Abstract

This dissertation investigates the interdisciplinary application of auction theory, game theory, and behavioral economics through AI-driven modeling and simulation, leveraging advances in artificial intelligence (AI) and data science. Using Game Refinement Theory and the Motion in Mind framework, combined with extensive auction data, a dual-perspective model (internal and external perspectives) has been developed to analyze complex participant behaviors in auction environments. This model captures not only the economic utility of participants under rule-based constraints but also the game utility driven by non-economic motivations, positioning auctions as a unique type of economic game.

Over 10,000 auction items from major auction houses Christie's and Sotheby's (2020–2023) were collected and analyzed, with simulation techniques applied to model and optimize key auction dynamics. Findings reveal a strong negative correlation between auction velocity and price deviation across various price segments, highlighting the crucial impact of non-economic motivations (e.g., status signaling, social recognition, emotional investment) on participant decision-making. Furthermore, an AI-based simulation system was designed to optimize auction participant experience and market performance, using auction simulation algorithms and feedback loops to dynamically analyze participant behavior patterns. This system enables real-time simulation of bidding decision processes, improving the predictive accuracy for complex decision-

making.

Technically, this research: (1) introduces a model of non-economic game utility to quantitatively analyze psychological and social motivations beyond economic utility, (2) develops an AI-driven dual-perspective simulation model linking ``irrational behavior'' of participants with overall auction dynamics, and (3) constructs an efficient data processing and simulation framework, combining game theory with AI to optimize auction systems. The results confirm the effectiveness of AI algorithms in modeling complex economic decisions and provide theoretical and empirical support for application to other interactive economic transaction systems.

This study contributes to the intersection of computer science, behavioral economics, and game theory, demonstrating the potential of AI and data-driven methods for simulating complex market dynamics and optimizing decision-making. Future applications of this model could extend to other economic game scenarios, providing deeper tools for modeling irrational behaviors in digital economic activities, supporting algorithm optimization, and guiding decision-making in real market contexts.

Keywords: Motion in mind, Game refinement theory, Non-Economic Utilities, Auction design, Auction Simulation, Gameplay incentives