Chapter XII
Nature-Inspired Knowledge Mining Algorithms for Emergent Behaviour Discovery in Economic Models

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ABSTRACT

Economic models exhibit a multiplicity of behaviour characteristics that are nonlinear and time-varying. Emergent behaviour appears when reduced order models of differing characteristics are combined to give rise to new behaviour dynamics. In this chapter we apply the algorithms and methodologies developed for nature-inspired intelligent systems to develop models for economic systems. Hybrid recurrent nets are proposed to deal with knowledge discovery from given trajectories of behaviour patterns. Each trajectory is subjected to a knowledge mining process to determine its behaviour parameters. The knowledge mining architecture consists of an extensible recurrent hybrid net hierarchy of multi-agents where the composite behaviour of agents at any one level is determined by those of the level immediately below. Results are obtained using simulation to demonstrate the quality of the algorithms in dealing with the range of difficulties inherent in the problem.

INTRODUCTION

Recurrent inference networks are introduced to represent knowledge bases that model dynamic intelligent systems. Through a differential abduction process, the causal parameters of the system behaviour are determined from measurements of its output to represent the knowledge embedded within (Al-Dabass, Zreiba, Evans, & Sivayoganathan, 2001). The

use of dynamical knowledge mining processes ensures that knowledge evolution is tracked continuously (Al-Dabass et al., 2002a). Meta-knowledge, defined in terms of the causal parameters of the evolution pattern of this first-level knowledge, is further determined by the deployment of second-level dynamical processes (Bailey, Grossman, Gu, & Hanley, 1996). In data mining applications, for example, there is a need to determine the causes of particular behaviour patterns. Other applications include cyclic tendencies in stock values and sales figures in business and commerce, changes in patient recovery characteristics, and predicting motion instabilities in complex engineering structures (Al-Dabass et al., 2002c). Full mathematical derivation is given together with simulations and examples to illustrate the techniques involved.

- **Knowledge Models:** To understand and control the behaviour of economic systems, models that represent the knowledge embedded within these systems are formulated and used to acquire this knowledge from measurements. In data mining applications, for example, there is a need to determine the causes of particular behaviour patterns. Applications include cyclic tendencies in stock sales figures in business and commerce, sudden movements in share indices changes, and in no economic areas, patient recovery characteristics and predicting motion instabilities in complex engineering structures.
- **Hybrid Inference Networks:** To represent the knowledge embedded within intelligent systems, a multilevel structure is put forward. By its very nature this knowledge is continually changing and needs dynamic paradigms to represent and acquire its parameters from observed data. In a normal inference network, the cause-and-effect relationship is static, and the effect can be easily worked out through a deduction process by considering all the causes through a step-by-step procedure which works through all the levels of the network to arrive at the final effect. However, reasoning in the reverse direction, such as that used in diagnosis, starts with observing the effect and working back through the nodes of the network to determine the causes.
- **Knowledge Mining for Stock Market Models:** Work in this chapter extends these ideas of recurrent or dynamical systems networks to economic models where some or all the data within the knowledge base is time varying. The effect is now a time-dependent behaviour pattern, which is used as an input to a differential process to determine knowledge about the system in terms of time-varying causal parameters. These causal parameters will themselves embody knowledge (meta knowledge) which is obtained through a second-level process to yield second-level causal parameters. These processes consist of a differential part to estimate the higher time derivative knowledge, followed by a non-linear algebraic part to compute the causal parameters.

ECONOMIC SYSTEM MODELLING AND SIMULATION USING HYBRID RECURRENT NETWORKS

Numerous economic systems in practice exhibit complex behaviour that cannot be easily modelled using simple nets (Berndt & Clifford, 1996). In this part we re-cast this problem in terms of hybrid recurrent nets, which consist of combinations of static nodes, either logical or arithmetic, and recurrent nodes. The behaviour of a typical recurrent node is modelled as a