Conf. on Intelligent Robotics and Applications. Singapore, 16 - 18 December, 2009

9 Jean-Daniel Dessimoz, "Cognition for a Purpose - Cognitics for Control", CogSys2010, 4th International Conference on Cognitive Systems, 27th & 28th January 2010, ETH Zurich, Switzerland

10 RobocupAtHome League: http://www.robocupathome.org (2010)

11 Benjamin Kuipers, *"How Can a Robot Learn the Foundations of Knowledge?"*, CogSys2010, 4th International Conference on Cognitive Systems, 27th & 28th January 2010, ETH Zurich, Switzerland

12 Jean-Daniel Dessimoz, Pierre-François Gauthey, *"RH4-Y – Toward A Cooperating Robot for Home Applications"*, Robocup-at-Home (RAH) League, Proceedings Robocup09 Symposium and World Competition, Graz, Austria, June- July 2009. Also : West Switzerland Univ. of Applied Sciences, Jean-Daniel Dessimoz: website for HEIG-VD RH4-Y cooperating robot for RAH context, March (2009), http://rahe.populus.org/rub/3

14 Jean-Daniel Dessimoz : La Cognitique - Définitions et métrique pour les sciences cognitives et la cognition automatisée, ISBN 978-2-9700629-0-5, Roboptics (eds.), Cheseaux-Noréaz, Switzerland, www.lulu.com, Aug.’08

15 http://en.wikipedia.org/wiki/Life, 25.4.2010