A Financial Services Gaming Simulation

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Abstract—The goal of this project was to design a card game simulation of financial trade markets. In a trading environment, a market maker quotes two prices for a specific type of financial instrument, such as a stock option. Traders then buy shares from or sell shares to the market maker. The decision of the market maker to quote prices at certain levels, and the traders’ decisions to buy or sell are based primarily on their independent estimation of the instrument’s fair market value, or the true price of the instrument, once all information has been accounted for. The goal of the market maker is to quote prices which best reflect the fair market value of the financial instrument. The simulation developed for this project was designed to accurately account for these behaviors.

This project sought to fulfill the need of the Susquehanna International Group of Companies (SIG) for a recruitment tool that can be distributed in large numbers at employment venues such as career fairs. The recruitment tool is essentially an informational CD-ROM that includes a home page, a game page with the simulation, and a quiz page with probability questions. This tool will help users assess their interest, and ability to perform in, a financial market making environment.

A University of Virginia (UVA) Systems and Information Engineering Capstone team worked with SIG to define a format and set of rules by which the simulation game would be played. A card game format was adopted in which cards from a standard fifty two card deck represent information that would bear impact on a financial instrument’s final price, such as earnings reports and news stories. The human player acts as the market maker and the computer players act as traders. Each player is dealt separate cards to simulate the diversity of information available in financial trade markets. There are three computer players and one human player. The capstone team developed the mathematical logic to be used by computer players in the game, and has created a working prototype of the game to test this logic. A graphical user interface (GUI) has also been developed to make the tool user friendly and aesthetically pleasing. This GUI was tested to validate its usability and aesthetics and was incorporated into the prototype simulation.

I. INTRODUCTION

The Susquehanna International Group of Companies (SIG) is a leading firm in institutional sales, research and market making. SIG is active in financial markets on five continents and has over 1400 employees with offices in the United States, Europe, and Asia. By acting as a market making firm in over 6000 NASDAQ and listed stocks, SIG is one of the largest U.S. option market makers [1].

Like all firms in the business world, SIG must maintain a strategic advantage over their competitors. There are several strategies which are common to almost all firms in any industry. One strategy is to attract better candidates for employment because high-quality personnel are essential for any business [2]. The motivation behind this project is that the implementation of its results will be an effective method of attracting better candidates for employment at SIG.

A. Problem Definition

This project sought to design a card game simulation of financial trade markets that will be included as part of a recruitment tool that SIG can distribute at career fairs and other employment venues. The simulation game had to accurately account for all of the major behaviors apparent in financial trade markets. The game also required an easy to use and aesthetically pleasing user interface to make it usable by the general public.

B. Background of Market Making and SIG

In order to fully understand the product of this project and the context in which it falls, a summary of financial market making is required. A financial market is made up by a collection of individuals and firms who own quantities of some kind of financial instrument, such as a stock option. Some individuals and/or firms assume the role of market makers, whose major function is to provide essential liquidity in financial instruments by allowing conversion of the instrument to cash and back [2]. This is an absolutely essential function in financial markets, as trading cannot occur unless financial instruments can be converted to and from cash. An individual or firm, like SIG, assumes the role of market maker by quoting two prices; one price at which the market maker is willing to buy a unit of the instrument from others, called the bid price, and one price at which the market maker is willing to sell a unit of the instrument to others, called the ask price. The ask price is always greater
then the bid price, and the difference between the two prices is called the spread. Once these market prices have been set, individuals interested in buying or selling units of the instrument conduct trades with the market maker. Effectively, the market maker acts as the middle man between someone who wishes to buy a unit of the asset and someone who wants to sell a unit of the asset. Because the ask price is always greater than the bid price, money is made for the market maker whenever a unit of the asset is purchased and then resold. In the game that the team has designed, the human player acts as the market maker in a fictional market of 3 computer players along with the human player. The human player’s goal is to make as much money as possible through setting market prices and engaging in trades with the computer players.

In both the real world and the game, the market maker sets market prices based on what they believe to be the fair market value of the instrument. The fair market value is the actual value of the financial instrument once all information has been taken into account. It is advantageous to guess around this value because if a firm sets their prices too high then participants of the market will only be interested in selling instruments to the firm. If a firm sets their prices too low then participants of the market will only be interested in buying from the firm. Making money on the spread necessitates both buying and selling behavior, and the best way to encourage this is to set the firms prices as close to the fair market value as possible, where in theory there should be an equal number of buyers and sellers.

The fair market value is assessed using information that the market maker has available to them. This information may encompass everything from a monthly stock report to a recent news report or the price history of the financial instrument. Some information will cause the price of the instrument to increase, such as favorable reviews from financial experts, and some information will cause the price of the instrument to decrease, such as a news report about a scandal. Past pricing information for the financial instrument is another particularly common source of information [2]. In the game that the team developed this information is simulated through the use of a standard fifty two card deck, where card values and suit determine the value of the instrument and whether it should be positively or negatively priced. In both the real world and the game environment, the market maker only has access to a limited amount of information, and as a result must make an educated guess of the fair market value. This is the true challenge of acting as a financial market maker.

II. METHODOLOGY

The Capstone team began this project by gathering requirements for the gaming simulation. The primary objective of this was to determine the rules by which the simulation game would be played and defining what information is exchanged during game play. From here the Capstone team was able to create a conceptual design for the behavioral models of computer players, and the GUI that would accompany the game. Once these designs were implemented in hard code they would then be tested and validated to ensure optimal performance.

A. Game Rules

All cards used for this game come from a standard fifty two card deck. Cards numbered two through ten are worth their face value. Face cards and aces are all worth ten, with red suited cards’ (hearts and diamonds) values being negative and black suited cards’ (spades and clubs) values being positive. The game begins when each player is dealt three cards face down. These cards are meant to symbolize information (such as a news article or stock report) that would be used to determine the price of a financial instrument, such as a stock option. Each player can see only their own cards, and there is no collaboration among the computer players.

The human player acts as the market maker, and must try to guess the fair market value and set a bid and ask price for the market based on that guess. In this game the spread must always be equal to four. Once a bid and ask prices have been set, trading ensues. Computer players may buy or sell to the human player. The first computer player to act gets the trade, at which point trading stops. Once trading has stopped, the market maker must adjust his guess of what the fair market value is based on the behavior of the computer player. The player then sets a new bid and ask price and begins a new round of trading. This process of price setting and trading continues until a price is set at which no computer players are willing to trade, at which point, the game ends. When this happens all of the players’ cards are revealed, and with them the true fair market value is revealed. If players hold any shares of the fictional instrument at this point, they are sold at the fair market value. Profits for each player are calculated and displayed according to the prices they bought and/or sold shares of the instrument at and the final fair market value at which it was sold. SIG envisioned a game in which there would be one human player and between two and six computer players. The team decided to use a game with three computer players.

B. Conceptual Formulation of Game Logic

The main challenge in developing the mathematical models for this gaming simulation was to quantify all of the information that is exchanged during the course of the game. At the very beginning of the game, the only information that any player has is the value of the cards in their hand. This gives each player an expected value for the remaining unseen cards. Players must use this information to make their initial estimate of the fair market value.

The next critical piece of information comes from the human player acting as the market maker. The human player sets a market by quoting bid and ask prices that are, in theory, based on what his/her estimate of the fair market value is. This provides the computer players with a rough estimate of the human player’s hand. The computer players then update their estimate of the fair market value based on this new information.
Additional information is exchanged when a computer player makes a trade after the human player has set a bid and ask price. By observing whether another trader wishes to buy or sell, all other players get a rough estimate of the trading computer player’s hand. If a computer player wishes to sell to the human player, it is an indication that they believe that the fair market value is below the price that the market maker has set, indicating that the value of this computer players hand is less than what the market prices imply. The opposite would be true if the computer player had indicated a desire to buy from the human player. Again, the computer players use this information to update their expectations of the fair market value.

Based on this new information, the human player then adjusts their estimate of the fair market value and sets new market prices, which inspires more trading. Each time the market maker sets a price and a computer player trades, additional information is exchanged. This information exchange continues until all players’ estimates of the fair market value converge to a roughly equal point, which in theory should be the final price that the human market maker sets.

C. Design of Graphical User Interface (GUI)

The goal of the user interface design was to create an interface that virtually anyone, regardless of experience with computers or trading, could use. As a result, the Capstone team focused on simplicity when designing the user interface. The user interface only provides the user with the ability to perform the essential functions of the game. Any information which would be either distracting or unnecessary was rejected during the design process.

The final design for the user interface is shown below in Figures 1 and 2. Figure 1 is an image of the interface for the game page before the game has started. This page displays a number of key functions can be identified easily. The Play button in the top left portion of the screen is what the user would press to start the game. The Help button to the left of the Play button is what the user would press if they had any questions regarding the rules of the game.

Figure 2 is the user interface of the game page after game play has started and the players have been dealt their hands. The human player’s cards can easily be viewed in the bottom left hand side of the screen. A player would change the bid and ask prices by using the scroll bar on the bottom right hand side of the screen. The selected price would then be submitted by hitting the Set Market button. The text box on the bottom left hand side of the screen conveys what is going on during the game to the player. Once a player submits a bid and ask price, this box will indicate which of the computer players would like to buy and sell the fictional instrument.

D. Validation and Usability Testing

As this Capstone project progressed deeper into the design and implementation phases, both the mathematical logic and user interface would need to be validated to ensure that the final product would be as effective as possible. A combination of professional assessment and usability testing of the product was used in this process.

1) Logic Testing Approach

To assess the accuracy of the simulation the team regularly sent the most up to date product to a pair of professional traders at SIG. Having professional experience in real trade markets put SIG traders in the position to gauge whether or not the game’s logic provided an accurate recreation of financial trading. These traders would then provide direct feedback to the team to point out errors and make recommendations for improvement.

2) GUI Testing Methods

Usability testing was conducted in order to assess the functionality of the product’s GUI. The test was comprised of a selection of specific screenshots of the product. Test takers were walked through each screen, asked to perform specific tasks, and constantly provided feedback about each task. Direct verbal feedback from the test takers and a written post test questionnaire were the primary criteria for measuring the effectiveness of the user interface design. The written questionnaire contained both open ended questions as well as Likert scale questions, in which test takers were
asked whether they strongly disagreed, disagreed, were neutral, agreed, or strongly agreed with certain statements. The Capstone team used a group of twenty two undergraduate students at the University of Virginia as test subjects. This group was comprised of students from a variety of majors and academic years in attempt to accurately reflect the diversity of the larger job seeking population.

III. RESULTS AND INTERPRETATION

Upon this project’s completion the Capstone team had successfully constructed a prototype version of the card game simulation. This prototype consisted of a working set of mathematical models and a fully functional GUI.

A. Game Logic Capabilities and Weaknesses

As the project progressed the team found that the simulation possessed a number of problems which could not be fully corrected by the time of the project’s completion. The general behavioral patterns of the computer players is correct, however each computer player’s estimate of the actual fair market value fails to converge close to the actual fair market value by the time the game is finished. This results in behaviors which one would not normally find in a real market making and trading environment, which compromises the overall accuracy of the simulation.

B. Usability Testing Results

The team found that the vast majority of the GUI was designed successfully. Virtually all of the test subjects found the majority of tasks and actions required during game play easy to complete. Furthermore, test subjects verified that the majority of information needed during game play was easy to complete. Furthermore, test subjects verified that the majority of information needed during game play was easy to see. However, the interface was not entirely free of problems. The most frequently cited problem was assessing whether or not a computer player wanted to trade after a market price was set. This was a problem for roughly 25% of our test subjects. This feature and any other which presented problems were modified upon the completion of usability testing.

IV. CONCLUSIONS

The goal of this project was to create a computer card game which simulates the behavior of financial trade markets. The Capstone team was required to develop mathematical models to quantify the behaviors observed in financial trade markets, design an easy to use and aesthetically pleasing user interface, and construct the prototype version of the simulation game. The Capstone team was successful in all of these endeavors, however the mathematical models used by the simulation must be refined before the product is ready for final implementation.

A. Summary of Core Tasks Completed

The first critical task that the capstone team completed was to define the rules for the card game simulation. Once this was done the conceptual design for the computer players’ behavior was developed and later implemented as mathematical models into the prototype simulation. With the definition the game rules, the team was also able to design and code the graphical user interface that player’s of the game would interact with. Usability testing was conducted on the graphical user interface, and the mathematical models were modified according to feedback received from professional traders who work for SIG.

B. Summary of Results

The capstone team was successful in developing a preliminary prototype for the simulation game. The general behavioral patterns of the computer players are correct, however the mathematical models that dictate computer player behaviors must be refined in order to provide a more accurate and realistic simulation. The graphical user interface component of the prototype was successfully designed, and usability testing confirmed that it is both aesthetically pleasing and easy to use.

C. Recommendations

The capstone team recommends that a follow up project be undertaken with the sole purpose of refining the mathematical models used to determine computer player behaviors. The product of this project is an excellent step towards a fully developed simulation game; however it is not ready for implementation. A second project which would focus on developing the mathematical models would be extremely beneficial in bringing the results of this project to an acceptable level of quality for full implementation.

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REFERENCES
