Bachelor Thesis Exposé

**Research and observation of reference market problems with artificial intelligence trading agents in a high-fidelity equity market simulator**

Can anomalies be detected and explained when autonomous trading agents are injected into a simulated equity market simulation environment?

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Content

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**Bachelor Thesis Exposé**

# Abstract

This bachelor thesis will

# Problem formulation

The following questions are to be answered within this bachelor thesis:

1. What are Discrete Event Simulations (DEMAS)?
2. What is an agent-based interactive discrete event simulator (ABIDES)?
3. What are the opportunities and possible use cases with discrete event simulations in an agent-based interactive discrete event simulator?
4. How complex capital market scenarios can be simulated?
5. How reinforcement learning trading agents can be trained in different market environmnets to…

# Target setting

A team of artificial intelligence researchers from the Georgia Tech University and the J.P. Morgan AI Research center provided in April 2022 the first Open Source publish of a stable Agent-based interactive discrete event simulator including an OpenAI gym environment for training reinforcement learning agents within market simulations. This toolset is providing nearly unlimited possibilities for researching on capital market problems.

The aim of this thesis is to explain the topic of Agent-based interactive discrete event simulations fundamentally and proof capital market theories through experiments….

# Structure

To see where the focus lies within this bachelor thesis, here is a proposal of page counts for each part:

(1) Explanation of terms and background 10

(2) Opportunities of agent-based interactive event simulations 2

(3) Preparing market experiments 3

(4) Agent-based capital market experiments 10

(5) Reinforcement learning agents in capital market experiments 5

(6) Conclusion and Outlook 2

# Accurals

This thesis focuses on research and observation of capital market scenarios with trading agents and reinforcement learning trading agents with a **special focus on** **market fees for market makers and trading agents from a stock exchange perspective**, since an examination of more and more complex financial market problems would go beyond the scope of this thesis.

# Content of each part

## (1) Explanation of terms and background

To fully understand the concepts of:

* How stock exchanges work and how they generate turnover
* How we define reference marktet problems
* What are discrete event simulations (DEMAS)
* What is the Agent-based interactive discrete simulator (ABIDES)
* What is a Markov decision process?
* What is a reinforcement learning trading agent, what is meant by training a policy?

#### (1.1) Opportunities of agent-based interactive event simulations

In this chapter I will explain the opportunities financial institutes and invidividuals with interests in capital markets theory will get with the toolset around ABIDES. And how this toolset could be used for solving for example financial market problems that can only be proven by experimental evidence, not by mathematical proof.

## (2) Preparing reference market experiments

First of all, I will explain how data scientists, financial market researchers, developers and artificial intelligence experts could use ABIDES for solving and evaluating reference market problems.

After that I want to define what I want to achieve within my bachelor thesis, how I plan to implement this problem through an experiment and what are the requirements to achieve the expected outcome. I also want to define for what purpose this tool with the solution could be used.

## (3) Agent-based reference market experiments

In this chapter I will decode, implement and evaluate some reference market problems. I will explain how we can create our customized reference market experiment, simulating this reference market problem and evaluate it afterwards.

Another subchapter in this chapter could be placing an extended reinforcement learning agent into our customized reference market experiment to see how a reinforcement learning Markov decision process learning agent would handle this problem by iterative learning in an environment.

#### (3.1) Reinforcement learning agents in reference market experiments

In this chapter I will explain how we can train a reinforcement learning trading agent in our customized reference market experiment, running this reference market experiment and evaluate the problem again.

## (4) Conclusion and Outlook

In this chapter I will explain what the outcome of my bachelor thesis was, how this conclusion could be seen and what the future of discrete event simulation experiments

((The bachelor thesis concludes with one or a combination of several proposed reference market problems for future observations and how stock exchange could use discrete event simulations for strategic decisions.))

**Abbreviations**

The following abbreviations are used in this exposé:

|  |  |
| --- | --- |
| ABIDES | Agent-based interactive discrete simulator |
| DEMAS | Discrete Event Simulation |
| RL | Reinforcement Learning |
| DRL | Deep reinforcement learning |
| DNN | Deep neural network |
| MM | Market Making |
| OTC | Over-the-counter |
| PnL | Profits and Losses |
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