Embodied Mind/A-Life

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Abstract. The workshop "Embodied Mind/A-Life" at KogWis99 discusses issues of embodiment and cognition from a particular bottom-up Artificial Life (A-life) viewpoint that focuses on minimal designs and the emergence of embodied action and cognition via interaction of an agent with its environment.

Motivation

Embodiment and cognition are two closely intertwined aspects of natural living systems, so closely connected that it has long been discussed whether cognition can exist without a body, and if embodiment can be defined without making reference to a cognitive system (Dautenhahn, 1996, 1999). Recent work in the areas of Artificial Life and Embodied Artificial Intelligence gives evidence for the crucial role of dynamic, embodied action and interaction with the environment as a constituent factor for certain cognitive capacities (Beer, 1995; Chiel and Beer, 1997). Thus, cognition as we know it seems to depend on a living physical body. On the other hand we can create artifacts like robots that have physical "bodies" (Brooks, 1991a,b). However, the proof of an autonomous robot, showing non-trivial behavior in an unstructured and dynamic environment (i.e. a system considerably more advanced than obstacle-avoidance and wall-following machines), and "surviving" over a long period of time in its environment (meaning the ability to regulate its internal states and to pursue its own agenda), is still to be shown. Furthermore, along with the recent development of software and in particular agent technology, the role of a "physical" body in embodiment has been questioned (Etzioni, 1993; Quick et al., 1999).

Based on recent research evidence, chances are that a bottom-up approach which has been studied extensively in Artificial Life research is a promising endeavor (Langton, 1989). Its aim is to produce interesting properties on the system level by designing components and interactions between components on different (lower) levels. System properties are then called emergent if they cannot be predicted from the properties of the dynamics of the components alone; they are rather a property of the dynamics of a system situated and interacting in its specific environment. To give an example of a commercially successful software system based on Artificial Life mechanisms and a strictly bottom-up oriented design philosophy: The enormous success of the computer game Creatures (Cyberlife) is only partially due to its sophisticated design of the agents and the world the agents are inhabiting. Instead, the modularity of the agent's architecture (which models biological systems) exhibits, in interaction with the user, an overall behavior which is often surprising even to the program's designer (Grand et al., 1997; Grand 1999). Thus, design and decomposition of systems into (functionally) relevant components is no contradiction to emergent behavior. However, it is still unclear how much design is necessary in order to develop a minimal artificially "living" system, apart from the questions how "living", "intelligence" and "cognition" can be defined for an artifact.

The workshop presentations discuss both fundamental issues of embodiment and cognition and also include presentations of relevant research projects.

Workshop Presentations

Seven papers were selected for presentation at the workshop. In the following we give a brief summary of each contribution.

Verkörperung und Teleologie. Martin Kurthen discusses embodiment and teleology. He argues that for biological systems, the only cognitive systems we know, the concept of a brain, as the center of cognition, that can be opposed to the extra-cerebral body, is not appropriate. The brain is itself a part of the body and other bodily parts like the sensori-motor organs are ultimately "parts" of the brain. A careful analysis of the functions of brain and body suggests that the conative aspects are of primary relevance to the embodiment of cognition: cognition is necessarily teleologic, and teleology needs at least factually a body. Thus, teleology is a key concept mediating between body and cognition. The central question whether teleology is necessarily embodied remains to be answered.

Der Kognitionsbegriff aus der Sicht der Verhaltens- und Neurobiologie. Hanspeter A. Mallot discusses cognition from an ethological and neurobiological point of view. In this view e.g. goal oriented spatial behavior, problem solving and object recognition are important elements of cognition which do not necessarily require symbolic information processing. The paper discusses the role of these elements in animals, giving examples of non-cognitive and cognitive forms of spatial behavior. The cognitive level is reached when the animal (agent) is able to move not simply by executing a chain of "recognition-triggered-responses" but by making decisions depending on different goals.

Minimum Conditions for Embodied Cognition: Lessons from the Biology of Unicellular Organisms. Joseph W. Lengeler, Bernd S. Müller and Franco di Primio pose the problem of how to search for minimum conditions for embodied cognition. Their discussion is based on the consideration of unicellular organisms, more specifically bacteria. The authors argue that cognition, as it is currently defined, can equally well be attributed to bacteria, because they show individual and social capabilities comparable with those of so-called "higher" organisms. As bacteria are the smallest and earliest known living systems, this suggests the radical conclusion that life and cognition can be considered synonymous.

Reaktivität vs. Zeitliche Handlungsabfolgen: Ein Konflikt der verhaltensorientierten KI. Eckart Schlottman, Dirk Spenneberg and Thomas Christaller present a position paper, which discusses the role of variable sequencing of actions in complex problem solving tasks. The discussion is based on the authors' work in behavior-oriented robotics, which has traditionally focused on tight sensori-motor loops. The position paper discusses how this approach might be complemented by introducing internal variables.

Termination of the swing movement depends on internal state. Michael Schumm and Holk Cruse are investigating the termination of the swing movement of stick insects (Carausius morosus) whose walking behavior has been previously studied extensively by Holk Cruse and his research team at University of Bielefeld. This paper presents new research which demonstrates the role of the internal state of the animal on its walking behavior, indicating a new coordination mechanism.

Lokutor - An Intelligent Communicative Presentation Agent. Jan-Torsten Milde and Tobias Ahlers introduce Lokutor, a virtual, partially autonomous human that can

be controlled by a user via natural language or a graphical user interface. *Lokutor* is an example of recently prospering agent research. Particularly relevant are communicative agents which are able to understand natural language and therefore show characteristics which are important for embodied human cognition.

Making embodiment measurable. Tom Quick and Kerstin Dautenhahn present a definition of embodiment which can a) be applied to different types of embodied systems (biological, software, robotic), and b) allow the investigation of metrics in order to make embodiment measurable. The core assumption in this paper is that systems can show different degrees of embodiment, and that appropriate metrics should be the focus of research in this field, rather than the often not very fruitful discussion of whether a system is embodied or not. Within the proposed framework embodiment can be understood and exploited without depending on any specific ontological context.

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