# The Unique-Bid Auction Research Paper Computer Systems Lab 2006-2007

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**Abstract**

The unique-bid auction is a developmental auction format that is rarely understood and more rarely used by auctioneers. Because there is no experimental data regarding this auction, they have no expectations of its performance. This project was designed not only to provide an opportunity for users to experience the auction, but also to shed some light on patterns in its behavior as the participants refine their bidding strategies.

# 1 Introduction

## 1.1 Purpose and Goal

The purpose of this project is to create an auction environment that allows human and robotic bidders to compete for a series of fictitious auction items. This project is an exercise in complex-systems modeling, artificial intelligence, and graphical interface and displays.

## 1.2 Auction Format

Before auction begins, the seller will set a range of acceptable bids for his or her item significantly below the market value of the item typically less than one percent. He or she will then decide the number of bidders that will be entered in the auction and the fee for participating such that the bidding fees alone equal the value of the item. Bidders then submit their bids and the item goes to the winning bidder for the value of his or her bid. The winning bidder is the one who submits the highest unique bid within the range. For example, if in a range from zero to 100 bidders submit bids of 100, 100, 100, 99, 99, 97, 96, 96, ... , the item will go to the participant who bid 97 because it is the highest bid that was not matched by another bidder.

# 2 Background

No academic work on the unique-bid auction has been published. The auction is rarely used by auctioneers because the significant profit goes to the winning bidder, with a slight profit for the seller. However, this type of economic research through computer simulation is similar to the research of experimental economics, a relatively new study in which economic theory is questioned and tested through the use of human simulations.

There is an online auction, UniqueAuction.com, that incorporates a variation on the unique-bid format. This website has experienced moderate success, which may be an indicator of the potential fiscal uses of the unique-bid auction.

# 3 Procedure and Methodology

## 3.1 Overview, Requirements, and Development Plan

The goal of this project is to create an auction environment that includes human and robotic bidders.

This project will be coded in Java because it is fast and contains the fundamental classes that will be necessary for the completion of this project.

The project is broken into several subsections, so that individual functions of the program can be written and developed without jeopardizing the underlying structure and success of earlier sections:

1. The fundamental structure of the auction, including the auction platform and appropriate means for bidders to submit their values.
2. The histogram that summarizes a round of data.
3. The graphical interfaces for the Auctioneer and the Bidders that will facilitate their operation of the simulation.
4. The function that saves the data of the experiment for future analysis.

## 3.2 Research Theory and Design Criteria

### 3.2.1 Iteration One

The first component of this iteration was to establish the basic framework of the auction, including the basic steps that would be necessary to conduct the experiment. In the first version of this iteration, random numbers are selected to represent the values of Bidder's bids. The program then selects the winning bid by first ordering the bids from largest to smallest and then determining the largest unique bid. The following is a sample output in this version:

```
 ----jGRASP exec: java Auction1

Max Unique: 28

1 29
2 29
```

```
3 28
4 26
5 24
6 23
7 23
8 23
9 22
10 22
11 22
12 21
13 20
14 17
15 17
16 16
17 16
18 16
19 14
20 13
21 12
22 12
23 10
24 10
25 7
26 6
27 6
28 4
29 3
30 2

 ----jGRASP: operation complete.
```

The second version of this iteration assigned basic strategies to the participants. Bidders were given a random quartile in which they would bid within that top percentage. In addition, the version introduced a human bidder into the auction. The output was also changed, displaying instead a frequency distribution of the data. The following is a sample output of this version:

```
 ----jGRASP exec: java Auction2
```

```
Max Unique: 22

30: 5
29: 5
28: 3
27: 3
26: 4
25: 3
24: 0
23: 0
22: 1
21: 1
20: 0
19: 0
18: 1
17: 1
16: 0
15: 0
14: 0
13: 0
12: 0
11: 0
10: 1
9: 1
8: 1

 ----jGRASP: operation complete.
```

The third version of this iteration converted every aspect of the previous versions into an object-oriented design: Auction to run the program and control the bidders, Player to hold the data for an individual bidder, and Strategy to decide which value to submit as a bid. In addition, the auction was repeated, representing the multiple rounds that would be present in future iterations of the project. Because every number was submitted by a unique Player, the program also submitted the characteristics of the winning bidder. The following is a sample output of the first round of this version:

```
 ----jGRASP exec: java Auction3
```

```
----------------------Round 1----------------------

30: 14
29: 10
28: 7
27: 9
26: 5
25: 3
24: 2
23: 0
22: 0
21: 2
20: 2
19: 0
18: 0
17: 1
16: 0
15: 2
14: 0
13: 0
12: 0
11: 1
10: 0
9: 0
8: 0
7: 0
6: 0
5: 0
4: 0
3: 1
2: 1
1: 0
0: 0

Winning bid is 17
There is 1 winner.
```

```
Winner: Player5
Stategy: Random: Top 50%
Wins: 1/1
```

#### 3.2.2 Iteration Two

The second iteration was devoted to creating the frequency histogram that displays the distribution of bids in the previous round. The first version of this iteration accepted an array of integers representing the frequency distribution created in the second version of the first iteration. The window that was produced contained a grid of JLabels, which were either colored black to represent part of the bar for that value, filled with text to label the graph, or left clear. The following is a sample output of this version:

#### 3.2.3 Iteration Three

The third iteration was devoted to creating the graphic user interfaces for the Auctioneer and the Bidders. The Auctioneer's interface contains:

1. A status bar at the top that guides the user through his required actions,
2. A display of the basic parameters of the experiment: round number, total number of rounds, number of participants, and bidding range,
3. A frequency histogram that displays the results from the previous round,
4. A button to progress the auction,
5. A summary of the auction results by bidder strategy, so that the Auctioneer can roughly access the behavior of the auction while it is running, and
6. A table of every participant in the auction, for which their basic performance is displayed, with an option to force any human player to continue the experiment or skip the round.

The following is the final version of the Auctioneer interface:
The Bidder's interface contains:

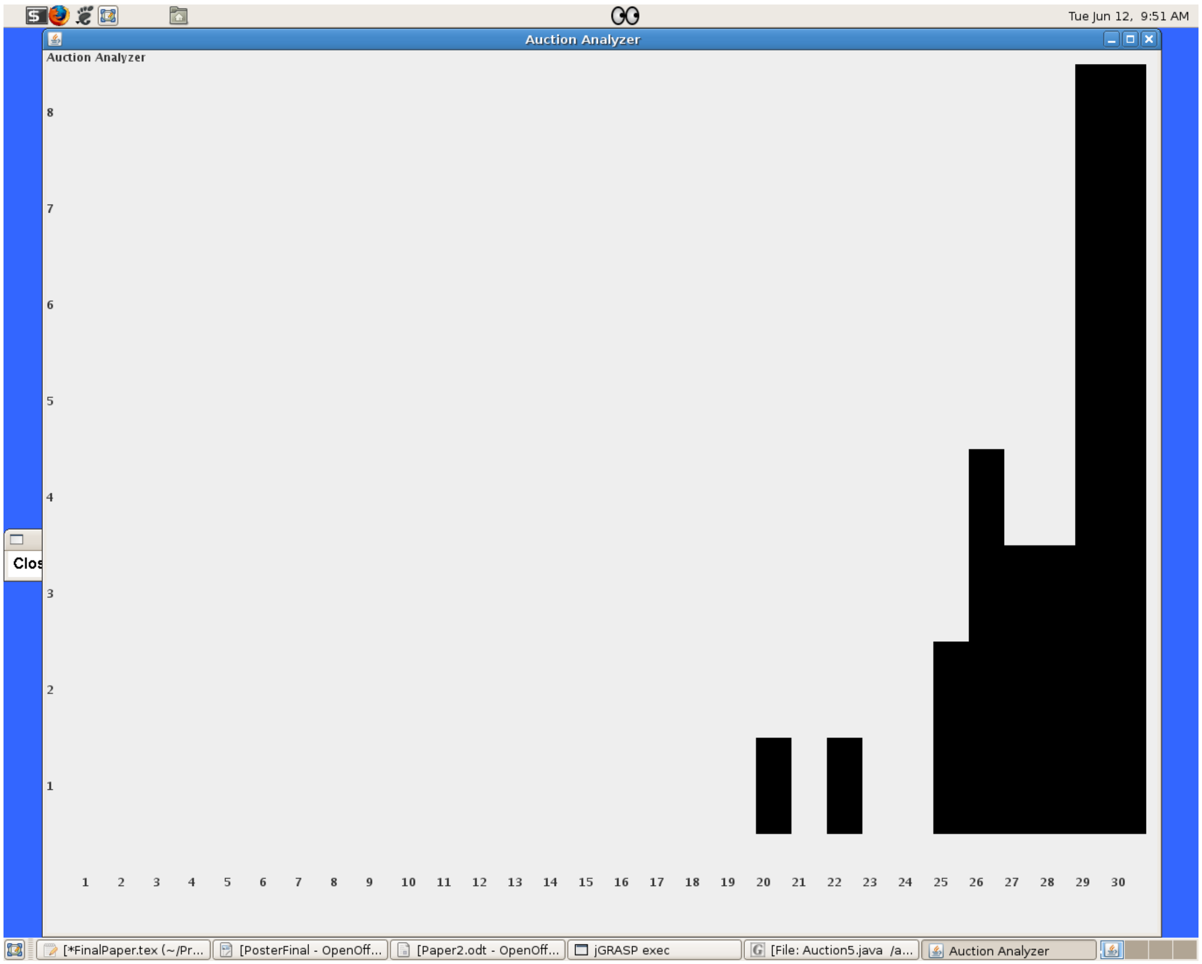


Figure 1: The first version of the bidding distribution display.

1. A similar status bar at the top that guides the user through his required actions,
2. A similar display of the basic parameters of the experiment: total number of rounds, number of participants, and bidding range,
3. A console for submitting a selected bid within the given bidding range,
4. Basic automatic bidding strategies including a random selection in a given percentile, a random selection of the top given number of possible

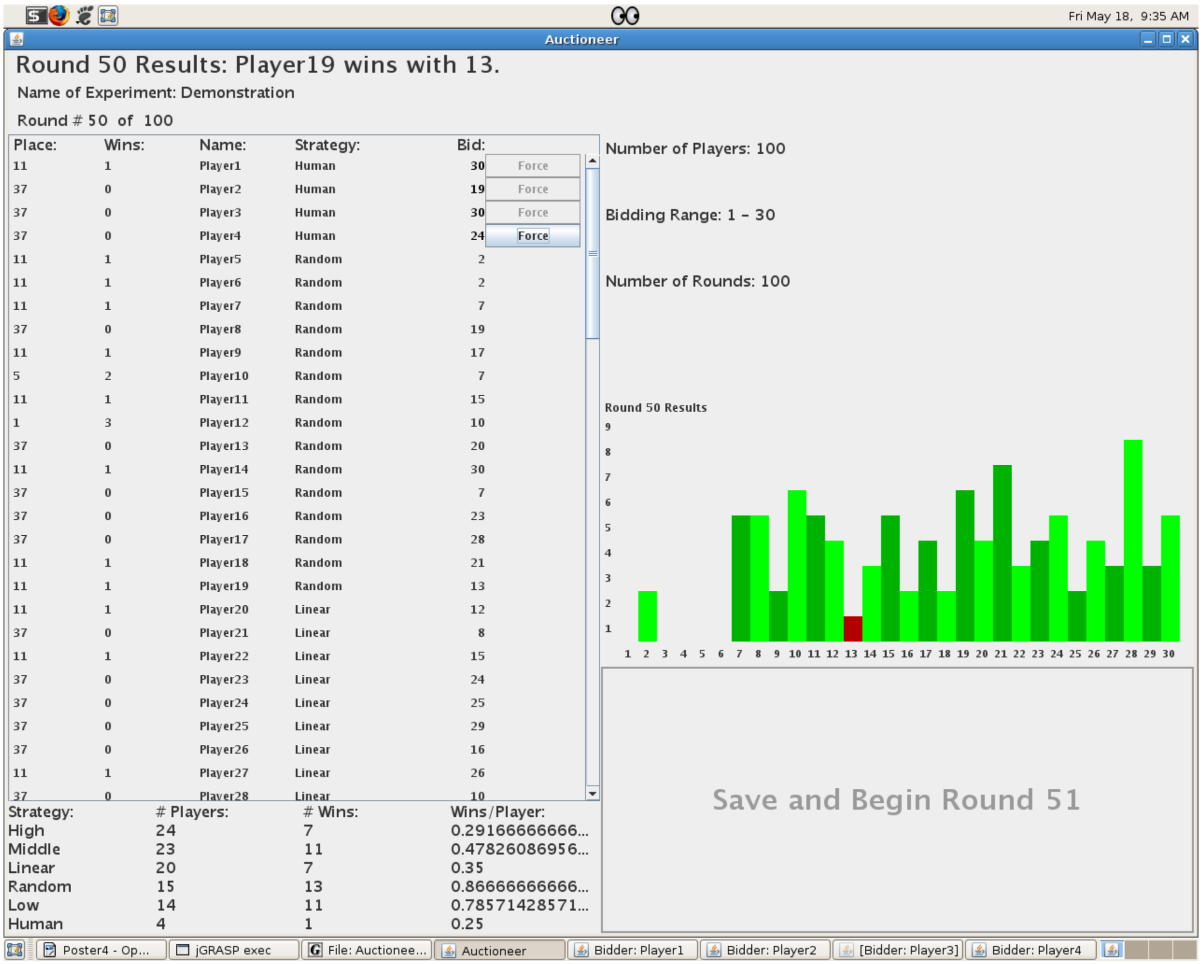


Figure 2: The final version of the Auctioneer interface.

bids, and a random selection of the previous given number of winning values,

5. A similar button to progress the auction,

6. A similar frequency histogram that displays the results from the previous round with the Bidder's bid and the winning bid distinguished, and

7. A ranking of every participant in the auction, with the bidder's position

in the table distinguished.

The following is the final version of the Bidder interface:

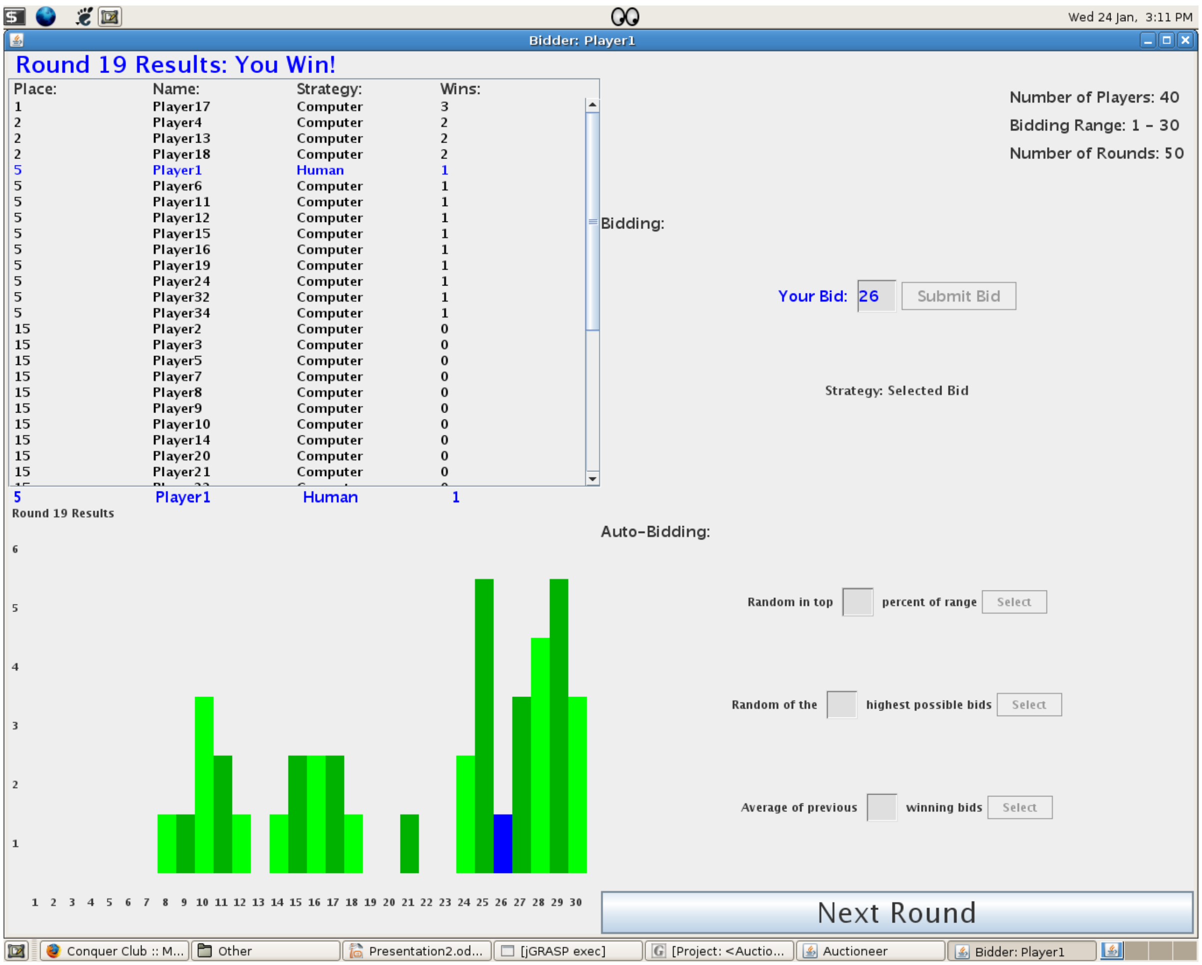


Figure 3: The final version of the Bidder interface.

### 3.2.4 Iteration Four

The fourth iteration was devoted to creating the function that saves the data of the round for future analysis. When the auction begins, the Auctioneer prompts the user to give a name to the experiment, for which the program creates a text file and writes to it after every round. The function writes to the text file:

1. The name, strategy, rank, and number of wins of each player,
2. The bid for each player and the winning bid for each round, and
3. The bidding distribution used by each robotic bidder in 5 evenly spread moments in the experiment (beginning, quarter of the way through, halfway through, and so on).

### 3.3 Testing and Analysis

The first iteration was difficult to test because it relies on the randomness and inclusiveness of the bidding functions (random bidding). However, the beginning code was simple enough to review very intensively to ensure that the entire range is covered. Once the bid-selection process was ensured to be correct, the remaining versions were easier to test because all of the data summaries were representative of a concrete, short data set.

The second iteration was very easy to test because it included only a display of a frequency distribution that was already correct. On nearly every occasion, the accuracy of the graph could quickly be determined by looking at that original distribution.

The third iteration was significantly harder to test because it included many organizational and inter-communicational changes from previous iterations. Many of the aspects of this iteration behaved similarly in all situations, so diverse testing was not required. Nevertheless, for the other, testable aspects of the iteration, careful review of the program code and examination of special situations were enough to guarantee its success.

The final iteration was also only partially testable. The saving of the bids and the winning bid, in addition to the characteristics of most of the players, was easy to confirm to be accurate. However, because the probability distribution that defined the robotic strategies was not as apparent, it was required to trust that the correct strategies were being recorded correctly.

## 4 Results and Conclusion

My purpose for this research project was to identify patterns in the behavior of the unique-bid auction. While I did not conduct an entirely humanoperated experiment, robotic bidders with realistic strategies revealed a great deal of insight into the auction.

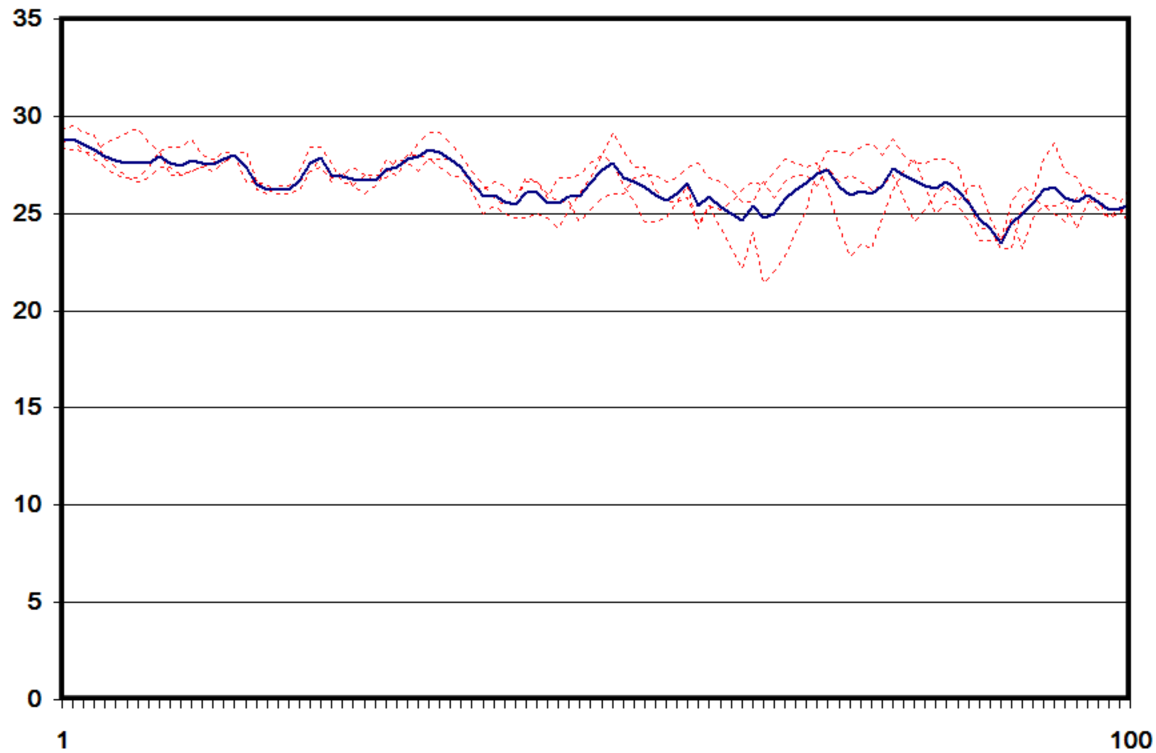


Figure 4: The average winning bid by round over many trials.

As can be seen in this graph of the average winning bid for each round in identical experiments, the winning bid begins near the highest value in the bidding range and then drops. This suggests that in the beginning, many of the participants bid too low, expecting the others to be bidding in the top many values. However, as the bidders refine their strategies (which represents the human players better understanding the foreign auction format), they come to better anticipate their opponents, causing the winning value to become lower.

The above graph represents the average first and third quartiles of all bids for each round in identical experiments. These figures mimic the behavior of

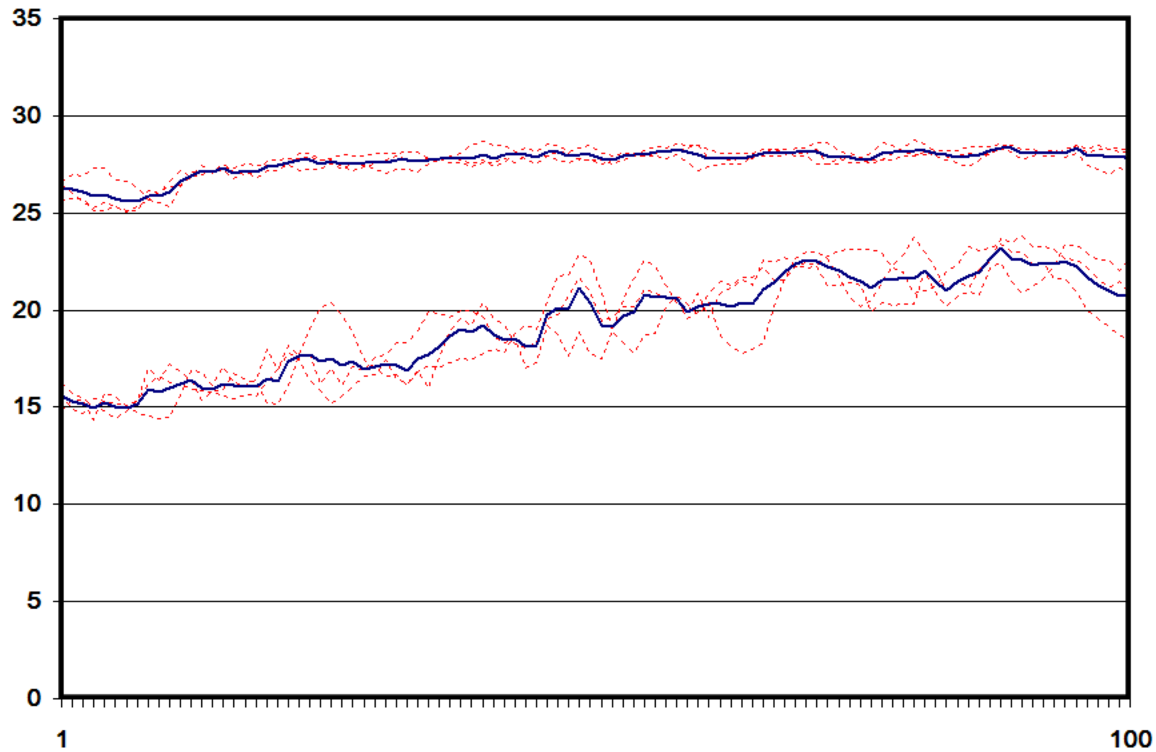


Figure 5: The average first quartile and third quartile of all bids by round over many trials.

the general spread of the bids. There are three patterns that seem to emerge in this data.

1. The spread of the bids submitted decreases vividly as the experiment progresses. When human players approach a new situation, they will have varied responses. However, as the bidders process the results of the early rounds, their diverse strategies converge on an equilibrium strategy.

2. The upper extremities of the spread increases slightly, representing the consistently high winning bids that occur throughout the experiment.

3. The lower extremities of the spread increase dramatically. The bid-

ders who select these low bids recognize very quickly that to succeed against these particular opponents, a strategy that selects a higher bid is required.

The purpose of this project was to determine the basic behavior of the unique-bid auction, an auction format that is rarely used partially because auctioneers do not have expectations of its performance. Based on strong patterns in robotic bidding, this auction shows patterns that resemble not only auction and market theory, but also that of fundamental strategic games. With more research like this, likely based on human participation, auctioneers might build the confidence in and understanding of this auction to use it in their transactions.

# 5 Acknowledgments

I would like to thank Bart Wilson and the professors of the Interdisciplinary Center for Economic Science for inspiring me to follow the path of economic simulation. Also, I would like to thank my past Computer Science teachers: Mr. Berry, Ms. Lynn, and Mr. Torbert, without whose instruction my project would not be possible.

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