

A Principled Approach for Systematic Mind Engineering*

Ricardo Sanz, Jaime Gómez, Carlos Hernández and Adolfo Hernando

Autonomous Systems Laboratory
Universidad Politécnica de Madrid, Spain
ricardo.sanz@upm.es

The systematic, engineering-grade construction of cognitive systems with up-to-human capabilities cannot be based on the exploratory programming methods that have populated the artificial cognitive systems effort for a simple matter of scale. We need a strong methodological focus to move from artisanship into the requirements-driven engineering methods that are necessary to build systems with the required set of competences in any design dimension (any-x systems).

The ASys Vision is a structured vision for any-x artificial mind engineering that is based on a universal conceptualisation of a situated, functional, self-aware cognitive system: an agent that exploits models —of the world, of the self— for the performance of situated tasks.

It has been demonstrated that the performance of a controller is related to its capability of internalising models of the systems under control (Conant and Ashby 1970). This result is well known in practice in the field of predictive process control; and while recognised by philosophers as early as Craik and theoretical biologists as Rosen, the question of model-based minds is still controversial in some fields (like some areas of neuroscience or enactive cognition).

The mental model then constitutes the very substrate of the agent's epistemology and is efficacious to the extent that it is in congruence with the reality surrounding the agent. This surrounding reality includes the agent's body, because model-based minds include models of the own body as part of their control strategical resources. That the biological mind represents and models the body is a well-known result from neuroscience and recent results and theories suggest that mental model execution sustains agent awareness. Obviously mental models are not complete; they capture only parts of the reality and in a usually simpler abstraction.

Model complexity hampers scalability of the exploitation strategy and hence the economy-driven evolutionary-shaped strategy of a cognitive agent is to build limited, focused ad-hoc models that are activated on-demand based on mental state and current perceptual flow.

The multiplicity of models and exploitation engines are integrated into hierarchical and heterarchical control structures. This is performed by metacontrol mechanisms — rendering nested controllers— and also by model federation —sharing of mental state between different subsystems. The activation of specific models/engines is what determines the agent's behaviour. This control reconfiguration strategy is realised by the emotional system of mammals. This is an interesting result produced by the ongoing ICEA project (www.iceaproject.eu).

This is the overall picture to be elaborated into painstakingly formal detail in the construction of complex controllers that scale up to human-levels. The major value of novelty of this approach comes from the consideration of the need of having not only self-models of the agent's own body —the widely claimed-for embodiment— but also of the agent's own mind beyond the commonly accepted issues of meta-knowledge. At the minimal level of scale this will produce minimal, distributed self-awareness. At the maximal level of scale this will render an integrated model of the agent as a cohesive entity: a “self”.

To achieve the required engineering process competence the initial formulation of this vision is in the form of architectural principles for general cognition derived from the abstract analysis of human minds (Sanz et al. 2007)

The ASys principled approach to mind engineering shall make possible the application of systematic model-based engineering processes that will enable not only the certifiable construction of human-level, self-aware cognitive systems, but the functional autonomy of the cognitive system based on the exploitation of its own engineering models. Because executable models of self will render metacognitive capabilities when executed over the virtual machines that will be the very substrate to the adaptive, conscious mind.

Details on the ASys approach to systematic mind engineering can be found in our website: www.aslab.org.

References

- Conant, R. C., and Ashby, W. R. 1970. Every good regulator of a system must be a model of that system. *International Journal of Systems Science* 1(2):89–97.
- Sanz, R.; López, I.; Rodríguez, M.; and Hernández, C. 2007. Principles for consciousness in integrated cognitive control. *Neural Netw.* 20(9):938–946.

*We acknowledge the support of the European Commission through grant ICEA: *Integrating Cognition, Emotion and Autonomy* and the Spanish Ministry of Education and Science through grant C3: *Control Cognitivo Consciente*.
Copyright © 2008, Association for the Advancement of Artificial Intelligence (www.aaai.org). All rights reserved.