Chapter IV
Higher Order Neural Network Architectures for Agent-Based Computational Economics and Finance

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ABSTRACT

As the study of agent-based computational economics and finance grows, so does the need for appropriate techniques for the modeling of complex dynamic systems and the intelligence of the constructive agent. These methods are important where the classic equilibrium analytics fail to provide sufficiently satisfactory understanding. In particular, one area of computational intelligence, Approximate Dynamic Programming, holds much promise for applications in this field and demonstrate the capacity for artificial Higher Order Neural Networks to add value in the social sciences and business. This chapter provides an overview of this area, introduces the relevant agent-based computational modeling systems, and suggests practical methods for their incorporation into the current research. A novel application of HONN to ADP specifically for the purpose of studying agent-based financial systems is presented.

INTRODUCTION

Economists have long recognized their inability to run controlled experiments a la their physicist and biologist peers. As a result, while much real science can be done using natural experiments, analytic mathematical modeling, and statistical analysis, a certain class of discoveries regarding the governing dynamics of economic and financial systems has remained beyond the grasp of such research. However, recent advances in computing show promise to change all that by gifting economists with the power to model large scale agent-based environments in such a way that interesting insight into the underlying properties of such systems can be obtained. It is becoming increasingly evident that engineering tools from the area of computational intelligence can be used in this effort.

Agent-based methods are enjoying increased attention from researchers working in economics as well as in pure and applied computation. The central focus of this still nascent field involves the generation of populations of interacting agents and the observation of the resulting dynamics as compared to some optimality criterion, analytically or otherwise obtained. Typically, some sort of learning algorithm, such as a simple feed forward multi-layer perceptron neural network, will be implemented in the model. Often other techniques of computational intelligence, such as genetic algorithms, will be used to evolve the population, showing the promise that gains in this area of computation have for social science investigation.

This chapter proposes taking a step forward in terms of the efficacy of algorithms applied to this agent-based computational study. We discuss the framework of Approximate Dynamic Programming (ADP), an approach to computational learning used successfully in applications ranging from aircraft control to power plant control. In particular, we investigate the artificial Higher Order Neural Network Adaptive Critic Design approach to solving ADP problems and how the use of these techniques can allow economics researchers to use more robust formulations of their problems that may admit richer results.

Typically, a multi-layered perceptron neural network architecture is utilized when implementing ADP techniques. We propose and discuss using HONNs instead. A HONN is a multi-layer neural network which acts on higher orders of the input variables (see Zhang 2002 for details) Many chapters in this volume present tutorials as to the use of these HONNs. This chapter is devoted to discussing ADP and proposing our novel approach of using a HONN engine to power ADP techniques specifically for applications in the study of agent-based financial systems.

The objective of this chapter is to introduce these frameworks, to discuss the computational economics problem types which can enjoy their benefits, and to discuss opportunities for novel applications.

BACKGROUND

The fundamental Agent-Based Computational Economics framework structure is overviewed in Testafasion (2006) and will be reviewed here. The particular formulation of the agent problem proposed in this chapter is based on the presentation in Chiarella (2003) and will be discussed following the general overview. Finally, other supporting literature will be surveyed to help solidify the main ideas of this section and to guide the reader in other directions of possible research interest.

Agent-Based Computational Economics

A standard course of study in economics grounds the reader in a host of equilibrium models: the consumer preference theory of microeconomics (Binger 1998), the wage determination cycle of labor economics (Ehrenberg 2003), the concept of purchasing power parity in international finance (Melvin 2000), and the Walrasian Auctioneer (Leijonhufud 1967) of macroeconomics. In all of these approaches to describing economic phenomena, the student is presented with top-down analytic treatments of the dynamics of an entire economy's worth of individual interacting agents. While the local scale behavior informs the higher level dynamics, it is only the global portion that enjoys

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