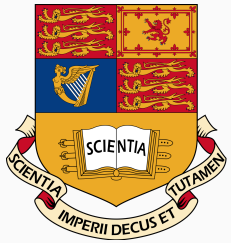

Reinforcement Learning for Portfolio Management

Related Work

Angelos Filos

January 19, 2018

Department of Electrical Engineering, Imperial College London

Optimal Asset Allocation Using Adaptive Dynamic Programming [Ralph Neuneier, 1997]

Problem Definition

- **Agents**
  - German Stock Index DAX
- **Agents**
  - Q-Learning via Neural Network
- **Scope**
  - Discrete Action Space (binary selection)

Results

- Outperformed benchmark strategy (MLP)

Pros

- Q-Learning via Neural Network

Reinforcement Learning for Trading Systems and Portfolios [John Moody, Matthew Saffell et al., 1997] i

Problem Definition

- **Metrics**
  - (Additive / Multiplicative) Profit
  - Wealth
  - Economic Utility
  - (Differential) Sharpe Ratio
- **Agents**
  - Real–Time Reinforcement Learning (Max Immediate Reward)
  - Q-Learning (Max Discounted Future Rewards)
- **Scope**
  - Single Asset Discrete Position
  - Multiple Assets (suggestions, no solution proposed)

Reinforcement Learning for Trading Systems and Portfolios [John Moody, Matthew Saffell et al., 1997] ii

Results

- Q-Learning outperformed Real–Time Reinforcement Learning in Artificial Data
- Real–Time Reinforcement Learning performed better in S&P500/TBill (binary) experiments
- Both agents beat "Buy and Hold" strategy

Pros

- (Differential) Sharpe Ratio $\rightarrow$ on-line training
- Multiple Assets (`softmax` output layer)
- Proof of concept

Policy Gradient Algorithms for Asset Allocation Problem [Pierpaolo Necchi, 2016]

Problem Definition

- **MDP**
  - State: Historic Prices
  - Reward: (Daily Log) Returns
  - Action: Portfolio Vector
- **Agents**
  - Policy Gradient with Parametric-Based Exploration
- **Scope**
  - Algorithmic Trading ("single asset")

Results

- Successful backtests on synthetic data
- Significance of transaction costs

Pros

A Deep Reinforcement Learning Framework for the Financial Portfolio Management Problem [Zhengyao Jiang, Dixing Xu, Jinjun Liang, 2017] i

Problem Definition

- **MDP**
  - State: Historic Prices (Prices Tensors)
  - Reward: (Daily) Returns
  - Action: Portfolio Vector
- **Agents**
  - Policy Gradient
    - CNN
    - LSTM
- **Scope**
  - Multiple Assets (`softmax` output layer)

A Deep Reinforcement Learning Framework for the Financial Portfolio Management Problem [Zhengyao Jiang, Dixing Xu, Jinjun Liang, 2017] ii

Results

- Outperformed most standard portfolio management algorithms
- Brute-Force sequential dependence and $\langle \mathcal{S}_t, \mathcal{A}_t, \mathcal{R}_t \rangle$

Pros

- Ensemble of Identical Independent Evaluators (EIIE)
- Portfolio Vector Memory (PVM)
- Multiple Assets (`softmax` output layer)

Cryptocurrency Portfolio Management with Deep Reinforcement Learning Problem [Zhengyao Jiang, Jinjun Liang, 2017] i

Problem Definition

- **MDP**
  - State: Historic Prices
  - Reward: (Daily) Returns
  - Action: Portfolio Vector
- **Agents**
  - Policy Gradient, implemented via CNN
- **Scope**
  - Multiple Assets (`softmax` output layer)

Cryptocurrency Portfolio Management with Deep Reinforcement Learning Problem [Zhengyao Jiang, Jinjun Liang, 2017] ii

Results

- Outperformed most standard portfolio management algorithms
- **Very Low** Sharpe Ratio (≈ 0.036886)

Pros

- 1D Convolutional Neural Network
- Multiple Assets (`softmax` output layer)
- Proof of concept

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