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Automated Trading Simulation

Feedback Response and Accomplishments since Deliverable 1

The feedback we received from the first deliverable was addressed. We are still having issues being able to use our Vanderbilt *people* websites and at this time neither of us have access. We will continue working on this and I will discuss this further with Dr. Adams this week. Tom Ho is a visiting research professor at Owen. He was in town a couple weeks ago and I had a chance to meet with him to discuss our project, his work, and available market data. His company, The Thomas Ho Company, does risk assessment and online trading, and he is interested in trading options using limit rather than market orders. While there is virtually no risk in using market orders for this purpose, there is a fee charged by the exchange for every transaction. For limit orders, however, the fee is refunded but more risk is taken on by the trader. This risk is because of the fact that the limit order may not ever be filled if the market price moves quickly past the limit price. In this case, if the limit order was placed to buy or sell shares of stock in order to hedge the options purchased, than the trader would be left un-hedged, taking on far more risk than planned [1]. Ho is interested in the development of an algorithm which would enable the agents, acting as traders, to determine the most profitable way of setting the bid/ask spreads according to the cheap/rich profile as determined by the Black-Scholes Model using limit orders instead of market orders while minimizing the risk of the trader. By giving the agents a set of rules, such as initial bid/ask spreads and ways to adjust the spreads, the agents could then learn how best to set the spreads based on their profitability. Ho offered to help us get stock market data feeds from either Owen or, if necessary, from his company. Conceptually

speaking, the private information for each agent would be its inventory position and cheap/rich model.

Algorithms Considered, Tradeoffs, and Decisions

We have considered a number of algorithms in regards to the agent decision making process and searches. One algorithm we plan to adapt to fit our project is minimax. We have both previously and successfully implemented minimax and we are comfortable with the predictability of the algorithm. We would use minimax to minimize the potential loss of the agents and to maximize the gain in profits.

Additionally, we have considered a number of search algorithms. Our states, which will be defined more specifically later in the semester, but will most likely consist of belief fields such as the inventory and portfolio and a demeanor or strategy, can be represented as nodes in a graph. At this point, we do not know exactly what the tree will look like, but depending on the shape and density, we will consider search algorithms such as A* and optimizations such as alpha-beta pruning. The complication with using A* is that we must define a heuristic. At this point, we think that an appropriate heuristic may be the value of the state such as the preference of the agent for cash versus other investments. If the tree is complex, we would like the implement alpha-beta pruning in order to reduce the number of nodes evaluated by the minimax algorithm. This would probably not be implemented initially, but could be introduced later in the project when the knowledge of agents increases and more potential states are possible.

Another algorithm we may use is presented by Kaihara [2] and relates the double auction model to a constraint satisfaction problem. The purpose of the algorithm derived is to find a solution using the different sets of equations provided, which deal with budget, supply and demand, production, and profit, to find a competitive equilibrium in the market. The research

done by Kaihara seems to be useful to our project and we will continue to analyze Kaihara's methods while relating them to our project this semester. The algorithm seems to be appropriate for our use, but a problem may be the complexity of the inputs and our unfamiliarity with it.

Contingency Plan

If we are unable to implement any of our more complex algorithms, we plan to fall back on focusing our work on the best simulation of the stock market possible. Our focus will be on the system itself. The actual stock market environment will be fine-tuned to be as easy to use as possible while still producing valuable results. We will also give up on the more complex algorithms and try and implement more of the simpler search algorithms and run simulations to see how the differences affect the trader's "intelligence" when playing the stock market. Since the work on the easier to implement algorithms is on the front end (figuring out how to adapt the "states" of each trader to be search). That will be mostly done since we plan on adding some search algorithms anyway. Therefor implementing more search algorithms will be easy and fruitful. We will have more time to devote to running and analyzing long term simulations to see which algorithms excel in the short term and which in the long.

Schedule Progress

We are just about on schedule. If you look at the schedule, we planned to meet with Tom Ho, which we did. That meeting helped us narrow our project. Since then, we have done more research and have worked out the details of what we plan to do. Clearly, we will have the more detailed design document done for this deliverable.

Project Changes since Deliverable 1

We have narrowed our topic considerably and have begun looking into existing research about automated trading systems. We are attempting to adapt the question posed to us by Tom Ho into a project that we, as non-experts in economics, can have working by April.

Additionally, we have discussed the differences in using game or auction theory. We have decided that different aspects of the project will be classified in different ways and we plan to use both theories. The stock market can be modeled as a two-sided or double auction. Depending on the complexity we decide on and the data available to us, we may use the single-dimensional double market, at least initially. In this model, there can be many potential buyers and sellers of a single item. Specifically, we will study continuous double auctions (CDA). In the CDA, agents bid for the amount desired when they want and an attempt is made when the order is received to match it with other orders in the central repository, known as the order book [3].

Multiagent Communication Discussion

Since KQML is used for communication between agents, we would use it for just that. Each of our agents is a trader in a virtual stock market. Therefore, we would use KQML to have the traders talk about the markets and share valuable information amongst each other. If we were to implement KQML, our simulation may be slightly more accurate since we are trying to simulate real people who obviously talk all the time. The only issue is that, that is a fine line to find. Too much communication and we will end up simulating illegal activities, thus making our results useless (since we assume most traders do not partake in such activities). This would be a disadvantage, a big one at that. In our simulation, the agents talk to one central controller who takes in and acts on each trader's order. Actually implementing KQML would be difficult in that we would have to decide what information a trader would want to give out about itself at each

point of contact. It would be another aspect of each of the trader's overall strategy since revealing too much information can give another trader an edge, but giving out just enough or even false information could help the trader giving the information.

Sources

[1] U.S. Securities and Exchange Commission. (2001, April 19). *Limit Orders* [Online]. Available: http://www.sec.gov/answers/limit.htm

[2] T. Kaihara. (2002, August 6). *Agent-Based Double Auction Algorithm for Global Supply Chain System* [Online]. Available: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=973230

[3] K. Leyton-Brown and Y. Shoham. (2010). *Multiagent Systems: Algorithmic, Game Theoretic and Logical Foundations* [Online]. Available: http://www.masfoundations.org/mas.pdf