On Modeling Adaptive and Cognitive Systems

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Synthetic computational methodologies have been used to model and simulate cognitive processes (e.g., perception, planning, navigation, inference, communication, language) from many different perspectives (see, e.g., Loula, Gudwin and Queiroz, 2007). In this book, the reader will find two types of contributions: models and experiments of adaptive and cognitive processes and agents, as well as theoretical and philosophical discussions about building adaptive and cognitive systems. These are complementary fields of research in adaptive and cognitive systems, as building such systems generally relies and starts with theoretical foundations and theoretical considerations are always raised when synthesizing such systems. Indeed, computer simulation, on one hand, is heavily influenced by both formal theoretical constraints and empirical constraints in the design of the environment, the morphological definitions of sensors and effectors, and the implementation of cognitive architecture and processes of the conceived artificial systems. On the other hand, simulations offer the opportunity to quantify and formalize ideas, concepts and propositions that constitute a theory in terms of programming (Parisi 2001). Most important, artificial cognition systems provide scientists with the means to perform 'mental experiments' about the necessary and sufficient conditions to observe processes of interest (Bedau 1998, Dennett 1998) – how would a certain system change, given different initial conditions and/or developmental path? What set of conditions is sufficient for the emergence of specific traits of the system?

Among synthetic computational methodologies, Artificial Life is a research area dedicated to simulation and synthesis of living systems and life-like behaviors. **Jon Umerez** discusses the relation between Artificial Life and Biology, comparing it with other extensions of Biology such as exobiology, biotechnological manipulation and biochemical synthesis. All of these research areas can be seen as leading to an enlargement of Biology, pushing the concept of life farther by identifying, re-creating and creating life forms. The author brings an overview of the field of Artificial Life through its history, its conceptual standing place, the different versions and approaches, and also its challenges and problems. In his work, Umerez concludes by recognizing the contribution of Artificial Life for a better understanding of life, but remains skeptic about its ambition on creating life-as-is-could-be.

In analyzing a fundamental property of living systems, described by Robert Rosen as closure to efficient cause, **Anthony Chemero and Michael Turvey** use the hyperset theory to understand this complexity related property. In his book, Rosen

argued that complex systems can not be computable because they contain impredicativities which are not computable, but Chemero and Turvey show that this argument is faulty. The hyperset theory and its graphing systems reveal that complex systems produce loops, and, by analyzing Rosen's metabolism-repair systems, Chemero and Turvey are able to recognize loops in these systems along with efficient and material causes. The computability of such systems would be possible by means of hypersets, already found to be computable, but there would still be other properties stated by Rosen in living systems that would still be needed for artificial life to be possible.

Gerd Doeben-Henisch, Ute Bauer-Wersing, Louwrence Erasmus, Ulrich Schrader and Matthias Wagner, raise methodological issues on building intelligent systems concerning its interdisciplinarity. The authors start from considerations about defining requirements in systems engineering and discusses consequences to Artificial Intelligence when building intelligent systems. As an interdisciplinary research endeavor, the authors advocate for a more close relationship between the field of computational intelligence and other disciplines studying intelligence.

A framework of adaptive automata as a control structure for cognitive agents is presented by **João Kogler Jr and Reginaldo Filho**. Adaptive automata are finite state machines whose behavior changes dynamically in response to inputs received, thus they are self-modifiable structures that can modify its rules. The authors describe a cognitive agent architecture with adaptive automata that could control an agent's behavior and they propose a first experiment to evaluate this new framework.

On modeling cognitive agents, **Guilherme Bittencourt** describes an unusual approach, applying logical expressions, typical of deliberative cognitive models, to build reactive embodied agents. In his framework, the environment, the actions and the internal perceptions are represented as truth values of propositional symbols. By relying on 'emotional flavors', also propositional symbols, Bittencourt says the agent can be embodied on the motivation to have good emotional flavors and avoid bad ones. Besides describing his logical framework formalism, including quantum representation, prime form manipulation formulae expansion and decomposition, the author emphasizes the memory model for his cognitive agent, describing memory structure and memory functioning. In his memory model, thoughts are kept, which relates abstract propositional symbols to emotional flavors, and which can be optimized after a 'daylight' activity, during a 'dreaming' cycle.

Gul Khan, Julian Miller and David Halliday also discuss memory on cognitive agents. Their agent, however, is given a 'brain' with a new type of developmental neuro-inspired computational network. The neurons in this approach are dynamical models of neuronal activity and interrelation, described as a genotype that undergoes a development phase during life-time and an evolutionary process by Genetic Programming. By testing their model in the classical AI Wumpus World, the authors were able to recognize the emergence of a signal recognizing behavior and the formation of memory in their agent.

Finally, a control system for artificial creatures employing emotions and goals is the subject of **Patrícia de Toro, Ricardo Gudwin and Mauro Miskulin**. They developed a cognitive architecture with two control levels, and focus their work around the high level one, extending a previously developed cognitive architecture. Emotional metaphors of fear (of obstacles), hunger (for energy recharge) and curiosity (for environment exploration) have to be coordinated together for the creature to be successful in its lifetime. Applying a genetic algorithm, they evolve this coordination between conflicting emotions by combining them into a 'desirability' function. Their simulations show the evolved solution can achieve results similar to a manually adjusted one, but with the advantage of being able to scale better then the hard-coded approach.

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