

Adaptiveness and Cognition: Towards Evolving Systems

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Guests

- **Adaptiveness and Cognition: Towards Evolving Systems**
- **Moderator: [Petre Dini](#), IARIA, USA / Concordia University, Canada**
- **Panelists:**
Leszek Holenderski, Philips Research, The Netherlands
George Giannakopoulos, University of Trento, Italy
Serge Kernbach, University of Stuttgart, Germany

Facts and Questions

Facts

- there are adaptive components and adaptive systems
- some of them might have 'brain', some not, yet still adaptive
- there are agent-based mechanisms, self-learning mechanisms, leading to certain autonomy

Questions:

- ? what is the core feature set towards evolving systems?
- ? what is the distance between utopia and realism, in dreaming/designing self-evolving systems?
- ? are there any methodology/guidelines for building such systems?

?

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Adaptiveness and Cognition

Towards Evolving Systems

panel @ ADAPTIVE'2009

Leszek Holenderski, Philips Research

about myself

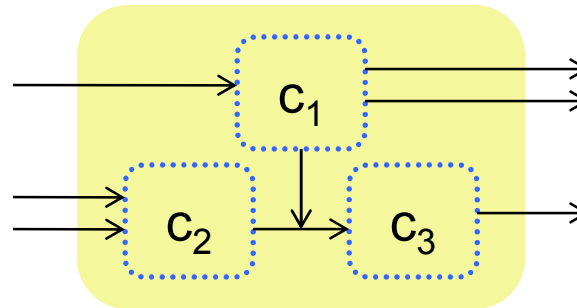
- A computer scientist with a strong background in formal methods
- Main interest: a rigorous development of complex HD/SW systems
- Worked at
 - *Warsaw University*, Poland
 - *Imperial College*, London, UK
 - *GMD (now Fraunhofer Institute)*, Sankt Augustin, Germany
 - *Siemens Research*, Munich, Germany
 - *TU/e (Technical University of Eindhoven)*, The Netherlands
 - *Philips Research*, Eindhoven, The Netherlands
- Half-academic, half-industrial career (from theory to applications)
- Recently involved in
 - robotics/emotiotronics (iCat)
 - home automation (e.g., activity based light control)
 - smart products (e.g., cooking companion)

smart products = smart reactive systems



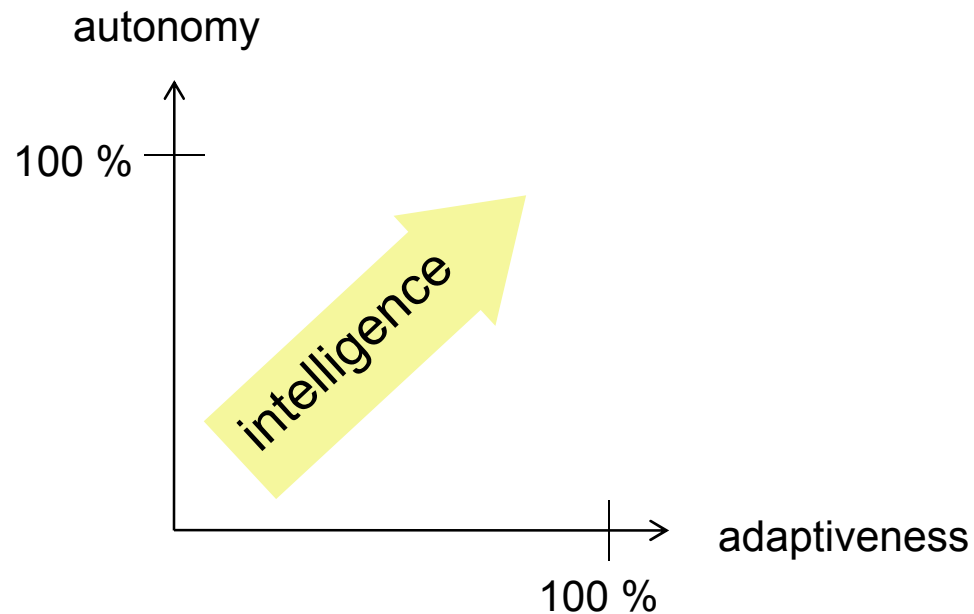
- Behaviour: a sequence of reactions
- Reaction: a pair *stimulus* → *response*
- Stimulus: current values of sensors
- Response: computed values of actuators

reactive systems can be hierarchic



autonomy, adaptiveness and intelligence

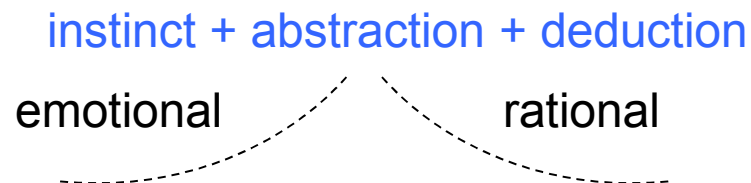
- Autonomy is to function without external help
- Adaptiveness is to function in changing “environment”



- Intelligence is a means to increase both autonomy and adaptiveness

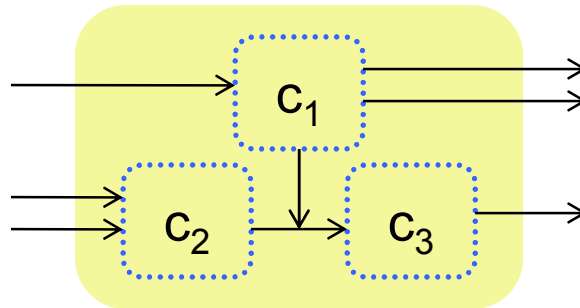
intelligence = instinct + abstraction + deduction

- intelligence: a set of all correct reactions employed by control
- concrete reaction: *stimulus* → *response*
- schematic reaction: *s_pattern* → *r_pattern*
- instinct: a set of concrete reactions
- abstraction: inferring schematic reactions from concrete ones
- deduction: inferring new schematic reactions from existing ones



cognition

A chain of internal reactions that leads to externally observable reaction



“evolving systems” is a questionable approach

- For smart products, in high-volume markets, evolving systems is a questionable approach
- To find a right set of reactions, by a [trial-and-error process](#), is
 - costly
 - unpredictable
 - dangerous for the “environment” (incorrect responses!)
- Instead, we try to exploit low-hanging fruits, by harnessing the end-user’s intelligence
 - emotional (via emotiotronics)
 - rational (via end-user programming)

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Adaptivity and Cognition: Towards Evolving Systems

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Cognition: The process of thought

- Information Extraction.
- Information Processing.
- Information Representation.
- Information Organization (e.g., Relations, Causality, ...).
- Information-based Reasoning.
- Information Update.

Adaptivity can be omnipresent.

Adaptivity: The ability to exhibit adaptation.

- Types of adaptivity.
- Factors of adaptivity.
- Model: a multi-objective iterative optimization process.
Volatile objectives.
- Objectives and feedback non-obvious.

Aiming at Cognition: The Adaptive Community to the World

- Reusability of methods.
- Application of techniques.

What more can we do?

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What more can we do?

- Reach further.

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- Methodology of adaptivity evaluation.

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- Reusability of methods.
- Application of techniques.

What more can we do?

- Reach further.
- Methodology of adaptivity evaluation.
- Rich benchmark datasets.

Aiming at Cognition: The World to the Adaptive Community

- **Data mining**, Information Extraction (Environment/Context Knowledge)
- **Machine learning**. (Optimization)
- **Topic models, Probabilistic DLs**. (Reasoning)
- Game theory. (Relation to and Evaluation of the Environment)
- Signaling game, Semantics, **Web of Entities (OKKAM)**. (Communication)
- Complex Systems (Environment/State Modelling)
- Cognitive Science (Psychology, Neuroscience)

and others...

Can Adaptivity Lead to Cognition?

- Is Cognition the target, so far?

Can Adaptivity Lead to Cognition?

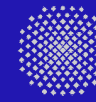
- Is Cognition the target, so far?
- Cognition is emergent.

Can Adaptivity Lead to Cognition?

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- Cognition is purposeful: Context-sensitive equilibrium.

Can Adaptivity Lead to Cognition?

- Is Cognition the target, so far?
- Cognition is emergent.
- Cognition is purposeful: Context-sensitive equilibrium.
- Reach for individual targets but **join results into overall effort.**



Adaptiveness and Cognition: Towards Evolving Systems

*Dr. Serge Kernbach
University of Stuttgart, Germany*

Evolving, yes !

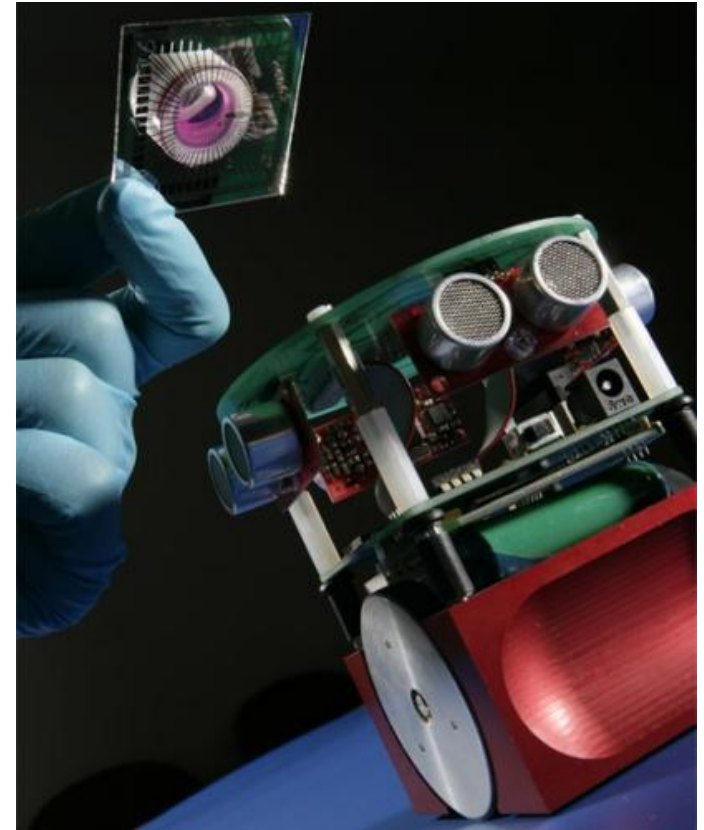


Plasticity is a key issue !

Huge problem: how to achieve it?



VS



Hybrid systems (bio-tech):
is this the ultimate answer to adaptivity in ICT ?

3. Future of ICT

Microsoft®



3. Is this a future of ICT ?



Adaptiveness and Cognition: Towards Evolving Systems

Leszek Holenderski, Philips Research

I have been recently involved in research on Smart Products¹. A smart product is a device that not only provides its basic functionality to a user but also cooperates with other (smart) products in a pro-active way, to enhance the overall user experience. Think of a smart kitchen where a cooking companion can help you to choose a recipe based on your preferences (deduced from observing your eating habits, for example), available ingredients in your (smart) fridge and the recipe's caloric weight, if you are on a diet. After you choose a recipe, the companion can guide you during the preparation of a meal. It can suggest using particular cooking appliances, if you happen to have them in your smart kitchen. It can warn you if you left the cooking plate switched on after you have finished cooking.

Smart products should be, well, smart. Users usually attribute smartness to autonomy and adaptiveness. A device is autonomous if it can function without external help. It is adaptive if it can function in a changing environment. An important means to increase both autonomy and adaptiveness is cognition (or more generally, intelligence).

The evolutionary approach to increasing the intelligence of products is questionable in the context of devices for a high-volume mass market. This is due to the trial-and-error nature of the evolutionary adaptation process. First, such a process is *computationally costly* and wasteful (only the last trial's result, the successful one, is used). This is a serious issue for resource constrained devices, which is almost always the case with high-volume market products, due to cost pressure. Second, the process is *unpredictable* because it does not guarantee finding the successful result. This is unacceptable for mass market. Third, the process is *potentially dangerous* for the "environment" in which the device is used because the device may function incorrectly in the adaptation phase (i.e., during the unsuccessful trials). This is also unacceptable for mass market.

Instead, one can try to exploit low-hanging fruits, by harnessing the user's intelligence, both emotional and rational. Emotional intelligence of users can be harnessed by adding a bit of emotiotronics to a device. Emotiotronics is electronics used to convey emotions. For example, the typical way a device signals to the user low battery level (and thus the need to charge the device) is to use a simple LED that changes its colour from green to red. Instead, imagine a device that signals the same situation by showing that it is tired (by using some more sophisticated actuators, of course). The device is perceived as smarter because it is perceived as having feelings, and we tend to attribute feelings to intelligence.

¹ [SmartProducts](http://www.smartproducts-project.eu/) is an Integrated Project funded by the European Commission's 7th Framework Programme (see <http://www.smartproducts-project.eu/>).

Rational intelligence of users can be harnessed by end-user programming, as a means to implant some of the user's intelligence in a device. The challenge is to make end-user programming so easy that the user perceives it as effortless. Otherwise, the device would be perceived as dumb rather than smart.

Adaptivity and Cognition: Towards Evolving Systems

George Giannakopoulos

2009-11-30

1 Cognition and Adaptivity

Cognition, as we know it from human agents, comprises a set of different information-oriented processes. These processes actually form an iterative overall process, which changes the inner state of the representational and functional system of the cognitive agent (e.g., human or system). When we refer to the *inner state*, we mean to differentiate the perceptive parameters, the representation parameters and the information organization parameters of the human agent, from the state of the environment, or *outer state*. The environmental parameters are usually considered to be the *context* for the cognition agent. This context should, according to my view of things, be treated as the *outer state* part of the overall state of the cognition agent.

The aim of the unified view of the inner and outer state is to understand the following. The information we receive and its integration into our knowledge base changes the way we will perceive and analyze information later. This is because embedded knowledge changes the inner state, which forms *together* with the outer state the overall state of a cognitive agent (or system). Also, acting and interactive with the environment can alter both the inner and outer state, leading to a new overall state.

Cognition involves such tasks as Information Extraction, Information Processing, Information Representation and Information Organization (e.g., Relations, Causality). At this point, the perceived information is converted, through organization, into usable knowledge. This further allows for Knowledge-based Reasoning. In the end of this set of processes, there is a step of Information Update, which updates the process parameters for all the aforementioned processes, based on the results of the processes themselves.

However, cognition is more an apparent, emerging set of behaviors, than a self-existing state. More precisely, I consider an agent to exhibit cognition, if she can perform a set of tasks that we consider *results* of cognition, e.g., communication, reasoning and so forth.

Overall, *adaptivity*, which is the ability to change oneself to reach optimality, according to a set of objectives, can be omnipresent as a support function in the cognition subprocesses. However, it is not necessarily the only way to cognition.

Concerning adaptivity in itself, I consider that it can be modeled as a multi-objective iterative optimization process, where the overall state of the system is described both by inner state and outer state parameters. The problem with adaptivity is mainly the difficulty to define the objectives, especially because they vary over time. In several cases, the objectives and feedback of the system is definitely not trivial to model, or is even completely unknown.

2 Aiming at Cognition

Aiming at cognition and at the evolving of adaptive systems, we should take into account both the tools that the scientific world can offer to the adaptive community, as well as the tools that the adaptive community can offer to the world.

2.1 From the World to the Adaptive Community

The adaptive community can make — and has already to some extent made — use of several Computer Science, Engineering, Mathematical or other domains. For example, for each of the numerous problems faced within the adaptive systems' community one can use: Data Mining and Information Extraction for environmental or context knowledge extraction; Machine Learning for optimization; Topic Models, (Probabilistic) DLs for Representation and (Uncertain) Reasoning; Game theory for the relation to and evaluation of the environment; Signaling Game Theory for induction of Semantics; Unique Identification (also see OKKAM Project at <http://www.okkam.org/>, Web of Entities) to facilitate Unique Reference in Communication and Processing, Complex Systems Modeling for Environment and Self-State Modeling; Cognitive Science (Psychology, Neuroscience, etc.) for the definition of objectives related to cognition.

2.2 From the Adaptive Community to The World

The adaptive community, on its part, can offer help to a multitude of application domains, but even in domains that have not been traditionally connected to adaptivity. Natural Language Engineering, for example, is a domain where we usually model language in a static representation (even if it is probabilistic), even though language is heavily affected by a set of environmental and communication factors.

Therefore, the adaptive community should aim to reach further into new domains. Furthermore, it is needed to define a set of *common datasets*, covering a wide spectrum of domains and applications, so that generic adaptive methodologies can be tested. Finally, a set of *evaluation methodologies* for adaptivity should be devised and applied to have a common understanding of how adaptivity can be quantified and measured.

3 Conclusions and Other Points

The adaptive community has not really targeted cognition, so far. Cognition in itself is an emergent behavior, based on a set of subprocesses, where adaptivity can be a horizontal-spanning support mechanism for all the subprocesses. Cognition is purposeful in human agents, in that it aims to reach a *context-sensitive equilibrium* (i.e., context-sensitive optimal state for the inner and outer states). The modeling of this equilibrium in different contexts and applications can be non-trivial and is an open research subject.

The adaptive community should reach for individual targets, but *join results into an overall effort* through common benchmarks and evaluation methods.