Chapter V
Evolutionary Auction Design for Agent-Based Marketplaces

Zengchang Qin
University of California, USA

ABSTRACT

Market mechanism or auction design research is playing an important role in computational economics for resolving multi-agent allocation problems. In this chapter, we review relevant background of trading agents, and market designs by evolutionary computing methods. In particular, a genetic algorithm (GA) can be used to design auction mechanisms in order to automatically generate a desired market mechanism for electronic markets populated with trading agents. In previous research, an auction space model was studied, in which the probability that buyers and sellers are able to quote on a given time step is optimized by a simple GA in order to maximize the market efficiency in terms of Smith's coefficient of convergence. In this chapter, we also show some new results based on experiments with homogeneous and heterogeneous agents in a more realistic auction space model. This research provides a way of designing efficient auctions by evolutionary computing approaches.

INTRODUCTION

In the first generation of e-commerce, bidders are generally humans who typically browse through well-defined commodities with fixed prices via the Internet (e.g., Amazon.com). Just like the traditional marketplace, purchases are done with the prices made by sellers; buyers and sellers still have little freedom in transactions. For customer-to-customer (C2C) e-commerce (e.g., eBay.com), sellers and buyers actually do the traditional trades, but through a new and more efficient medium—the Internet. Their freedom is also limited because both sellers and buyers still use the traditional methods of browsing to look for the goods they want. With the advent of agent technology, software agents can act as real-world traders. In comparison to human traders, software

agents have the advantages of being very fast, cheap, and offer a tightly controlled environment in which a diverse range of experiments can be performed. A **trading agent** may represent a company or a customer hunting for maximized utility which means profit for the sellers or savings for the buyers. In this scenario, freedom can be greatly increased by allowing negotiation between opposite traders (i.e., sellers vs. buyers) in a large predefined cyberspace for transactions. This space can either be embedded in or independent of the current Internet. As a result, commerce may become much more dynamic and the market less frictional. This kind of commerce is referred to as agent-mediated e-commerce or the second generation of e-commerce (He, Jennings, & Leung, 2003a). Since the traders search in a very large space of commodities for matching their preferences, how to efficiently search this space and what protocols the traders have to follow in order to have a trustworthy and efficient market are all key problems for this new research area. In this chapter, a method of using **genetic algorithms** (GAs) for trading protocol designs, or market mechanism designs, is discussed.

Trading agent design is an important research branch in both multi-agent systems and computational economics. Many different types of **trading agents** have been proposed. There is even a trading agent competition (TAC) held annually since 2000.[1] In this chapter, we explore the possibility of using evolutionary computing for auction designs but not the **trading agents** themselves, so that only two simple types of agents are used: **zero intelligence** (ZI) and **zero intelligence plus** (ZIP) agents. ZI agent was proposed by Gode and Sunder (1993) who presented results that appear to indicate that a random guessing strategy can exhibit human-like behavior in **continuous double auction** (CDA) markets. However, Cliff (1997) indicated that the price convergence of ZI traders is predictable from *a priori* analysis of the statistics of the system, so that a more complex bargaining mechanism or some "intelligence" may be necessary. Consequently, a type of agent with simple machine learning techniques was developed and referred to as **zero intelligence plus** (ZIP) agents. Further experiments by Das, Hanson, Kephart, and Tesauro (2001) showed that ZIP agents outperform their human counterparts.

Market mechanism design is an important topic in classical economics, computational economics, and finance (LeBaron, 2000; Wurman, 2001). Using **genetic algorithms** for market mechanism designs was first proposed by Cliff (2001). A continuous **auction space** model was proposed and explored by a GA to maximize the market efficiency. Some hybrid auctions with more desirable market dynamics, which had never been found in the real world, were discovered (Cliff, 2003). However, the **auction space** model proposed by Cliff is not an exact analogue to single-sided real world auctions such as the **English auction** (EA) and **Dutch flower auction** (DFA). Qin and Kovacs (2004) proposed a new **auction space** model which is an exact analogue to real world auctions. In this chapter, we give a review of the research of using GAs for automatic auction designs and present some new results by using heterogeneous **trading agents** (i.e., a mixture of ZI and ZIP agents), which shows that the optimal auction for heterogeneous agents could be a human-designed one while the optimal auction for homogeneous agents is a hybrid one, given the same **supply-demand** schedule.

In the second section, a brief introduction on experimental economics, auctions, and the measure for evaluating the market performances are given. In the third section, we give a detailed description of the **trading agents** used in this chapter. The fourth section gives the idea of using GAs for auction designs, and the fifth section gives the results based on the experiments with homogeneous and heterogeneous trading agents.