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Towards a Cognitive Multi-Agent System for Building Control

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Abstract
Fitting a bionically inspired cognitive model to a technical application domain is a challenging task. This work presents the fundamental steps in applying the SiMA-based cognitive model ECABA to the domain of building automation. The focus of the paper is to show the initial steps and challenges for implementing the human inspired mechanisms of drives and social rules when modeling a cognitive control system for a non-human body. We then illustrate the flexibility and extensibility of the intended distributed cognitive approach by presenting the iterative development of a simple reactive system with interacting components. Using a simple use case, we show how the cognitive processes can be implemented and utilized in a multi-agent system to provide a first, reactivity-based control system.

Keywords: cognitive control systems, cognitive architecture, building control, AGI, multi-agent systems

1 Introduction

The field of building control poses many challenges. As intelligent buildings continue to develop and gain complexity, so do the demands for more sophisticated control systems [1]. When looking at the problems related to building control, like the high number of sensors and actuators, the vast variety in building designs and involved components as well as dynamics of inhabitants and building usage, we recognize a clear relation to the challenges addressed by cognitive architectures in the field of artificial general intelligence (AGI). These frameworks utilize knowledge from other scientific domains, like cognitive neuroscience, to create adaptive and flexible systems that deal with dynamic, interactive and not fully known environments [2]. We decided on the cognitive architecture SiMA (Simulation of the Mental Apparatus & Applications, formerly named ARS) [3] as a base for developing a cognitive, model-based control system, since it considers a holistic perspective on human cognition, including drives and emotions. We believe these aspects essential when dealing with systems on the complexity level of building control. We expect that successful application of a bionically inspired model of cogni-

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tion in the control-engineering domain can open up the road for embedding future controllers with human-like intelligence. Until now, SiMA has been used to model human-like behavior, for example in artificial life simulations dealing with human interaction scenarios [4], or in social simulation, where the model was used to predict consumer decisions in the energy provider domain [5]. The foundational work in transferring SiMA to the new domain of building automation was performed in the ECABA project [6], which defined the approach on a theoretical level. In this work, we now report experiences from the basic development steps for a distributed cognitive model implemented as a multi-agent system, for a typical building automation use-case. Multi-agent solutions have gained attention within the building automation community due to their ability to cope with the complexity involved in building energy management systems ([7][8][9]) and handle conflicting goals related to human comfort and energy efficiency ([8][10]). Our model uses the multi agent approach to implement a distributed cognitive architecture for operating the building using a generic, human-inspired control system. Distributed cognitive control systems have been studied for air traffic control applications [11] and control of robots [12], however to our knowledge no feasibility test results are available.

2 The ECABA Model

Foundation for the ECABA model is SiMA, a human-inspired functional model of mind [3] and translate it into the domain of control systems. ECABA is based on multi-step information processing and covers reactive behavior and proactivity via reasoning and state elaborations. The so-called *primary process* in ECABA controls reactive behavior, necessary for handling important goals that require quick response, while the *secondary process* controls deliberative behavior that enables the system to cope with its long-term goals.

Central concepts in ECABA are embodiment for the generation of goals, emotions to modulate decision-making and context-based goal evaluation. The body, in this case, encapsulates the system's sensorimotor capabilities and physical properties related to materiality. Therefore, it enables a generative approach towards determining system's goals. The concept of *emotion* sketched in [13] is used to capture the history of system-environment interaction by influencing the internal state representation. They enable a fine-grained evaluation of the system goals. As such, the system constantly evaluates priorities and may modify its plans to pursue a more urgent goal, or it may choose to adjust its strategy if it observes that the initial expectations are not fulfilled according to the selected plan. In Figure 1, the ECABA architecture is shown on a high level.

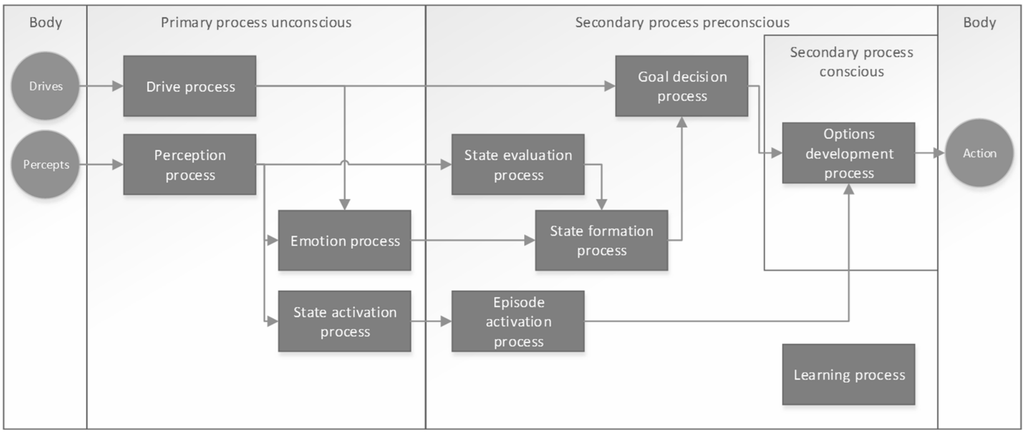

Figure 1: The ECABA architecture