1 Algorithmic Learning in Double Auctions

The double auction, where sellers place asks, and buyers place bids forms the bedrock of modern financial and economic markets. Recent developments in artificial intelligence suggest that it is possible for bots to learn to trade fairly successfully in double auctions. Much more ambitiously, it is suggested that AI can take the place of human participants in the marketplace. I propose to test the limits of this claim seriously.

First, I want to study how well self-learning algorithms can improve on simple trading rules in the double auction. The metric for success is the average return and volatility of return, across a fixed trading horizon, against a variety of opponents/algorithms. I propose to test Deep Q-Learning Networks (DQN) since they have demonstrated remarkable success on many games and controlled simulations of real-world problems. In 1993, Rust and his coauthors found that sophisticated algorithms cannot beat simple trading rules. In this research study, I propose to allow DQN agents to play millions of games against a variety of opponents to see if they are able to improve on simple trading rules. An important extension would be to extend the results to one with multiple tradable items in the portfolio.

Secondly, once I have established that DQN agents can learn to trade just as well as humans, I want to study how the learning of one DQN agent can interfere with that of other agents, i.e., in a situation of multi-agent learning. In this study, I will see what kinds of market design and information availability are critical to allow multi-agent learning to arrive at market efficiency. The outcomes can be compared against quantities and prices that would clear the market instantly. We can also test if prices become martingales i.e. random walks, assuring that historical data is no longer exploitable and all information is compounded into prices. The design rules would consist of rules regarding payment, fees, reserve prices, etc. I will also see the effect of different information (offers unaccepted and accepted, timing of the offers, etc.) on the market outcomes. I will use a fully randomized trial to obtain inference.

Thirdly, once I have demonstrated that DQN agents can learn to trade just as well as humans and found the right kind of market design for this, I want to test if market design can itself be delegated to AI. This would involve studying the ability of a regulator DQN agent which experiments with different market rules over time. The main question here is whether this agent can successfully improve on the market design found in phase two of this research program. The regulator DQN can be allowed to change payment rules, fees, reserve prices, volume limits, etc.

Lastly, to answer the above questions about multi-agent learning I need to train multiple DQN agents through a process of experimentation and exploitation. Initially the DQN agents would explore a lot and settle into their preffered strategies. But it is also an important question about what kind of strategies are evolutionarily stable. To do so, we need to observe DQN agents conducting limited exploration over a much longer time frame i.e. millions of repeated games. The key question is: do the agents converge on some strategies and never deviate? or do they cycle between sets of strategies (each mutually best)? Do agents take on the role of certain "types" of traders, commonly seen in financial markets i.e. chartists and fundamentalists?

The answers to these questions will determine whether AI is capable of replacing humans as traders and regulators in financial markets.