Chapter 5.1
The Goose, the Fly, and the Submarine Navigator:
Interdisciplinarity in Artificial Cognition Research

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ABSTRACT

Interdisciplinary research provides inspirations and insights into how a variety of disciplines can contribute to the formulation of an alternative path to artificial cognition systems. The chapter suggests that results from ethology, evolutionary theory and epistemology can be condensed into four boundary conditions. They lead to the outline of an architecture for genuine cognitive systems, which seeks to overcome traditional problems known from artificial intelligence research. Two major points are stressed: (a) the maintenance of explanatory power by favoring an advanced rule-based system rather than neuronal systems, and (b) the organizational closure of the cognitive apparatus, which has far-reaching implications for the creation of meaningful agents.

INTRODUCTION

Old Problems with Designing a Mind

The history of artificial intelligence and cognitive science shows that the *complexity* of the structures and dynamics of cognition have often been underestimated. Typical examples include the scaling problem of microworlds, which become NP-complete as soon as they are populated by a nontrivial amount of objects, and the difficulties in formalizing the enormous complexity of human expertise in knowledge-based systems. This matter of fact can be attributed to: (1) the naive-realistic approach (Riegler, 1992), which is mainly based on Cartesian dualism, which distinguishes between subjective and objective levels of description, and (2) the objectification of "information." These aspects created problems that have been hampering research in artificial intelligence (AI) ever since. Among them are the *Symbol Grounding Problem* (Harnad, 1990), which demands an account for meanings, and the *Frame Problem* (Dennett, 1984; Pylyshyn, 1987), which asks for the appropriate form of representation of sensory input in real-world environments, where the number of possible propositions and their mutual relationships are practically infinite.

Dissatisfaction with traditional methods of research has led to the search for alternatives, such as artificial life (Langton, 1989, 1992). It focuses on the *behavioral and evolutionary foundations* of life in general and cognition in particular (Wilson, 1991). Autonomous agents are studied in terms of (cognitive) systems that interact with each other and with their respective environments. These approaches press for an understanding of mechanisms responsible for the generation of behavior rather than for the specification and implementation of isolated cognitive functions. In recent years this has resulted in the formulation of the "embodiment" paradigm, i.e., the concept that cognition is intimately connected with the functioning of the body (Lakoff, 1987; Riegler, 2002; Ziemke, 2003) such that sensory and motor functions as well as information-processing and memory components are no longer considered independent and sequentially working parts of the cognitive apparatus.[1]

In general, work on artificial cognition systems can be viewed as the creation and investigation of self-organizing cognitive creatures and meaningful systems made by humans. These systems are an attempt to find the fundamental dynamical principles underlying biological phenomena, which in turn can be used to recreate these phenomena in other physical media (Langton, 1992). Since this research includes animats (Wilson, 1991), mobile robots (Brooks, 1991) and software agents inhabiting virtual realities and operation systems (Etzioni, 1993), any theory rooted in this alternative movement must reside on a *functional-abstract level* in order to be applicable in as many domains as possible. In this context, "functional" refers to the concept that we can abstract from the material structure of living entities. For example, it is obvious that the behavior of animals per se is not directly encoded in their respective genotype. Rather, the morphological structure of an organism serves as a predisposition for its behavioral repertoire. In other words, the physics of the body provides the basis for cognitive behavior in humans but it does not determine it. Other predispositional structures could serve the same purpose such that the issue of embodiment does not relate to the physical instantiation but rather to how the system relates in its entirety to the structure out of which it has emerged.

Given the problems traditional approaches face, the objective of this chapter is to show how interdisciplinary considerations can provide inspirations and insights into how a variety of disciplines can contribute to the formulation of an alternative path to artificial cognition systems. This demonstration is twofold: (1) I shed light on four potential problems that may also affect those new approaches. In particular, I argue that syntactical "PacMan"-models are unlikely candidates for genuine cognitive systems. Furthermore, such systems should not be based on situational-behaviorist designs that forgo internal states, nor should they rely on crisp symbolic production systems. And finally from a complexity-based perspective, I argue against the use of neural networks. (2) In order to build an alternative road to ACS, I suggest condensing observations in ethology, evolutionary theory and epistemology into four boundary conditions. They lead to the outline of a cognitive architecture that seeks: (1) to overcome traditional problems discussed in the introductory paragraphs, and (2) to avoid the pitfalls pointed out in the following section. The proposed model framework will be evaluated and compared with other, mainly neural network-related approaches. The chapter concludes with a description of future trends and problems that still need to be addressed.

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