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Intelligent Agents in An Electronic Financial Market

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Abstract

With the recent advances in emerging technology, the study of intelligent agents has become one of the most important fields in understanding today's world. The voluminous information available in the financial market has given rise to the exploration of agent technology for analyzing data and making critical business decisions. This project investigates an intelligent multi-agent architecture in an electronic financial market. In contrast to most current research that has focused on the single-agent approaches, we investigate the potential of developing a collection of multiple intelligent agents and examine the learning and ecologically evolution behaviors. By creating an electronic financial market through the development and the analysis of coordination and interactions among multiple intelligent agents, we shall be able to better understand the process of knowledge discovery and data mining. In addition, the study of such virtual organization will bring up plenty of challenging research issues in electronic commerce.

1. Introduction

Predictive modeling techniques have played important roles in financial investment applications. Over the past few decades, many approaches have been proposed in the literature to forecast future prices. A variety of tools can be used to create trading models and handle portfolio management. Artificial Neural Network, for example, is one of the tools that has demonstrated success in pattern recognition, prediction and classification. It provides new modeling opportunities for difficult problems that have been traditionally modeled by statistical procedures and other methods. It has also found applications in many business settings such as stock selection, bankruptcy prediction, fraud detection, etc. Recently, there has been numerous proposals on employing hybrid models such as expert systems, neural networks and genetic algorithms to manage portfolios (Lo 1994).

The objective of this research is to construct an intelligent multi-agent architecture for a financial market. In contrast to most current research that has been focusing on the single-agent approaches, we investigate the potential of developing a collection of multiple intelligent agents and examine the learning and ecologically evolution behaviors. We choose foreign currency exchange market as our initial study domain. The reason is simply that the currency exchange information indicates an important economic index in both domestic and the international monetary market. Accurate forecasting of exchange rates are particularly useful to governments and companies in making decisions on investment and trading. In addition, the availability of data made the study possible.

2. Financial Market and Trading Rules

Essentially, all the places where one can conduct purchases or sales of currencies can be viewed as a currency exchange market. For example, when you travel overseas, oftentimes you will need to buy certain amount of traveler's checks to carry with you. That is considered as a trade in the foreign exchange market. Broadly speaking, the foreign exchange market is a financial market where financial services buy or sell currencies between banks. In general, the center of the currency is the dollar. The currency trader is a banker who provides the fundamental financial service of converting one currency into another. While the price change of certain currencies in certain European exchange market is relatively stable, the volatility of some markets in some other parts of world such as the Latin America or Asia can get real high. Although dramatic change in foreign exchange market may not be frequent, there does exist times when such a
change can occur within a real short periods of time. This requires that traders constantly monitor his/her bank's assets to manage the risk by providing the service of exchanging currencies. The risk of an individual trader could be exposed to may be unnoticeable small. However, when an agent as a banker represents an organization such as a bank involved, the degree of the risk can get much higher. Most of the time, the traders communicate via world wide communication networks or telephone to complete trading.

Forecasting of prices and the study of trading behaviors and rules in such financial market have aroused tremendous interests. Historically, simple filter rules (e.g. go long when the exchange rate rises by x% above its previous local low; sell when it falls y% below its previous local high) have been used in this market. Another commonly used trading rule is moving average. Technical trading has also been studied and has shown to be profitable in the foreign exchange market (Chinn et al. 1995). Recently, research has been conducted on searching for an "optimal" trading rule by Genetic Programming approach (Neely et al. 1996). While these studies provide important information and can be used in guiding the trading, little research has been conducted on exploring the joint effects of multiple agents in such financial market. In the next section, we briefly describe a market model and its corresponding multi-agent architecture for an electronic financial market.

3. Agent Architecture for an Electronic Market

In this project, we propose to simulate an electronic financial market and study coordination and interaction behaviors among multiple intelligent agents. The specific financial market we choose to model is the foreign exchange market. The trading model aims to capture agents' decision making process. We assume that the major goal of each agent is to attempt to gain profit by increasing its holdings while minimizing the potential risks. Agents make such decisions on how much of a currency to buy or sell. The factors that may influence an agent to make such decision may include trading history such as the previous price and current holding of assets. In addition, other information such as some critical events that appear in the headline news, the trading behavior of other agents could also be factors that affect an agent's trading decisions. Agents may suffer from a loss through a negative change in his or her holdings.

A multi-agent architecture is designed to support agent's decision making process in the foreign exchange market. The proposed architecture provides a testbed that a variety of experiments can be carried out. The market model is initially populated with a number of different types of agents. At each iteration, each agent forecasts next period's price and makes a trade by contacting another agent and offering a bid. They then proceed to negotiate on the price and the quantity of currency to be exchanged. Within this architecture, each agent can be either a human trader or a machine which can respond based on certain predictive modeling methods. Agents make judgments based on each individual's predictions of market price directions. The behavior of each agent depends on the cues each agent recognizes and the actions each agent takes. Although the central goal of each agent is similar, each individual agent is characterized with different internal representation which may lead to the different problem solving behavior. Once the trade is complete and the market clears, the accuracy of each agent can be calculated and the price of the next period will be revealed.

Amongst the numerous learning algorithms that have been proposed for predicting futures, we have identified the following ones as our intelligent agents.

NNAgent:

The first agent we developed is based on the neural network (NN) model. The idea of development of neural networks is inspired by the computational aspects of a human brain. The reason we choose neural network models is that neural networks have found extensive applications in classification, pattern recognition, prediction, etc. Neural networks can be extremely useful in financial engineering and modeling due to the high non-linearity characteristics present in the financial data (Refenes et al. 93).
GP Agent:

The second agent is constructed based on the theory of Genetic Programming (GP). GP is an extension of the genetic algorithm, which applies the crossover mechanism to functions represented as tree structures. The concept of genetic programming is that a process akin to natural selection should, over time, evolve functions which are "fit" in their environment.

HMM Agent:

Another possible agent is constructed based on the Hidden Markov Model (HMM). A HMM is a collection of finite state connected by transitions. Each state is characterized by two sets of probabilities. It includes a transition probability, and either a discrete output probability distribution or a continuous output probability density function, which defines the conditional probability of emitting each output symbol from a finite alphabet or a continuous random vector, based on the given state.

The construction of the above agents has been completed and has demonstrated some interesting results. Presently, the predicting performance of NNagent is very impressive, although it requires tremendous amount of training time. The advantage of GPAgent is that it is able to generate some kind of rules. The performance of HMMagent depends largely on the representation of the model. In addition, we also plan to include the fundamental analysis agents and other agents that have shown success in the traditional financial market. The development of the architecture and the experiments are underway. The data we use here consists of over twenty-years of the average of daily US. Dollar bid and ask quotes for other five currencies including DM, yen, pound, sterling, and Swiss franc. The data is originally collected from the European Commission and all exchange rates over two decades. The proposed framework can be used to simulate the dynamics of the currency exchange markets. Within this framework, agents make decisions on buying and selling a particular currency based on their anticipation of the direction that market will drive prices to. They then respond to the market with a decision to buy or sell. Multiple agents participate in this electronic market that define the prices they sample. An important role that cannot be ignored in the foreign exchange market is the intervention of central bank. With current advance in information technology, trading can be made through internet. Network security can be an important issue to ensure the accuracy of such transactions. Several other interesting issues related to agent and market behaviors such as competition and co-evolution are being investigated.

4. Summary and Discussion

Research on intelligent agents and coordination of multi-agent has drawn tremendous interest from business communities (Lin et al. 1996). This research is intended to study agents' complex decision making process in a simulated electronic financial market. Each agent makes its own decision by adapting to different market conditions. In addition, more agents such as the inductive agents and other statistical agents, can be incrementally added to the market. Furthermore, unlike the most familiar futures markets for commodities where trading is conducted in a central market, there may not be a face-to-face action in the foreign exchange trading. All information arrives at the market through wireless networks or telephone lines. Thus, the next step can be carried out by creating an adaptive market in a distributed Java environment. The study of such virtual organization will bring up plenty of challenging research issues in electronic commerce.

References available upon request.

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