Chapter IX

Making Meaning in Computers: Synthetic Ethology Revisited

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Abstract

This chapter describes synthetic ethology, a scientific methodology in which we construct synthetic worlds in which synthetic agents evolve and become coupled to their environment. First we review the motivations for synthetic ethology as an experimental methodology and explain how it can be used to investigate intentionality and meaning, and the mechanisms from which they emerge, with a special emphasis on communication and language. Second, we present several examples of such experiments, in which genuine (i.e., not simulated) meaningful communication evolved in a population of simple agents. Finally, we discuss the extension of the synthetic ethology paradigm to the problems of structured communications and mental states, complex environments and embodied intelligence, and suggest one way in which this extension could be accomplished. Indeed, synthetic ethology offers a new tool in a comprehensive research program investigating the neuro-evolutionary basis of cognitive processes.
Introduction

Synthetic ethology was developed as a methodology for constructing experiments in which artificial agents could exhibit real (i.e., not simulated) intentionality and other mental phenomena. Our first experiments using this methodology demonstrated the evolution of communication in a population of simple machines and illustrated ways of relating the emergence of meaning to underlying mechanisms (MacLennan, 1990, 1992, 2001, 2002; MacLennan & Burghardt, 1993). In these experiments, as I will explain, the communications were meaningful to the artificial agents themselves, but they were only secondarily and partly meaningful to the experimenters.

This chapter has two purposes. The first is to review the motivations for synthetic ethology as an experimental methodology and to explain how it can be used to investigate intentionality and meaning, and the mechanisms from which they emerge, with an especial emphasis on communication and language. The second purpose is to reconsider these issues with the hindsight of fifteen years, and discuss new approaches to the use of synthetic worlds in the scientific investigation of problems in epistemology and cognitive science.

Background

Definition of Synthetic Ethology

**Synthetic ethology** can be defined as an experimental methodology in which the mechanisms underlying cognitive and intentional phenomena are investigated by constructing synthetic agents and observing them in their *environment of evolutionary adaptedness* (EEA, the environment in which they have evolved), which is also synthetic. These synthetic worlds are commonly constructed inside a computer. I will briefly summarize the most important considerations motivating the synthetic ethology paradigm (a fuller discussion can be found in MacLennan, 1992).

In discussing his research program in *synthetic psychology*, which was a direct inspiration for synthetic ethology, Braitenberg (1984, 20) distinguished “uphill analysis and downhill invention.” By this he meant to distinguish the enormous difficulty of analyzing natural systems, as opposed to the comparative simplicity of synthesizing systems exhibiting a behavior of interest. His intention was to advocate the synthesis of neural networks and robots exhibiting intelligent behavior as an important adjunct to the analysis of intelligent agents in nature. Synthetic ethology extends this approach to phenomena for which populations and their evolution are relevant, such as communication.

The synthetic approach is especially valuable for investigating phenomena that depend essentially on the evolutionary history of the agents. Our ability to test evolutionary hypotheses about natural species is limited; we cannot go back into the past and restart...
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