Thesis Project Portfolio

Embodied AI for Financial Literacy Social Robots

(Technical Report)

High-Frequency Trading and its Impact on Retail Investors

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Pulkit Rampa

Spring, 2023

Department of Systems Engineering

Table of Contents

Sociotechnical Synthesis

This document introduces a technical report focusing on financial literacy education in K-12 schools using artificial intelligence (AI) and a research paper on the impact of high-frequency trading (HFT) on retail investors. While both papers are not directly related, they both address critical aspects of finance and its intersection with technology. Through this research, I aim to inform readers about the history and modern-day state of finance and education, exploring the evolution of technology in these domains, and providing insights into potential future developments and trends to watch out for.

The technical report discusses the development and evaluation of an AI system designed to teach financial literacy to fourth-grade students using NAO humanoid robots. Financial literacy is a critical skill that empowers individuals to manage their finances effectively and make informed decisions, ultimately leading to economic self-sufficiency. With the growing integration of AI in various disciplines, including K-12 education, there is a rising demand for AI systems that support financial literacy education for younger students. Not all students learn at the same pace, and many view the personalized learning experience enabled by AI as the future of education.

The NAO robot system aims to provide an engaging and interactive learning experience. The paper evaluates the system's performance in a real fourth-grade classroom using multiple metrics, such as efficacy, robustness, feasibility, and student enjoyment. While the results show that the AI-driven NAO robot facilitated retention of the material, it did not significantly outperform traditional guided worksheets. However, students reported higher levels of enjoyment when using the robot compared to worksheets.

These findings demonstrate the potential of the NAO robot system for future use and highlight areas for improvement in future work. By incorporating AI in financial literacy education, the study provides a foundation for developing more effective and engaging tools for teaching young students critical financial skills going forward. As technology becomes cheaper and lesson plans are developed for a wider degree of subjects, the opportunity for large-scale personalized learning becomes more of a reality. This will help bridge the gap in education opportunities regardless of socioeconomic background.

The research paper offers a comprehensive analysis of the high-frequency trading (HFT) industry, focusing on its impact on retail investors and other stakeholders. HFT involves the use of sophisticated technology and algorithms to trade stocks and securities on the scale of nanoseconds. Retail investors, on the other hand, are individuals who trade stocks and securities in personal accounts, typically for long-term savings and retirement planning.

The paper traces the evolution of HFT from the late 1990s and early 2000s, driven by the emergence of electronic trading platforms and increased access to real-time market data. HFT has revolutionized financial markets, and today it constitutes a significant share of total trading volume across major exchanges, with proprietary trading firms, hedge funds, and investment banks as the primary players. Understanding the implications of HFT on retail investors is essential since they represent everyday people that are not large financial institutions. The paper investigates the positive and negative effects of HFT on retail investors by examining two case studies: the 2010 Flash Crash and the more recent GameStop Short Squeeze. These events underscore the potential ramifications of HFT on market stability and investor confidence.

Additionally, the paper discusses the current policy and regulatory landscape, exploring potential reforms and legal efforts to address HFT-related challenges. In my research, I also examined the regulatory policies of countries such as Spain, Italy, and France which have a much smaller HFT presence in their financial markets. I evaluated the effects of such policies on market dynamics, liquidity, and investor protection, and offered potential solutions specific to the U.S. regulatory landscape. This comprehensive analysis sheds light on the complex relationship between HFT and retail investors, providing potential insights for policymakers, regulators, and market participants.