Automated Trading Agent in Cryptocurrency Market

Group 7 Final Project

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Agenda

1. **Motivation**
   Why we applied reinforcement learning into cryptocurrency trading

2. **Objectives**
   The objectives of this study in business and analytics aspect

3. **Proposed Approach**
   How we require data, craft impactful features, and
   applied applied double actor-critic architecture with recurrent neural network

4. **Experiments**
   Demonstrate our experiment result, and demo how our trading agent works

5. **Conclusion**
   Recap this study, and discuss with future work to improve

Motivation

Pursuing Profits in Cryptocurrency Market

Gigantic Profit Margin in a Short Amount of Time

Bitcoin worth on $3451.55 on 2019/2/7, and worth $12,647,99 on 2019/6/25.It's a **3.6X** growth in about 150 days.

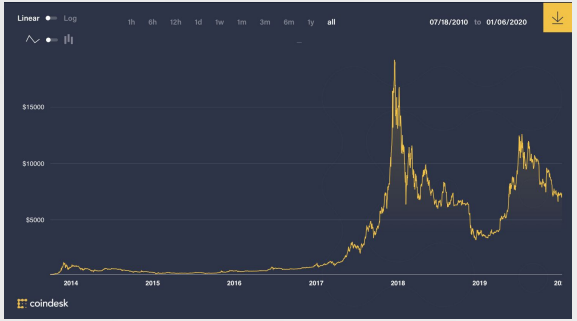
This tremendous growth allures many greedy investors eager to make profit in Cryptomarket.

Extremely High Volatility of Crypto as well…

However, large profit margin comes along with high volatility. The volatility for investor is a kind of double-edge sword. Investors needs to endure high risk of losing a significant amount of investment.

The Precise Decision Policy is required

In order to hit the jackpot in cryptocurrency market, investors need a precise and reasonable policy to decide when to long or short in the right timing.



Objectives

Business & Analytics Goals

Business Goals

- Maximize the value of portfolios (crypto & money) at the end of a given time.

Analytics Goals

- To develop an **Automated Trading Agent** able to learn the profitable trading policy, without any human interventions.

Data Description

Bitcoin / Ethereum / Litecoin Daily Price

BTC / ETH / LTC

We select Bitcoin / Ethereum / Litcoin as our experiment. These three cryptos are the **top three largest cryptocurrency market capital**. The underlying mechanisms are adapted to other many cryptocurrencies. Therefore, we expect this study could apply to other scenarios.

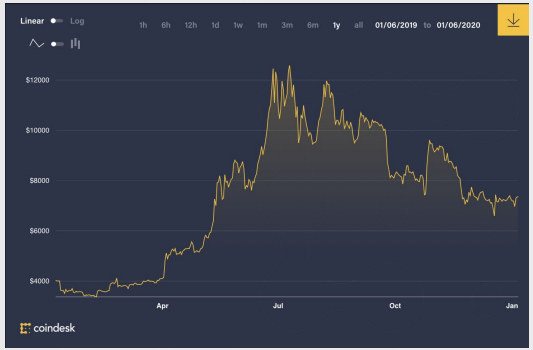
Source : coindesk

Column: Open, High, Low, Close, Volume

Training Set : 2016/5/17 - 2018/12/31

Test Set : 2019/1/1 - 2020/1/6

Bitcoin (BTC) **Ethereum (ETH)** **Litecoin (LTC)**



2019 Bitcoin Price Chart

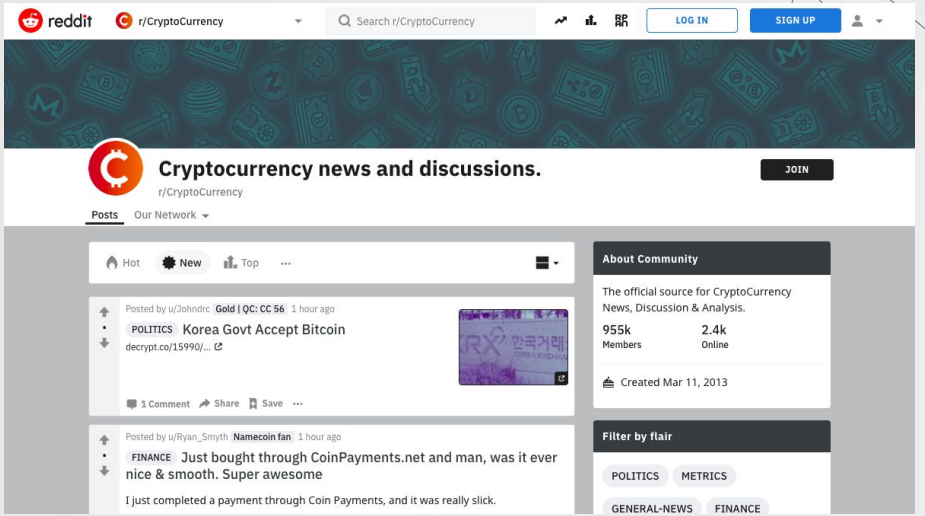
Proposed Approach

Sentiment Analysis

Source : Reddit Cryptocurrency posts

Date : 2016/5/17 - 2020/1/6

Number of Posts: 1,671,326



Screenshot of Reddit Cryptocurrency Forum

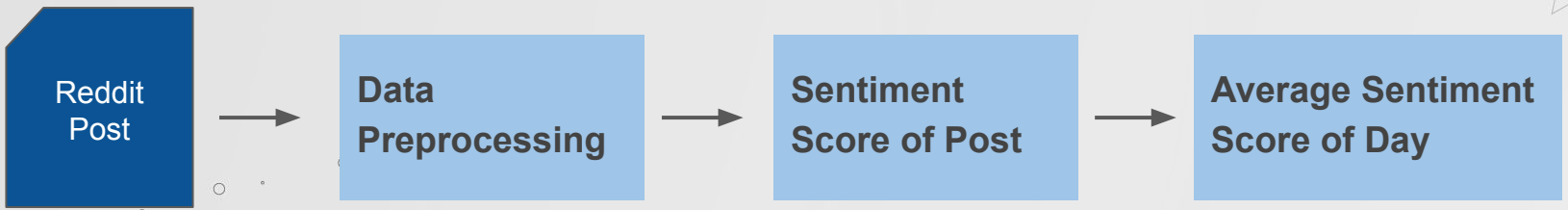
Proposed Approach

Sentiment Analysis

Introduce a **Market Sentiment Index** to reflect cryptocurrency market dynamics

- People tend to get greedy when the market is bullish which leads to **FOMO phenomenon**.
- People sell their currency irrationally in bearish.

Flowchart



Proposed Approach

Sentiment Analysis

Data preprocessing

- Remove punctuations, urls … etc.
- Lemmatizing (playing -> play, looked -> look)
- Lower case

Sentiment score

- Using pretrained sentiment classifier
- **Words Example** : Appreciate: Positive, Poor: Negative, Glad: Positive … etc.
- **Sentence Example** : “SoftBank, the 62nd largest company in the world and Japan’s biggest internet and telecommunications corporation has co-launched a decentralized blockchain development contest for entrepreneurs and startups with Topcoder” -> **Positive**

Proposed Approach

Technical Indicator

Up to 7 meaningful indicators

- Moving Average
- Stochastic Oscillator
- MACD
- Relative Strength Index, RSI
- Bollinger Bands
- On Balance Volume
- Aroon

Technical Indicator

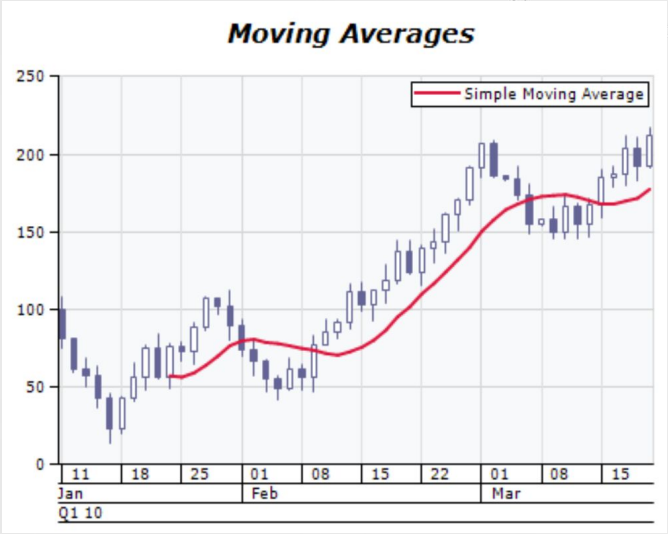
Moving Average, MA

MA helps smooth out price action by filtering out the “noise” from random short-term price fluctuations.

$$SMA = \frac{A_1 + A_2 + \ldots + A_{n-1} + A_n}{n}$$

$$A = average\ in\ period\ n$$

$$n = number\ of\ time\ periods$$



Ref: https://www.investopedia.com/terms/m/movingaverage.asp

Technical Indicator

Stochastic Oscillator, KD

A stochastic oscillator is a momentum indicator comparing a particular closing price of a security to a range of its prices over a certain period of time.

$$RSV = \frac{C_n - L_n}{H_n - L_n} \times 100\%$$

$$K_n = \alpha \cdot RSV_n + (1-\alpha) \cdot K_{n-1}$$

$$D_n = \alpha \cdot K_n + (1-\alpha) \cdot D_{n-1} \quad (usually\ \alpha = 1/3)$$

$n = trading\ period (usually\ n = 9)$

$C = the\ last\ closing\ price$

$L = the\ lowest\ price\ over\ the\ last\ n\ period$

$H = the\ highest\ price\ over\ the\ last\ n\ period$

Ref: https://www.investopedia.com/terms/s/stochasticoscillator.asp

Technical Indicator

Moving Average Convergence/ Divergence, MACD

MACD shows the relationship between two moving averages of a security's price.

EMA : Exponential moving average

Difference $DIF = EMA_{12} - EMA_{26}$

Signal $DEM = MACD = EMA_9$

Histogram $OSC = DIF - DEM$

Ref: https://www.investopedia.com/terms/m/macd.asp

Technical Indicator

Relative Strength Index, RSI

RSI measures the magnitude of recent price changes to evaluate overbought or oversold conditions

Relative Strength $$RS = \frac{EMA_{Up,n}}{EMA_{Down,n}}$$

Relative Strength Index

$$RSI = \frac{EMA_{Up,n}}{EMA_{Up,n} + EMA_{Down,n}} \times 100\%$$

Ref: https://zh.wikipedia.org/wiki/%E7%9B%B8%E5%B0%8D%E5%BC%B7%E5%BC%B1%E6%8C%87%E6%95%B8

Technical Indicator

Bollinger Bands, B-Bands

A technical analysis tool defined by a set of lines plotted two standard deviations (positively and negatively) away from a simple moving average (SMA) of the security's price.

$$BOLU = MA(TP,n) + m * \sigma[TP,n]$$

$$BOLD = MA(TP,n) - m * \sigma[TP,n]$$

$BOLU = Upper\ Bollinger\ Band$

$BOLD = Lower\ Bollinger\ Band$

$MA = Moving\ average$

$TP(typical\ price) = (High + Low + Close) \div 3$

$n = Number\ of\ days\ in\ smoothing\ period\ (typically\ 20)$

$m = Number\ of\ standard\ deviations\ (typically\ 2)$

$\sigma[TP,n] = Standard\ Deviation\ over\ last\ n\ periods\ of\ TP$

Ref: https://www.investopedia.com/terms/b/bollingerbands.asp

Technical Indicator

On-Balance Volume, OBV

On-Balance Volume uses volume flow to predict changes in stock price.

$$OBV = OBV_{prev} + \begin{cases} volume, & if\ \ close = close_{prev} \\ 0, & if\ \ close = close_{prev} \\ -volume, & if\ \ close = close_{prev} \end{cases}$$

$$OBV = Current\ \ on-balance\ volume\ level$$

$$OBV_{prev} = Previous\ \ on-balance\ volume\ level$$

$$Volume = latest\ \ trading\ \ volume\ amount$$

Ref: https://www.investopedia.com/terms/o/onbalancevolume.asp

Technical Indicator

Aroon Indicator

Aroon indicator is used to identify trend changes in the price of an asset, as well as the strength of that trend.

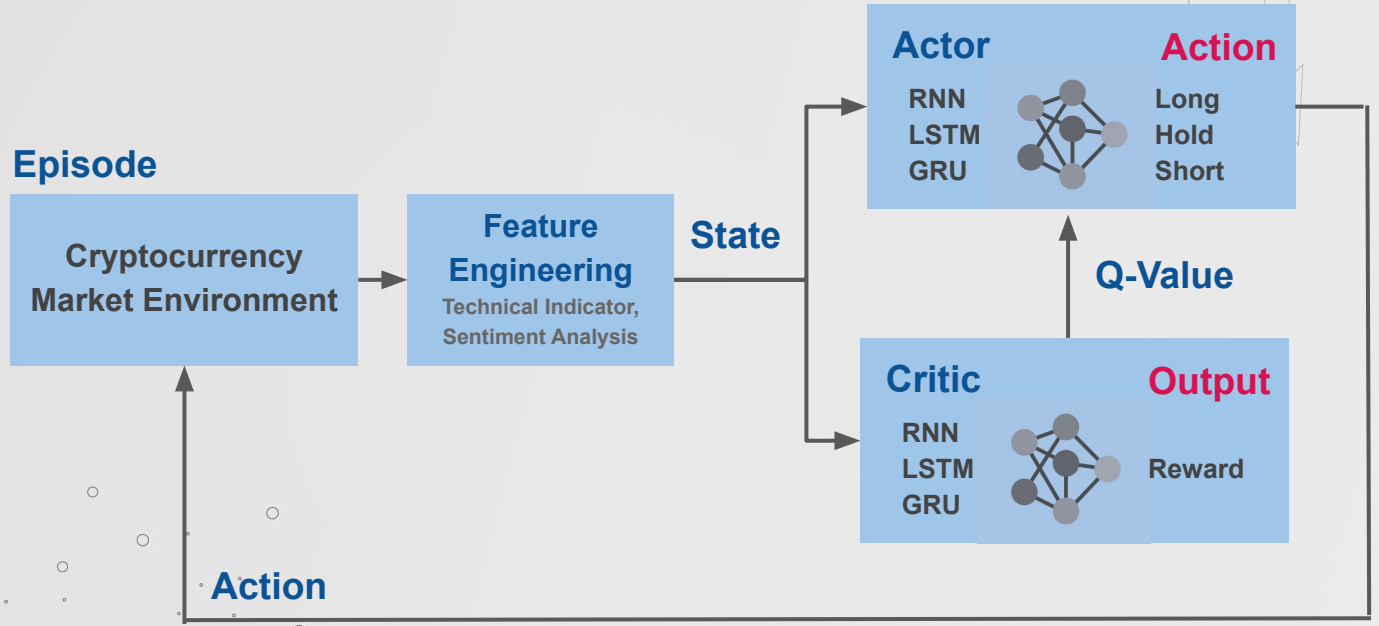
$$Aroon\ Up = \frac{25 - period\ since\ 25\ period\ high}{25} \times 100$$

$$Aroon\ Down = \frac{25 - period\ since\ 25\ period\ low}{25} \times 100$$

Ref : https://www.investopedia.com/terms/a/aroon.asp

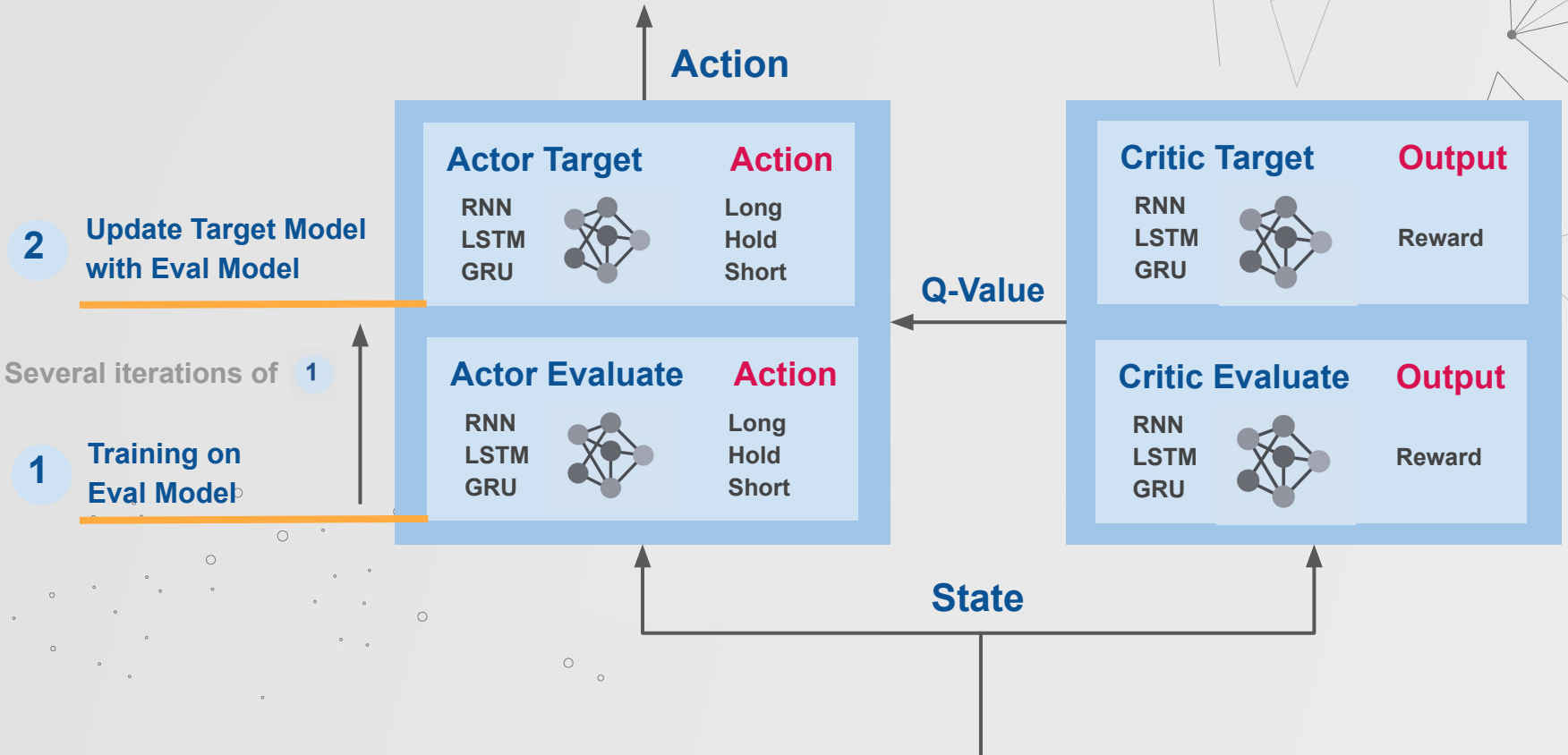
Proposed Approach

Actor-Critic with RNN



Proposed Approach

DQN of Actor-Critic



Proposed Approach

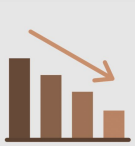
Agent Trading Actions

Long

Agent expects the price of crypto will rise in the future, therefore he purchase crypto at current price.

Hold

Agent considers that there is no profit margin in the near future.



Short

Agent believes the price of the crypto will decrease in the future. Anticipating to make a profit by buying the crypto at the lower price.

Experiments

Trading Agent Performance

BTC

Best Model

Model : GRU

ROI : +3.033%

Experiments

Trading Agent Performance

ETH

Best Model

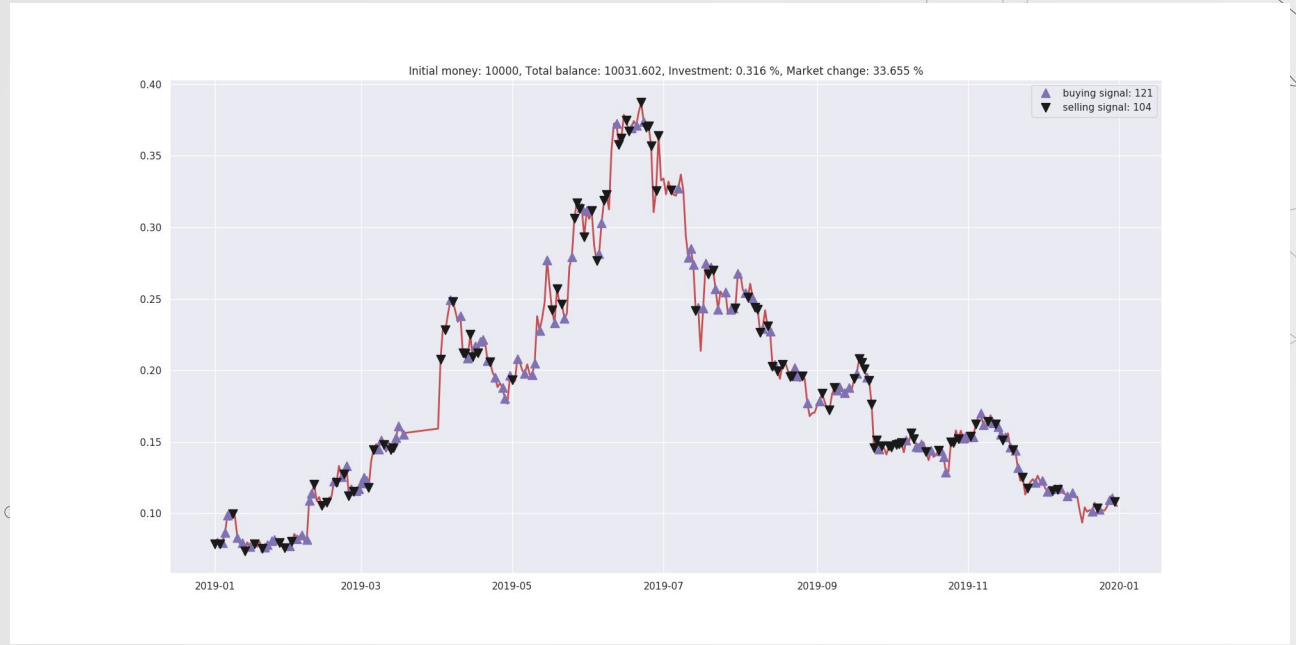
Model : GRU

ROI : -0.337%

Experiments

Trading Agent Performance

Litecoin



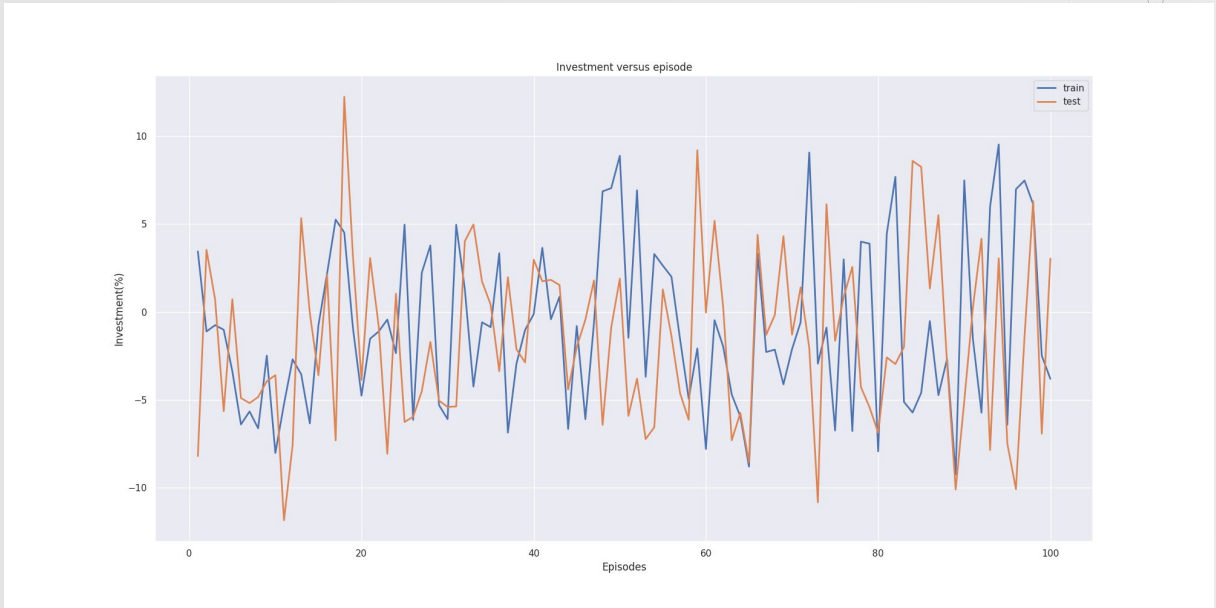
Best Model

Model : GRU

ROI : +0.316%

Experiments

Performance through Episodes : Bitcoin



Conclusions

Future Works

Improve Model Architecture

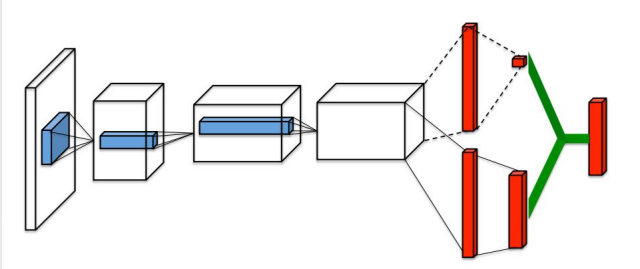
- **Attention Mechanism**

  Enable model to have the ability to assign weights to input feature accordingly.

  This mechanism is expected to let the most relevant features to have larger impact to final outcome.

- **Dueling Actor-Critic Model**

  By adjust this type of structure to the network head allows the network to better differentiate actions from one another, and significantly improves the learning.



Dueling Model

Conclusions

Future Works

Diversify Cryptocurrencies Investment Portfolios

- **Able to trade more or less based on agent's confidence**

  We simplify cryptocurrencies market actions into only three behavior within one trading unit : Long, Short, Hold. However, the investors in real world have nearly infinite actions that they can trading for more than one units based on their forecasting confidence.

- **Include other cryptocurrencies into agent investment target**

  So far, our agent can learn and trade with one crypto at a time. This means our agent can only seek profit opportunity in one specific target. By this constraint, we may miss great amount of opportunities. Therefore, we expected our agent are able to take multiple cryptos into consider at same time, and to maximize profits of investment portfolios.

Conclusions

Recap

- Applied **sentiment analysis** and **technical indicators** to reflect crypto market dynamics.
- Developed an **Automated Trading Agent** based on **actor-critic reinforcement learning** architecture and various **recurrent neural network.**
- Our last episode agent are able to achieve **up to ROI 3 % on BTC, 0.3% on LTC -0.337% on ETH** under high volatility crypto market.

Proposed Approach

Sentiment Analysis

Classifier	Precision	Recall	F1	Accuracy
Multinomial NB	0.67	0.51	0.56	0.51
LSTM				