Application of Deep Reinforcement learning in Algorithmic Trading and Portfolio Management

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Introduction

- It is a problem of time series data where we will predict the closing stock price.
- We will frame our problem as a portfolio consist of one single stock together with agent cash.
- Input to our model would be
  - Open
  - High
  - Low
  - Close
  - Volume
- We train our model to predict close price

Dataset & Features

- 9 years of historical data of stocks were gathered of five different companies (Apple, Google, Microsoft, Coca-Cola, Tesla) from Yahoo finance.

  They are split as follows:

  Training: 1st Jan 2012 to 31st Dec 2018

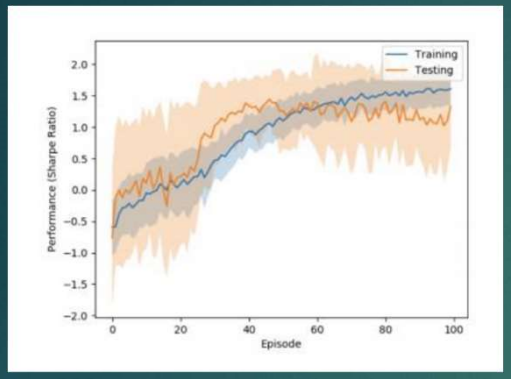
  Testing: 1st Jan 2019 to 31st Dec 2020

The chart shows the simple visualization of stock price from Yahoo finance. It contains the data of 5 days with 5 minutes interval.

Model Implementation

- Deep learning technique
  - Long Short-Term Memory (LSTM): Stock price time series data is decomposed by wavelet transforms (WT) to eliminate noise. Then stacked autoencoders is applied to generate high level features. Then LSTM was trained to predict the next day's closing price.
- Reinforcement Learning technique
  - Recurrent Reinforcement Learning (RRL): It is used for discovering investment policies which eliminate the need of building forecasting model and result in better accuracy.
  - Deep Q-Network (DQN): It is capable of learning control policies form high dimensional input data.

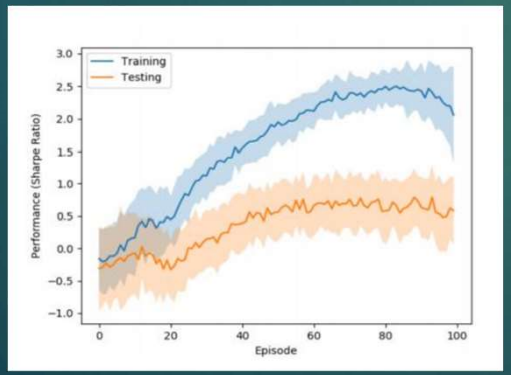
Results (From Paper)



Sharp ratio of Apple Stock

Perf Indicator	B&H	S&H	TF	MR	TDQN
Sharpe ratio	1.182	-1.682	1.291	-0.781	1.603
Profit & loss	81371	-84382	64232	-38920	107922
Ann. return (%)	22.38	-107.71	28.19	-13.92	38.12
Ann. volatility (%)	28.39	48.12	27.76	26.12	28.96
Prof. ratio (%)	96.89	0.83	41.98	59.83	50.37
P&L ratio	∞	0.27	3.193	0.378	3.672
Sortino ratio	1.367	-3.971	1.716	-0.692	1.973
MD (%)	31.83	88.91	13.12	58.63	18.19
MD duration	67	236	31	214	19

Performance Assessment on Apple



Sharp ratio of Tesla Stock

Perf Indicator	B&H	S&H	TF	MR	TDQN
Sharpe ratio	0.213	-0.281	-0.789	0.412	0.293
Profit & loss	26921	-27420	-72921	8913	78
Ann. return (%)	25.91	-5.29	-96.19	18.32	14.83
Ann. volatility (%)	51.87	44.92	54.92	55.82	54.82
Profitability ratio (%)	95.82	0.93	32.19	62.02	34.02
P&L ratio	∞	0.92	0.792	0.920	1.391
Sortino ratio	0.928	-0.339	-1.283	0.792	0.620
MD (%)	59.12	58.39	89.32	78.31	59.95
MD duration	289	189	238	2178	390

Performance Assessment on Tesla

Conclusion and Future Work

- Deep Q-Network achieved good results on training data of Apple, Microsoft, and Google.
- It didn't work well on Tesla's data. There is a limitation in this algorithm
- It only works well with low variance stock data not with the high variance data.
- In future, would like to explore the extending the observation space to enhance the observability of trading algorithm.