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VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

FACULTY OF INFORMATION TECHNOLOGY
FAKULTA INFORMAČNÍCH TECHNOLOGIÍ

DEPARTMENT OF INTELLIGENT SYSTEMS
ÚSTAV INTELIGENTNÍCH SYSTÉMŮ

REINFORCEMENT LEARNING FOR AUTOMATED STOCK PORTFOLIO ALLOCATION
VYUŽITÍ ZPĚTNOVAZEBNÉHO UČENÍ PRO AUTOMATICKOU ALOKACI AKCIOVÉHO PORTFOLIA

BACHELOR'S THESIS
BAKALÁŘSKÁ PRÁCE

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BRNO 2023

Bachelor's Thesis Assignment

Institut:	Department of Intelligent Systems (UITS)
Student:	**Lapeš Zdeněk**
Programme:	Information Technology
Specialization:	Information Technology
Title:	**Reinforcement Learning for Automated Stock Portfolio Allocation**
Category:	Artificial Intelligence
Academic year:	2022/23

Assignment:

1. Study the state-of-the-art methods for automated stock portfolio allocation. Focus on the methods based on reinforcement learning and planning in Markov Decision Processes.
2. Experimentally evaluate selected open access tools for automated portfolio allocation including e.g. FinRL-Meta and identify their weak points.
3. Propose and implement improvements of a selected method/tool allowing to mitigate theseweak points.
4. Using suitable benchmarks and datasets, perform a detailed experimental evaluation of the implemented improvements with the focus on the portfolio allocation returns.

Literature:
Rao A., Jelvis T., Foundations of Reinforcement Learning with Applications in Finance. 1st Edition, Taylor & Francis 2022
* Li, Xinyi and Li, Yinchuan and Zhan, Yuancheng and Liu, Xiao-Yang, Optimistic Bull or Pessimistic Bear: Adaptive Deep Reinforcement Learning for Stock Portfolio Allocation, In ICML 2019.
* Liu X.-Y. Rui J. Gao J. aj.: FinRL-Meta: A Universe of Near-Real Market Environments for Data-Driven Deep Reinforcement Learning in Quantitative Finance. Workshop on Data Centric AI 35th Conference on Neural Information Processing Systems at NeurIPS 2021.
* Mao Guan and Xiao-Yang Liu. 2021. Explainable Deep Reinforcement Learning for Portfolio Management: An Empirical Approach. In ICAIF 2021.

Requirements for the semestral defence:
Items 1, 2, and partially 3.

Detailed formal requirements can be found at https://www.fit.vut.cz/study/theses/

Supervisor:	**Češka Milan, doc. RNDr., Ph.D.**
Head of Department:	Hanáček Petr, doc. Dr. Ing.
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Abstract

This thesis focuses on the design and implementation of a model capable of making decisions in a very fast-changing financial environment. It is based on the modern portfolio therory and reinforcement learning. In the first step, a simulation environment is created that allows testing various strategies. In the second step the agent is trained to try to achieve the maximum return. In the third step, the agent is tested on real data.

Abstrakt

Tato prace se zameruje na navrh a implementaci modelu schopnych delat rozhodnuti ve velmi rychle se menicim financnim prostredi. Vychazi z teorie moderniho portfolia a posilovaneho uceni. V prvnim kroku je vytvoreno simulacni prostredi, ktere umoznuje testovat ruzne strategie. V druhem kroku je trenovan agent, ktery se snazi dosahnout maximalniho navratu. V tretim kroku je agent testovan na realnych datech.

Keywords

Klíčová slova

Reference

LAPEŠ, Zdeněk. *Reinforcement Learning for Automated Stock Portfolio Allocation.* Brno, 2023. Bachelor's thesis. Brno University of Technology, Faculty of Information Technology. Supervisor doc. RNDr. Milan Češka, Ph.D.

Reinforcement Learning for Automated Stock Portfolio Allocation

Declaration

I hereby declare that this Bachelor's thesis was prepared as an original work by the author under the supervision of Mr. Milan Češka, Ph.D. I have listed all the literary sources, publications and other sources, which were used during the preparation of this thesis.

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Zdeněk Lapeš

December 27, 2022

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Chapter 1

Introduction

The portfolio allocation is a problem that has been studied for a long time. The problem is to find the optimal allocation of the portfolio, given a specific set of securities.

The portfolio management task is basically the most important to the finance institutions, like banks, hedge funds and asset management companies. It help traders understand the market and its risks.[1]

The portfolio allocation was widely studied in a standart ways, like the Markowitz portfolio theory[2, p. 4], the CAPM model and the Black-Litterman model.

The stock market is a wide and quick changing environment and people are emotionally based, which means, that behave based on their emotions and only a few people can do rational decisions. This could be problem, specifically when you need to decide based on what you know about given asset.

In this thesis, I will focus on the application of RL in the field of finance, specifically in portfolio allocation. The goal of portfolio allocation is to find the optimal portfolio of assets that maximizes the expected return for a given level of risk.[1]

Deep Reinforcement Learning (DRL) methods have been used in many different fields, such as robotics, video games, and finance. And studied how much a change in input would influence the output is important to understand what contributes to the decision making process of the DRL agents.[1]

Bibliography

[1] GUAN, M. and LIU, X.-Y. *Explainable Deep Reinforcement Learning for Portfolio Management: An Empirical Approach.* arXiv, 2021. DOI: 10.48550/ARXIV.2111.03995. Available at: https://arxiv.org/abs/2111.03995.

[2] ŠIRŮČEK, M. and KŘEN, L. Application of Markowitz Portfolio Theory by Building Optimal Portfolio on the US Stock Market. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis.* Mendel University Press. september 2015, vol. 63, no. 4, p. 1375–1386. DOI: 10.11118/actaun201563041375. Available at: http://dx.doi.org/10.11118/actaun201563041375.