Semantic and Formal Representation of Cognitive Models for the Metacognitive Architecture CARINA

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INTRODUCTION

A cognitive model is a computational model of internal information processing mechanisms of the brain for the purposes of comprehension and prediction. Cognitive models are developed to study different aspects of cognition; attention and multitasking, judgment and choice in decision-making and skill acquisition in dynamic situations. CARINA metacognitive architecture runs cognitive models. However, CARINA does not currently have mechanisms to store and learn from cognitive models executed in the past. Semantic Knowledge Representation is a field of study which concentrates on using formal symbols to a collection of propositions, objects, object properties and relations among objects. In CARINA Beliefs are a form of represent the Semantic Knowledge, which are elements about facts, concepts or objects. The aim of this chapter is to formally describe a CARINA-based cognitive model through of Denotational Mathematics and to represent these models using a technique of Semantic Knowledge Representation called Beliefs. A CARINA-based cognitive model contains a problem, goals, mental states, beliefs, actions and reasoning rules. All the knowledge received by CARINA is stored in the semantic memory in the form of Beliefs. Thus, a cognitive model represented through beliefs will be ready to be stored in semantic memory of the Metacognitive Architecture CARINA. Finally, we present an illustrative example that describes a cognitive model of a syntactic analyzer for opening questions using beliefs, a structured natural language notation named NGOMS-L and a domain-specific visual language called M++.

Semantic Knowledge Representation is a way of modeling and introduce knowledge using tools that represent notions or concepts (Rajman & Chappelier, 2010) as well as formal symbols in a collection of propositions. Semantic Knowledge Representation is the area of Artificial Intelligence concerned how

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knowledge can be symbolically manipulated and represented in an automated way by reasoning programs (Levesque, 2004). A cognitive model is a computational model of some internal information processing mechanisms of the brain used in the area of Artificial Intelligence for the purposes of comprehension and prediction (Levesque, 2004). Also, a cognitive model is a theoretically grounded and empirically guided specification of the mental representations and processes involved in a given cognitive function (Zacarias, Magalhaes, Caetano, Pinto, & Tribolet, 2008). Cognitive architectures have been used to create cognitive models of a variety of intelligent systems (Langley, Laird, & Rogers, 2009). A cognitive model of a task constructed in a cognitive architecture is runnable and produces a sequence of behaviors (Cox, Oates, & Perlis, 2011). Cognitive architectures have been used to create cognitive models of a variety of intelligent systems (Forstmann & Wagenmakers, 2015). A cognitive architecture is a general-purpose control system inspired by scientific theories developed to explain cognition in animals and humans (Langley et al., 2009).

A Metacognitive Architecture is a cognitive structure which is able to reasoning about itself (Cox et al., 2011). CARINA is a metacognitive architecture for artificial intelligent agents (Caro et al., 2018). CARINA is derived from the MISM Metacognitive Metamodel (Caro, Josyula, Cox, & Jiménez, 2014). When the reasoner executes a cognitive model in CARINA it is necessary that the cognitive model that was executed be stored in the Semantic Memory in form of beliefs for to be subsequently retrieved. Several researches have presented different ways of Semantic Knowledge Representation in Cognitive Architectures. ACT-R represent the semantic knowledge in units called chunks (Anderson, 1996), SOAR is based on the form of representation of ACT-R, where each chunk collects a number of pieces of environmental information in a single unit (Gobet et al., 2001). CLARION uses various representations according to the type of knowledge used: explicit objective knowledge is symbolic, while implicit procedural knowledge is sub-symbolic (Kotseruba, Gonzalez, & Tsotsos, 2016).

Recent researches on cognitive architectures show some representations of knowledge, for example, Vector LIDA (Snaider & Franklin, 2014) employs high-dimensional vectors. High-dimensional vector spaces have noteworthy properties that make them attractive for representation models (Snaider et al., 2014). These vectors have interesting properties that make them attractive for representations in cognitive models. LEABRA (O'Reilly, Hazy, & Herd, 2015) are based on a purely connectionist model that allows the representation of knowledge. This model represents a worthy explanation of connections for the functional structure and interaction of human attentional networks (H. Wang & Fan, 2007), the early versions of cognitive architectures did not have a powerful semantic memory system that facilitated the development of search processes but rather used relational databases displaying an interface to communication, which made these search processes slower and more complicated. In cognitive architectures the development of cognitive agents requires experts in the language of each architecture to establish the way of representing knowledge and can reason about the world based on a system of semantic memory. The creation of cognitive agents is a difficult task and there is no standardized way to develop them, for that reason, CARINA uses different cognitive approaches such as self-regulation, metacognition and metamemory.

Nowadays it is a difficult and time consuming task to use cognitive architectures for the development of cognitive agents because this type of assignment requires expertise in the own language of that architecture and a very particular knowledge about forms of semantic representation of the architecture. In addition, there is no a systematized way in cognitive sciences neither in computer sciences to design cognitive agents even more if these agents are to perform self-regulation, metacognition and metamemory. The focus of this paper is to present the appropriate Semantic Knowledge Representation of a cognitive model in CARINA. Currently, the metacognitive architecture CARINA executes cognitive