Reinforcement Learning in Financial Markets Trading Strategies

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Introduction

- The total market capitalization of the U.S. stock market is currently 46,199,811.4M $
- Average daily trade volume approximately 1% of market cap
- Characteristics:
  - Dynamic, Uncertain and hard to predict
  - Dependant on diverse and multiple factors
  - Has so much social and economical effects

Introduction

- RL shows great performance in dynamic and complex environments
    - autonomous cars
    - robotics
- Lack of Supervised Data in the Stock Markets
- RL could also be leveraged in stock markets and automatic trading.
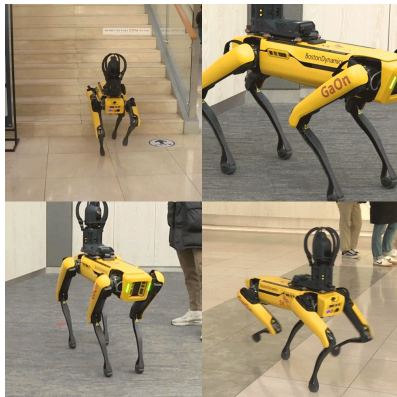
Problem Definition

- Develop an RL-based model that recommends a candidate **portfolio** with the highest value
- Aim to identify the most effective RL approach for portfolio optimization.
- Available Methods:
  - SAC
  - PPO
  - DQN
  - DDPG
 - A2C

Related works limitations

1. Numerical methods:
   a. Defining a deterministic way of market analysis
   b. Calculate factors for trading
   c. Lack of scalability and explainability with growth of markets' complexity
2. ML-based methods:
   a. They try to predict stock prices, not optimizing portfolios
   b. Example: Logistic Regression
   c. Hard to convert their results to trade actions
   d. Unaware of market-related parameters
      i. Turbulence
      ii. Risk factors
   iii. Volatility factors

Framework: FinRL

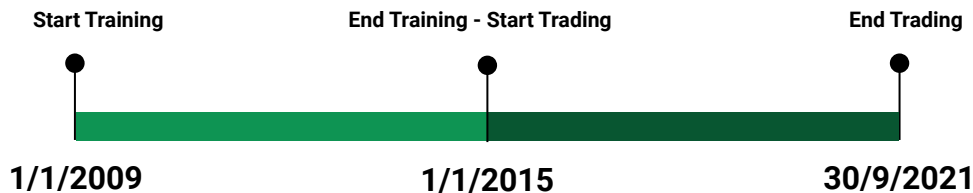- The first open-source framework for financial reinforcement learning [4]
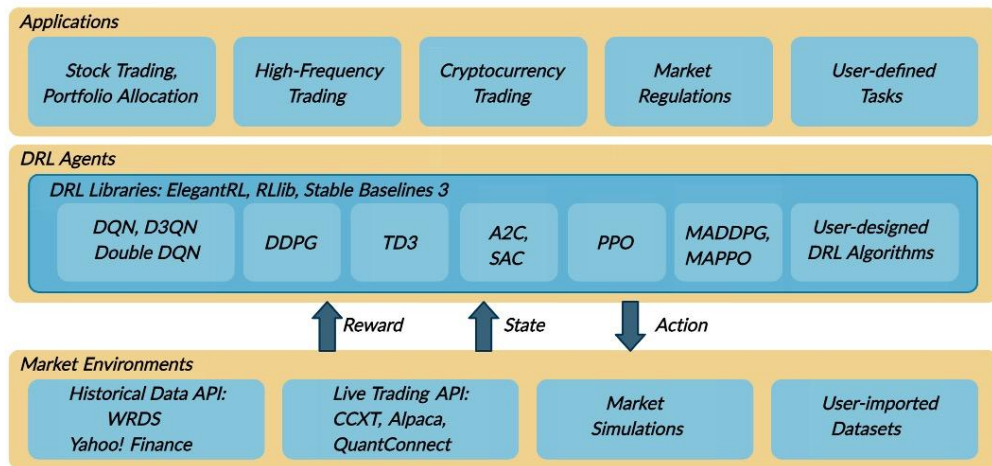
Proposed Method

- State
  - Available Cash
  - Current Prices of Each Stock
  - Current Holding of Each Stock
  - Widely used stock indicators such as
    - ADX: shows trends
    - RSI: shows overvalued - undervalued condition
    - etc.
- Action
  - Trade Volume for Each Stock
- Reward
  - Portfolio Value after 1 Timestep
- Initial State:
  - 1M $ Cash and 0 for all stocks
- Agents:
  - SAC, PPO, DDPG, A2C, TD3.

Agent

State, Reward
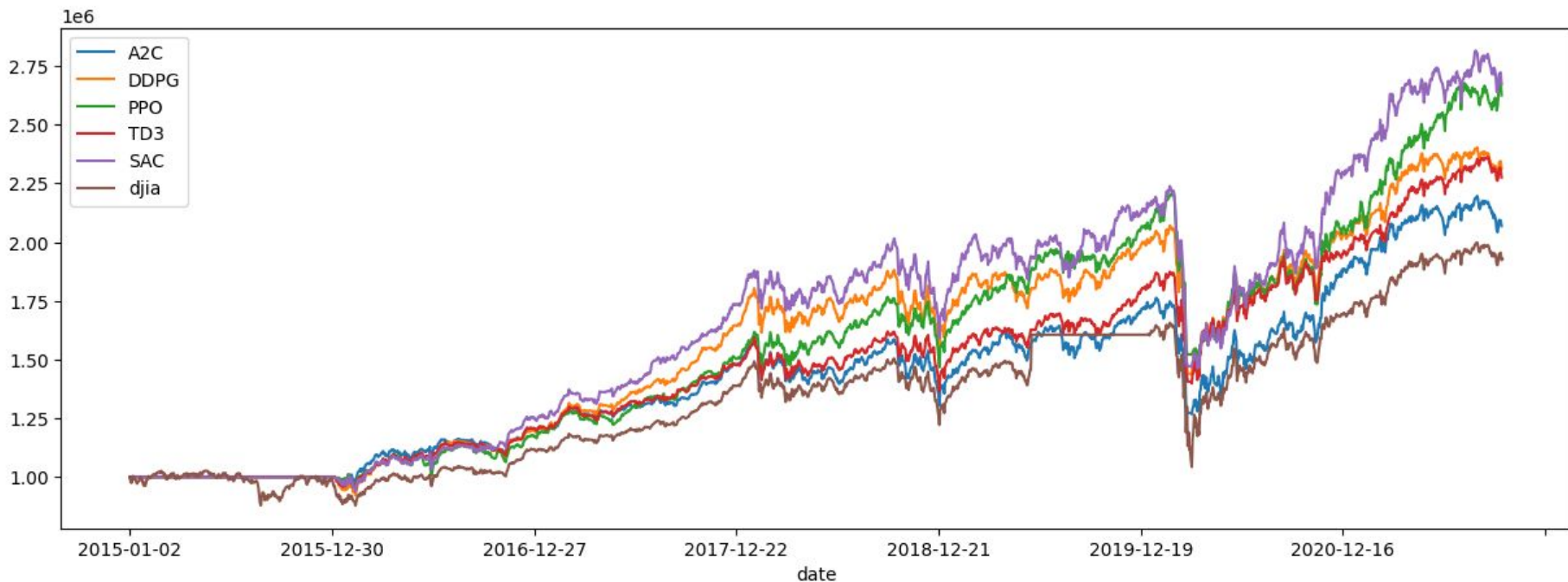s_t, r_t

Action
a_t

Environment
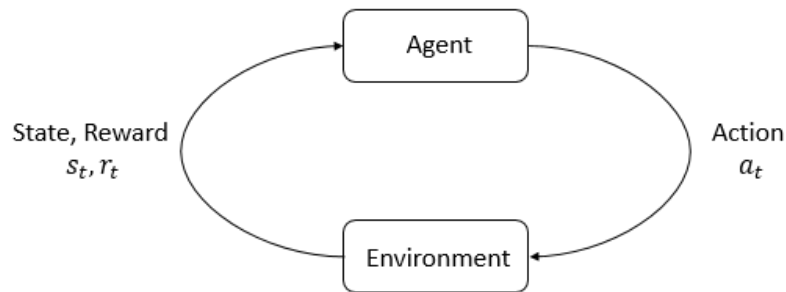
Experiments and results

- We use DJ30 as Dataset
- Fetched from Yahoo Finance Platform
- Dow Jones
  - One of the most famous stock market indexes
  - Consists of 30 prominent worldwide companies
  - Apple, Cisco, Boeing, Walmart, ...
  - Overall value of 11T $
  - Daily Trade Volume of near 300 M $

Start Training **End Training - Start Trading** **End Trading**

1/1/2009 **1/1/2015** **30/9/2021**

Evaluation & Results

Evaluation & Results

- RL results significantly better than baseline
  - Baseline: 1M$ > 2M$
  - SAC, PPO: 1M$ > 2.75M$
- It performance follows the general market trends
- It can be an assistant to recommend some actions.

Limitations & Future Works

- There are some numerical methods who works as good as RL-based approaches
- While RL assistance in trading is a significant development, transitioning to a fully automated RL trader represents a substantial leap.
- The stock market data can have limited samples relative to the complexity of the problem resulting in poor performance in real-world scenarios.

- Adding more features to enrich our decision making process:
  - Using language models to digest stock and economy news
  - Adding more market indicators to features
  - Design RL algorithm with special focus on trading market

Thanks

Any Question?

References

[1] Xiong Z, Liu XY, Zhong S, Yang HB, Walid A. Practical Deep Reinforcement Learning Approach for Stock Trading (2023).

[2] Liang Z, Chen H, Zhu J, Jiang K, Li Y. Adversarial deep reinforcement learning in portfolio management. arXiv preprint arXiv:1808.09940. 2018 Aug 29.

[3] Jiang Z, Xu D, Liang J. A deep reinforcement learning framework for the financial portfolio management problem. arXiv preprint arXiv:1706.10059. 2017 June 30.

[4] https://github.com/AI4Finance-Foundation/FinRL-Tutorials/tree/master