Chapter XXXVIII

Games, Supply, Chains, and Automatic Strategy Discovery Using Evolutionary Computation

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ABSTRACT

The use of evolutionary computation is significant for the development and optimisation of strategies for dynamic and uncertain situations. This chapter introduces three cases in which evolutionary computation has already been used successfully for strategy generation in the form of work on the Iterated Prisoner's Dilemma, Rubinstein's alternating offers bargaining model, and the simple supply chain model. The first two of these show how evolutionary computation has been applied to extensively studied, well-known problems. The last of these demonstrates how recent statistical approaches to evolutionary computation have been applied to more complex supply chain situations that traditional game-theoretical analysis has been unable to tackle. The authors hope that the chapter will promote this approach, motivate further work in this area, and provide a guide to some of the subtleties involved in applying evolutionary computation to different problems.

INTRODUCTION

The use of evolutionary computation is important in the development of strategies for dynamic, uncertain situations or for any situation where a simple strategy has many parameters to tune. While game theory and theories of equilibrium are highly effective tools for the

analysis of various problems, they suffer from being unable to deal with the increased complexity and uncertainty inherent in many real-life situations. Strategies requiring a large number of parameters to be tuned cannot effectively be optimised by hand both because those numbers may be so large, but primarily because interactions between the parameters are often difficult to understand.

One such problem is that of supply chains and what strategies should be used by participants to operate effectively within them. Tackling this problem is important because trading electronically will become increasingly important in the future, and a need will exist, if it does not already, for many of the transactions to be handled fully automatically (He, Jennings, & Leung, 2003; Sandholm, 1999; Walsh, 2001). Even relatively simple supply chain scenarios prove difficult to analyse, and it is usually necessary to resort to domain knowledge in order to develop strategies. While this approach to strategy creation is capable of producing good solutions, it is difficult to foresee how they will respond in unexpected situations, guarantee robustness, and ensure maximum effectiveness in the face of change. Furthermore even an effective hand-crafted solution is likely to require a large number of parameters to be tuned, and doing this manually could well prove impossible either because the number of parameters is so large or because they interact in a way that is difficult to understand.

Evolutionary computation (EC) gives us the potential to address these issues. By defining the supply chain environment, or indeed any other environment, in terms of a reasonable strategy representation scheme and practical strategy evaluation mechanism, EC is able to evolve strategies and/or good parameter sets to tackle the problem.

In this chapter we will be looking at three different strategy generation problems and how

EC can be used to tackle them. The first of these, Iterated Prisoner's Dilemma (IPD), introduces strategy generation using EC and shows how different algorithms have been used to tackle the same problem. The second problem, Rubinstein's alternating offers bargaining model (RAOBM), is used to demonstrate that EC can find a known optimal strategy. The final problem is defined by the simple supply chain model (SSCM). For the SSCM we show how EC can be used to tackle a far more complex strategy evolution problem by using a supporting strategy framework. In each case we examine why a particular EC algorithm is most appropriate, while discussing past efforts and presenting recent work.

GAME THEORY

Game theory has been highly successful in its application to situations such as the Prisoner's Dilemma (PD) and Rubinstein's bargaining game, along with many others. By starting from a notion of rationality and often complete information, it has proven invaluable and provided a good indication of how to behave in different situations. Since its initial formulation various theories of equilibrium have been posited to help explain how and why certain outcomes do (or should) occur within a game. Some of these, along with other terms, will be referred to during the course of this chapter; we briefly recap these now.

- **Dominant Strategy:** A strategy that yields superior results regardless of the opponent's move.
- **Dominant Strategy Equilibrium:** The outcome of a game reached when all players have a dominant strategy and play it.

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