Backtesting Using a Neural Network Blackbox Algorithm to Analyze Delta Airlines Stock

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Introduction

Using a Machine Learning Algorithm to assess profitability of trading stock.

Machine Learning Algorithm

Black Box Algorithm

- Neural Network
- 3 Hidden Nodes

Input

- Predicted Low/High/SD Price
- Predicted Low/High Return
- Predicted Slope

Output

- Buy, Sell, Keep decisions

Definition

- Input is defined by respective minimum/maximum prices for past n days , n=5

Parameters

- Logistic Regression
- Threshold = between .1 and .4
- Stepmax = $1e^6$

Stocks

- Delta Airlines (DAL)
- S&P 500 (^GSPC)

Using The Neural Network

A Neural Network “recognize[s] underlying relationships in a set of data through a process that mimics the way the human brain operates” *(1)*

Use of Hidden Nodes

- “Fine-tune the input weightings until the neural network’s margin of error is minimal” *(1)*
- “Extrapolate salient features in the input data that have predictive power regarding the outputs” *(1)*

What we found

Overall result

- Neural Network ⇒ effective in generating profitable returns

Best trading strategy

- Williams Percent Range for single stock
- Williams Percent Range for stock portfolio
- ***Neural network***

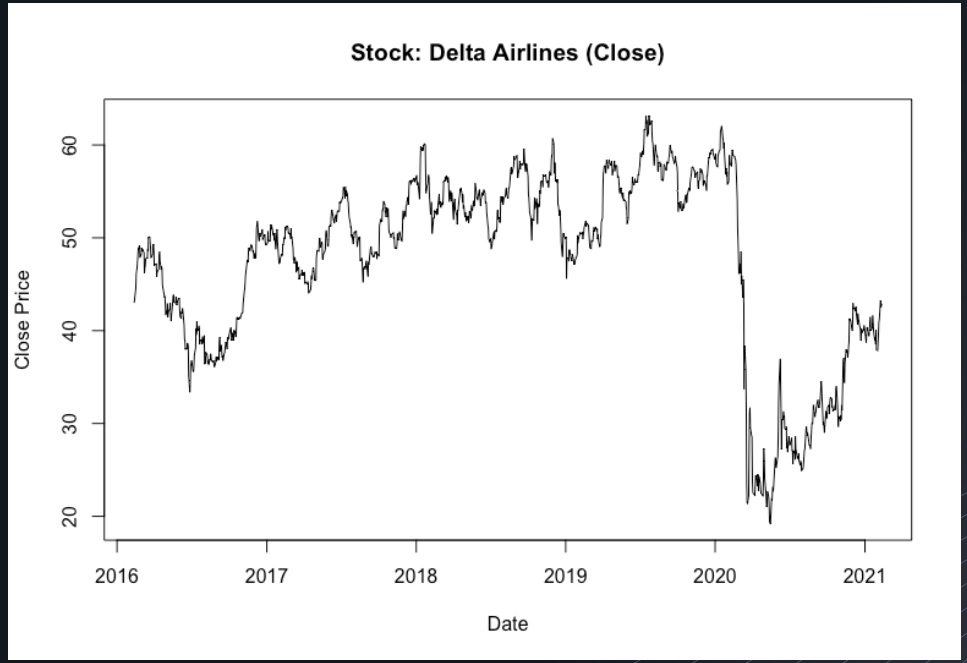
Data

Descriptive Analysis of Delta Airlines and S&P 500

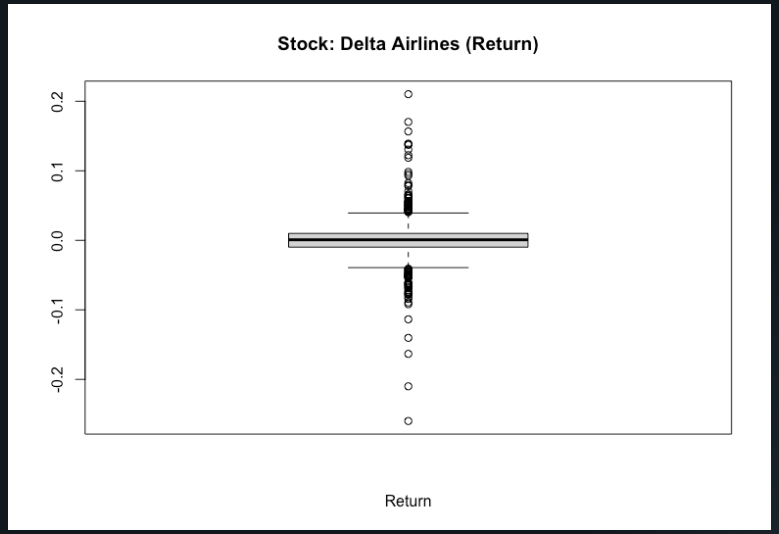
DAL - Summary

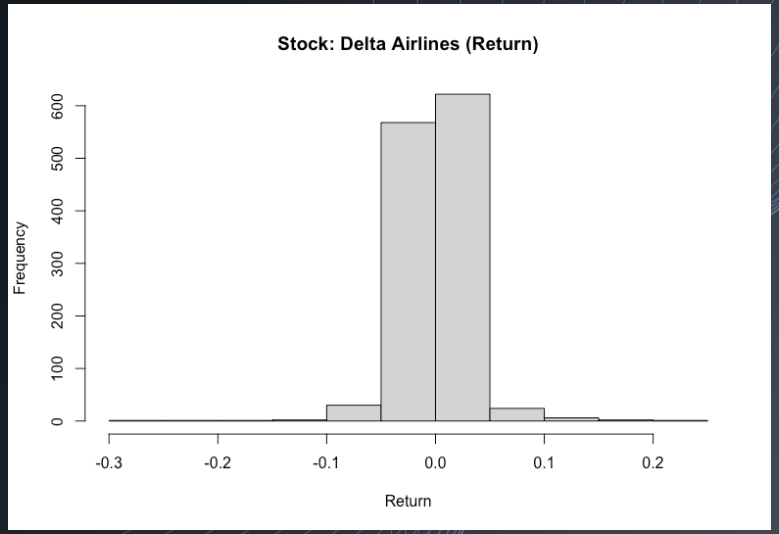
Summary of DAL Stock Data							
	Date	Open	High	Low	Close	Adj. Close	Volume
Min	2/12/16	18.80	19.54	17.51	19.19	19.19	1076000
1st Qu.	5/13/17	41.38	41.88	40.75	41.35	39.43	5802550
Median	8/13/18	50.03	50.53	49.53	50.01	47.03	8003600
Mean	8/12/18	47.48	48.08	46.85	47.45	45.44	12269337
3rd Qu.	11/11/19	54.83	55.35	54.26	54.74	54.74	12053600
Max	2/11/21	63.23	63.44	62.38	63.16	63.16	134626500

DAL - Time Series Close Price



DAL - Return

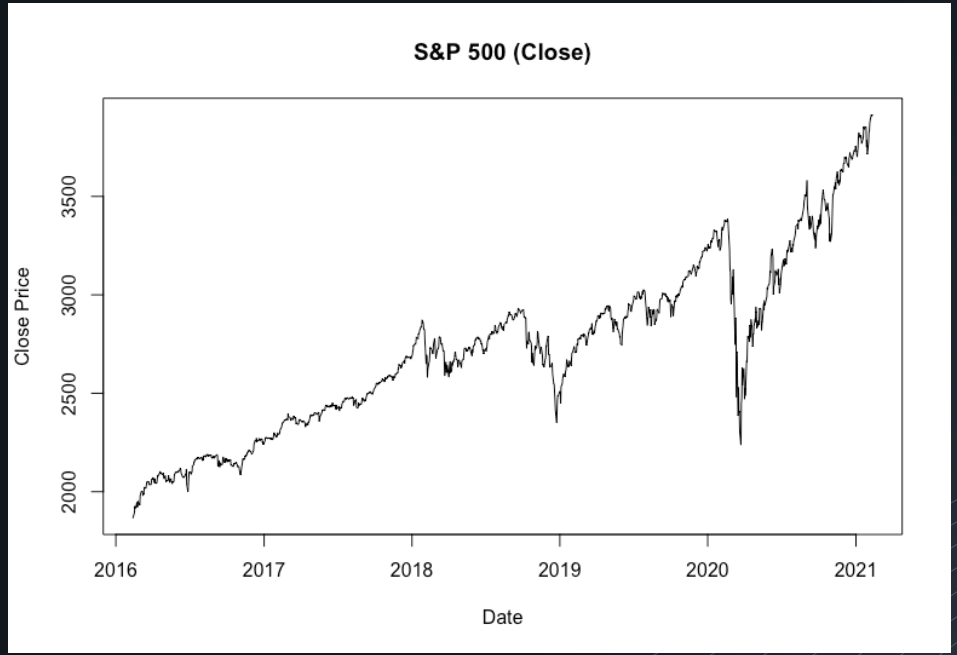

Stock: Delta Airlines (Return)
0.2
0.1
0.0
-0.1
-0.2
Return


Stock: Delta Airlines (Return)
Frequency
0
100
200
300
400
500
600
-0.3
-0.2
-0.1
0.0
0.1
0.2
Return

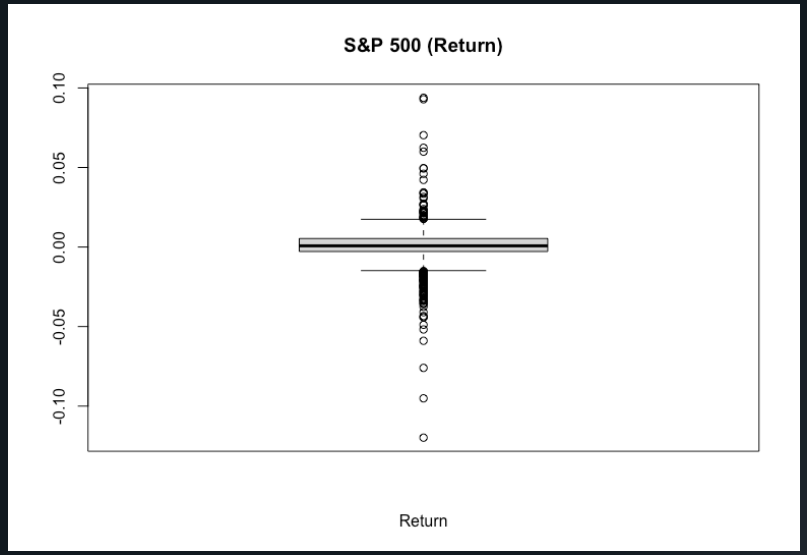
S&P 500 - Summary

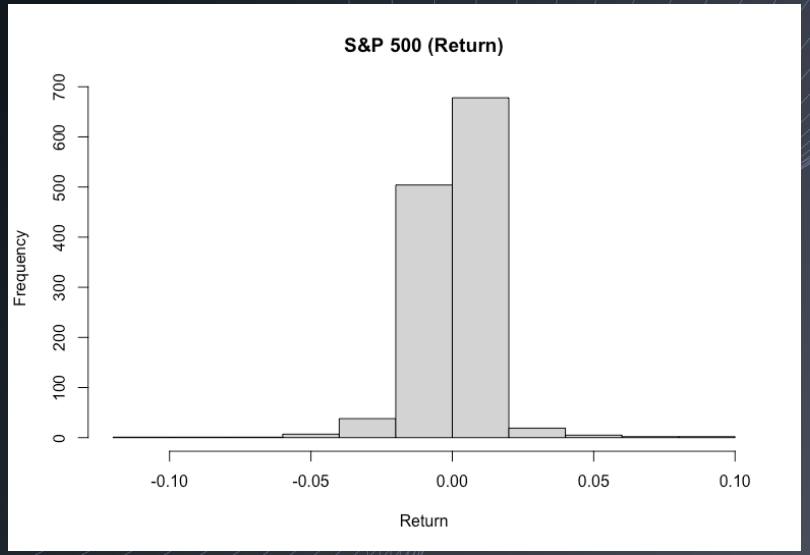
Summary of S&P 500 Data									
	Date	Open	High	Low	Close	Adj. Close	Volume	Market Return	Return
Min	2/12/16	1833	1865	1833	1865	1865	1.30E+09	-0.12	-0.12
1st Qu.	5/13/17	2392	2399	2381	2391	2391	3.30E+09	0.00	0.00
Median	8/13/18	2730	2743	2712	2728	2728	3.64E+09	0.00	0.00
Mean	8/12/18	2727	2740	2712	2727	2727	3.89E+09	0.00	0.00
3rd Qu.	11/11/19	2971	2986	2957	2974	2974	4.15E+09	0.01	0.01
Max	2/11/21	3921	3932	3903	3916	3916	9.88E+09	0.09	0.09
NA's								1	1

S&P 500 - Time Series Close Price



S&P 500 - Return





Method

How we approached the problem.

1. Data and Libraries

Obtaining and importing necessary data

- DAL & ^GSPC

Completed Descriptive Analysis

- Data summary
- Closing prices
- Return

Libraries used in Analysis

- devtools
- neuralnet
- dplyr

2. Creating Signals & Inputs

Signals

- Return 5 days ahead > 0.02 ⇒ Buy (B)
- Return 5 days ahead < -0.01 ⇒ Sell (S)
- Return 5 days ahead $-0.01 \leq x \leq 0.02$ ⇒ Keep (K)

Inputs

- Predicted Low/High/SD Price
- Predicted Low/High Return
- Predicted Slope

3. Building the Model - Our Model

```
NN***year***<-neuralnet(
        data = data***year***,
        Decision ~ Pred.LoPrcPast + Pred.HiPrcPast + Pred.LoRetPast +
         Pred.HiRetPast + Pred.StdPrcPast + Pred.SlopePast,
        hidden = 3,
        act.fct = "logistic",
        linear.output = FALSE,
        stepmax = 1e^6
        threshold =  .1 or .15 or .4)
```

3. Building the Model - Our Model

Subset data by year

- 2016, 2017, 2018, 2019, 2020, 2021

Yearly data was used as training data set for each year

Used model to predict the next year’s investment

4. Implement Trading

Six Scenarios	Current Signal ⇒ Buy	Current Signal ⇒ Sell	Current Signal ⇒ Keep
Previously Holding ⇒ Yes	*Keep Stock, Generate investment return*	*Sell stock, No Investment return*	*Keep Stock, Generate investment return*
Previously Holding ⇒ No	*Buy stock, Investment return stays the same*	*No Stock, Investment return stays the same*	*No Stock, Investment return stays the same*

5. Evaluate Performance

Sharpe Ratio

- Compares return on investment to risk of stock
- Calculated for
  - Investment Strategy ; One Time Investment ; One Time Market

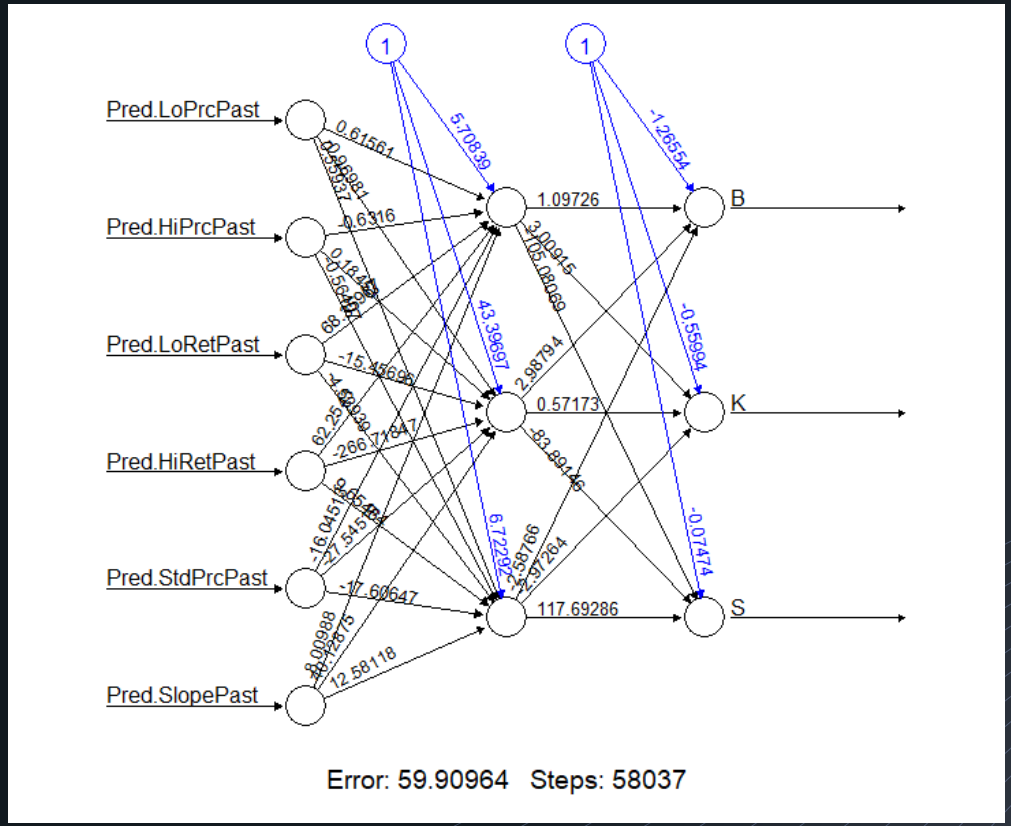
Jensen Alpha

- Average return on investment
- Positive values ⇒ Greater performance
- Calculated for
  - Investment Strategy ; One Time Investment

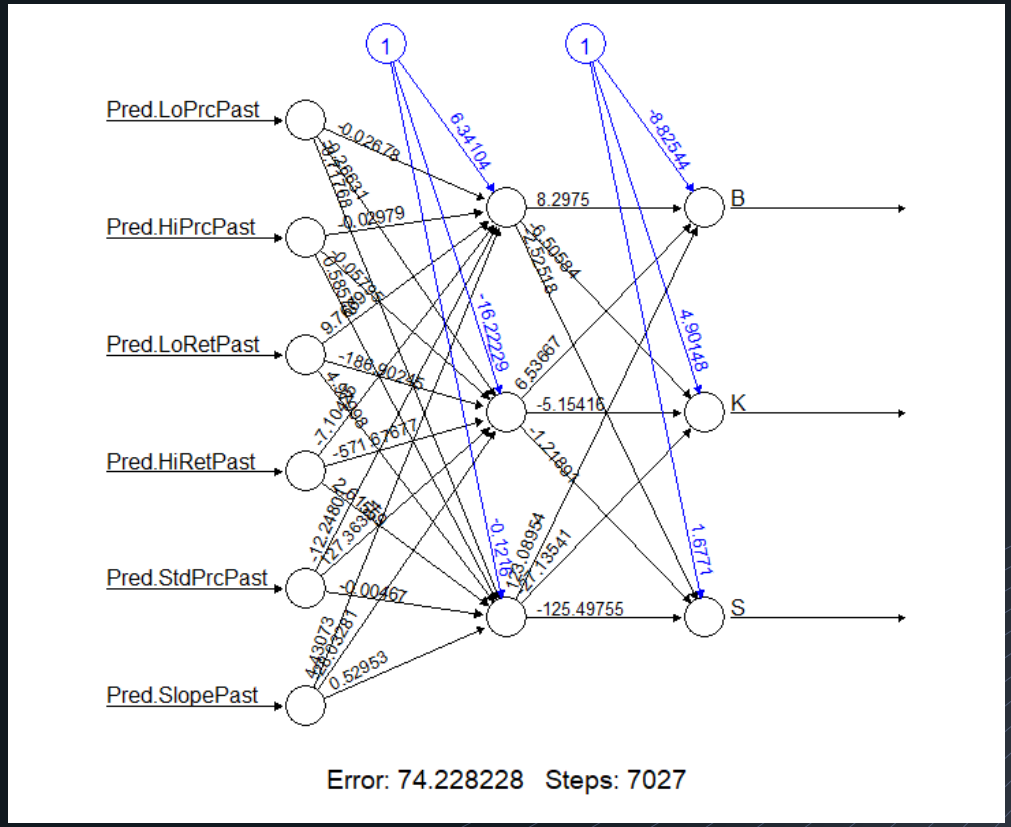
Analysis

Attacking the problem.

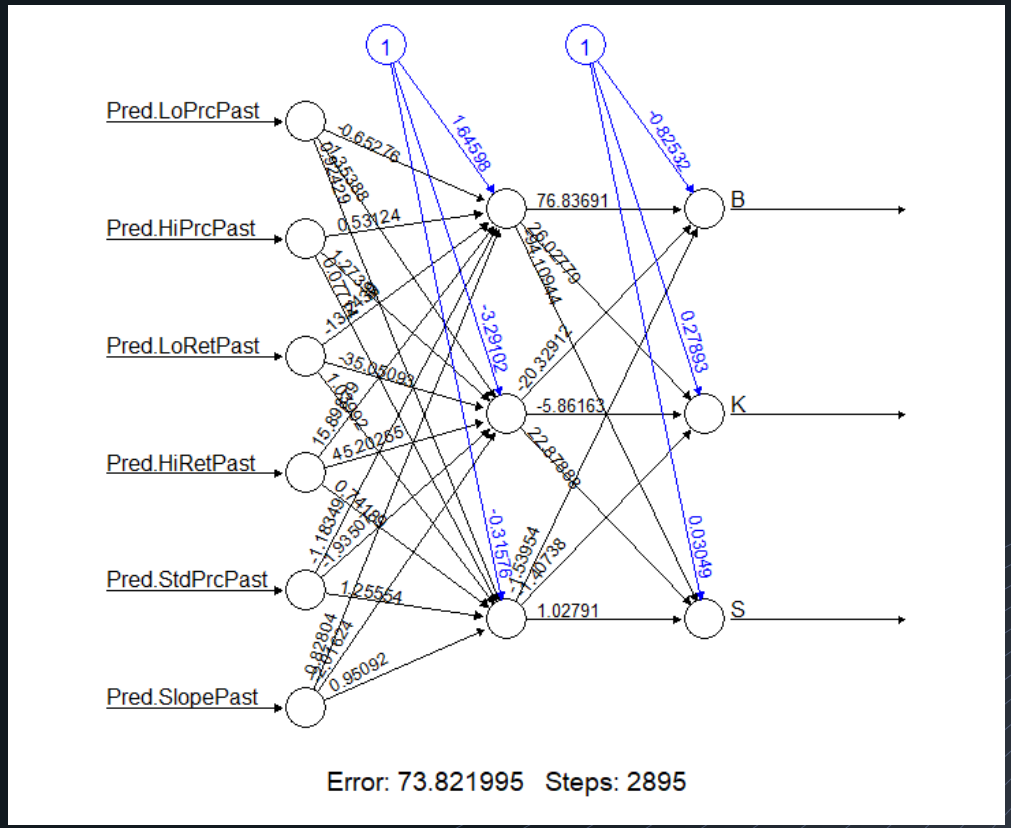
Neural Network Model - 2016



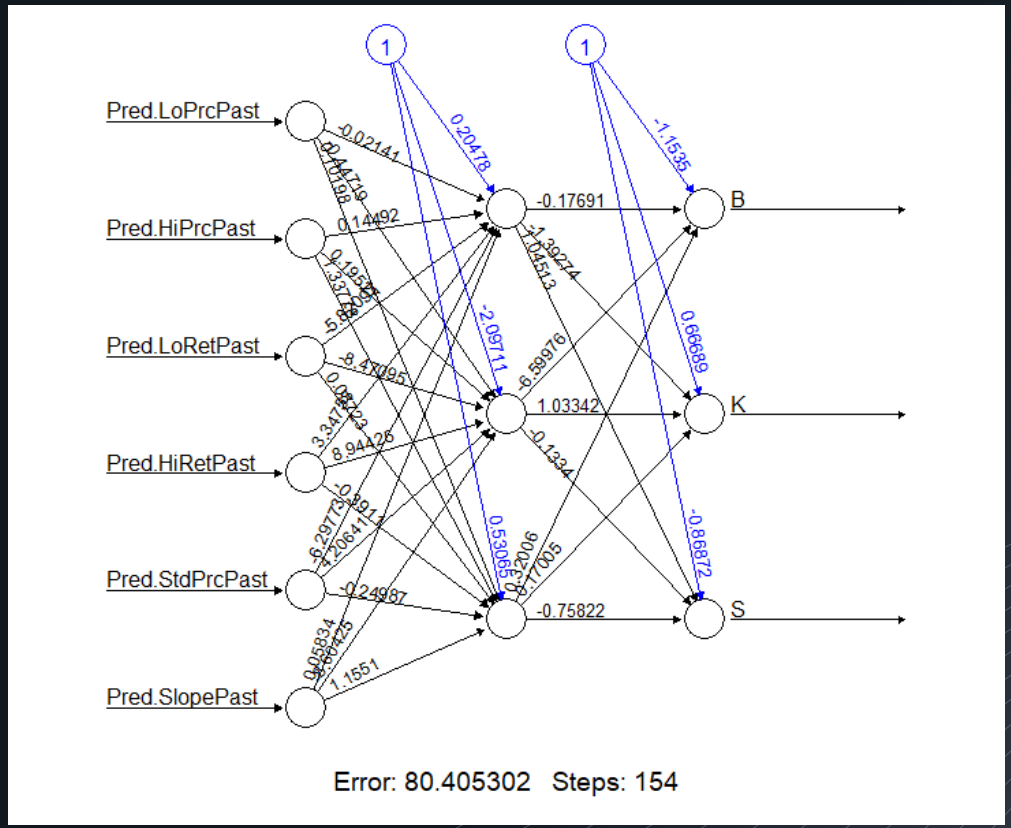
Neural Network Model - 2017



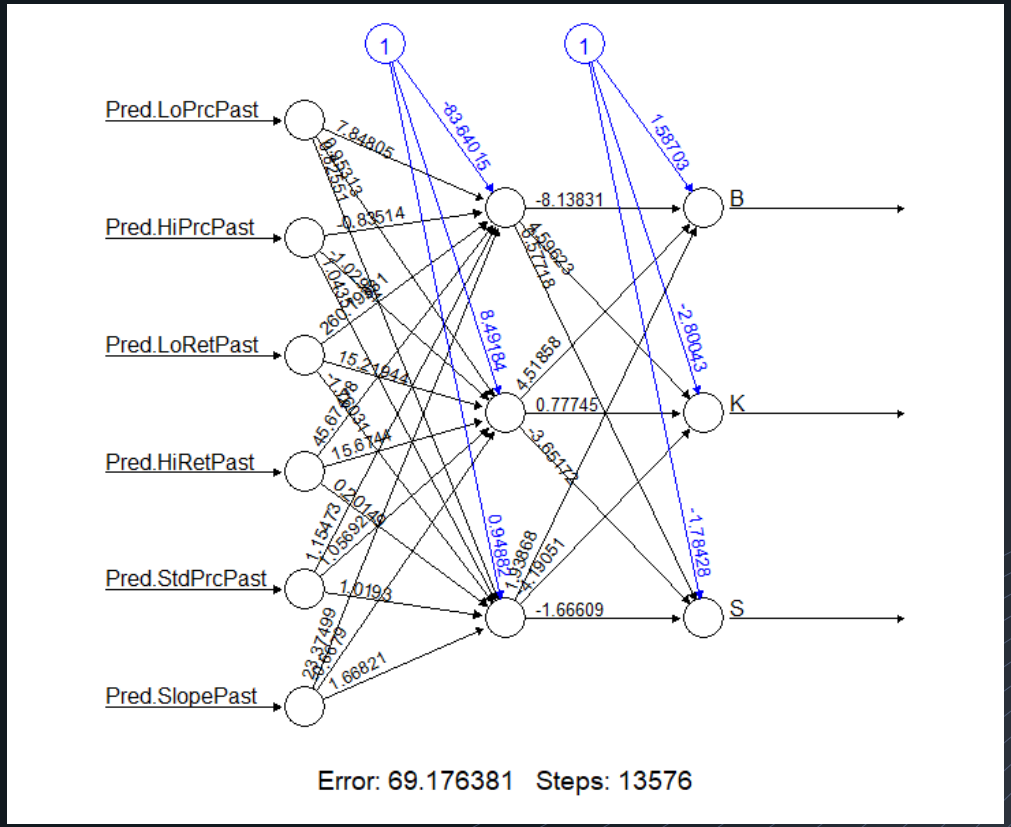
Neural Network Model - 2018



Neural Network Model - 2019



Neural Network Model - 2020



Assessing Performance - Sharpe Ratio

Sharpe Ratio			
	Investment	Stock	Market
2017	0.63	0.67	2.7
2018	0.43	-0.28	-0.29
2019	1.02	0.8	2.1
2020	NaN	-0.06	0.61
2021	2.56	0.67	2.01
	-	-	-
5-year period	0.7	0.13	0.76

- 2020: All predictions were classified as a "K" or Keep.
  - COVID-19
  - Model Parameter Constraints

Assessing Performance - Jensen Alpha

Jensen Alpha		
	Investment	Stock
2017	0.01	-0.19
2018	0.05	-0.03
2019	0.03	-0.11
2020	0	-0.32
2021	0.51	-0.26
	-	-
5-year period	0.06	-0.13

- 2020: All predictions were classified as a “K” or Keep.
  - COVID-19
  - Model Parameter Constraints

Comparing Performance - Sharpe Ratio

Mini project 1: Williams Percent Range analysis of a single stock

Sharpe Ratio, P = 10	
DAL Stock Evaluation	-0.839
One-time Investment into DAL	0.153
One-time Investment into S&P 500	0.832

Mini project 2: Williams Percent Range analysis of a stock portfolio

Sharpe Ratio (By Year)			
Year	**Portfolio**	**Benchmark**	**Market**
2016	-2.21	1.01	1.52
2017	-1.93	2.35	2.7
2018	-2.64	-0.15	-0.29
2019	-1.42	1.20	2.10
2020	-1.29	0.45	0.61
2021	-0.79	1.95	2.47
-	-	-	-
entire period	-1.54	0.69	0.83

Comparing Performance - Jensen Alpha

Mini project 1: Williams Percent Range analysis of a single stock

Jensen Alpha, P = 10	
DAL Stock Evaluation	-0.451
One-time Investment into DAL	-0.136

Mini project 2: Williams Percent Range analysis of a stock portfolio

Jensen Alpha (By Year)		
Year	**Portfolio**	**Benchmark**
2016	-0.39	0.04
2017	-0.46	0.02
2018	-0.54	-0.11
2019	-0.70	-0.04
2020	-0.43	0.1
2021	-0.40	-0.04
-	-	-
entire period	-0.50	-0.01

Conclusion

Our findings.

Findings

Neural Network generated positive returns for each year, with the exception of 2020

- Restrictions of our model
- COVID-19

Most Effective Trading Strategy

Of three trading strategies, Neural Network was the most effective

Neural Network came close to outperforming the market

- Sharpe Ratio $_{investment}$ = 0.70
- Sharpe Ratio $_{market}$ = 0.76

Continuation of this strategy would result in long term profits

Ways to improve our analysis going forward

Adjust the model

- Increase the number of hidden nodes

Change our Parameters

- Alter the threshold values
- Alter the stepmax values

Work Cited

1. https://www.investopedia.com/terms/n/neuralnetwork.asp

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