Chapter VI

Evolutionary Computation as a Paradigm for Engineering Emergent Behavior in Multi-Agent Systems

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ABSTRACT

In the multi-agent system (MAS) context, the theories and practices of evolutionary computation (EC) have new implications, particularly with regard to engineering and shaping system behaviors. Thus, it is important that we consider the embodiment of EC in "real" agents, that is, agents that involve the real restrictions of time and space within MASs. In this chapter, we address these issues in three ways. First, we relate the foundations of EC theory to MAS and consider how general interactions...
among agents fit within this theory. Second, we introduce a platform independent agent system to assure that our EC methods work within the generic, but realistic, constraints of agents. Finally, we introduce an agent-based system of EC objects. Concluding sections discuss implications and future directions.

INTRODUCTION

With the advance of computational power and communications speed, we now live in a computational world where a large number of software agents may be acting on behalf of even the most casual user: searching for music, comparing pension schemes, purchasing goods and services, identifying chat partners, etc. Moreover, these agents may be collaborating with those of other users, while spawning and managing agents of their own. In more formal settings, a business, academic, or government user may simultaneously employ many software agents to manage workflow, trade goods or information, collaboratively solve problems, etc. In the future, even relatively simple household appliances may play a role in this churning system of interacting, computational agents.

The behavior of a multi-agent system (MAS) is a result of the repeated (usually asynchronous) action and interaction of the agents. Understanding how to engineer adaptation and self-organization is thus central to the application of agents in the computational world of the future.

Desirable self-organization is observed in many biological, social, and physical systems. However, fostering these conditions in artificial systems proves to be difficult and offers the potential for undesirable behaviors to emerge. Thus, it is vital to be able to understand and shape emergent behaviors in agent-based systems. Current mathematical and empirical tools give only partial insight into emergent behavior in large, agent-based societies. Evolutionary Computation (EC) (Back et al., 1997) provides a paradigm for addressing this need. Moreover, EC techniques are inherently based on a distributed paradigm (natural evolution), making them particularly well suited for adaptation in agents.

In the MAS context, EC theories and practices have new implications. Agents that interact according to these theories are no longer locked inside the laboratory conditions imposed by EC researchers and users. Thus, it is important that we consider the embodiment (in a sense similar to that in Brooks et al., 1998) of EC in “real” agents, that is, agents that involve the real restrictions of time and space within a MAS.

We address this issue in two ways. First, we have developed a platform independent agent system, to assure that we work within the generic, but
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