

**Stock Market Prediction using Time Series Analysis and Neural Networks**

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# Abstract

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# Methodology

## Data Acquisition

Data was obtained from Yahoo Finance. The data spans from 1st July 2014 to 28th June 2024. The data is in the general form:

*Date,Open,High,Low,Close,Adj Close,Volume*

*2014-07-01,23.3799991607666,23.517499923706055,23.282499313354492,23.3799991607666,20.68042755126953,152892000*

*2014-07-02,23.467500686645508,23.514999389648438,23.272499084472656,23.3700008392334,20.671592712402344,113860000*

*2014-07-03,23.417499542236328,23.524999618530273,23.299999237060547,23.50749969482422,20.793209075927734,91567200*

The data was obtained using the Yahoo finance package in Python. By use of a dictionary the 20 companies selected were iterated through and their data written to CSV files. Yahoo Finance was preferred since it offers data for each company separately.

## Data Preprocessing

Data was imported into MATLAB in bulk and stored in an array. This enables the use of iteration and control structures to access the data. Warnings are suppressed for cleaner output and if there are any missing values they are pointed out.

This allows for missing values to be dropped to ensure that operations are not skewed or curtailed by this data.

Furthermore, data is normalized between the range of 0 and 1 for our Time Series Analysis and Neural Network models to be able to work with our data. Only numerical columns are normalized. The column *date* is not affected in any way.

## Machine Learning Models

### Times Series Analysis

### Neural Networks

We decided to use a Feedforward Neural Network that:

* Has 40 hidden nodes
* Trains for a maximum of 1000 epochs
* Uses the adam optimizer
* Utilizes 75% of the data to train
* Utilizes 25% of the data to test
* Uses the Mean Squared Error to test the error of the results
* Utilizes validation data from 1st July 2024 to 26th July 2024

The neural network uses different functions to compute the values. In simplified terms a neural network is a polynomial function whose parameters we do not know. That is, we do not know the degree, variables or coefficients. Nonetheless, what we do know are the weights and biases. These weights and biases are updated using polynomial functions that differentiated and integrated as needed. Furthermore, an activation function and delta variable are employed to control the rate at which the weights and biases are updated. This modification of weights and biases is how the model ‘learns’.

#### Forward Propagation

For forward propagation the functions employed are:

The function above computes a linear combination of the weights and biases then this linear combination is transformed using a non-linear function. This enables complex relationships to be learnt.

The function receives the output from the entry node and then computes the linear combination of weights and biases which are then transformed by the Sigmoid function (defined below).

This function is the Rectified Linear Unit (ReLU) activation function which outputs a value directly if it is positive. Otherwise, it outputs zero.

This function is the Sigmoid function which maps any real-valued number into the range (0, 1).

#### Back Propagation

The function below is the loss function which calculates the Mean Squared Error (MSE) between the actual values and the predicted values. The aim is to minimize the value obtained from the loss function to get a more accurate neural network.

The function below is the derivative of the loss which indicates how much the loss changes with a small change in the predicted output. If  is greater than *y*, the derivative will be positive, suggesting that decreasing   will reduce the loss. Conversely, if   is less than *y*, the derivative will be negative, indicating that increasing  ​ will help reduce the loss. This will inform the network on the way weights and biases should be updated.

This function is the derivative with respect to weights. This term assesses the sensitivity of the output with respect to the input of the activation function. The product with *h* reflects how changes in the weights affect the output based on the current output from the first layer. This derivative is then employed in backpropagation to adjust the weights in the direction that reduces the loss.

The last function is the derivative with respect to bias. Similar to the derivative with respect to weights function this one is used to adjust the bias in the direction that minimizes the loss.

#### Gradients

The functions are the derivatives with respect to the hidden layer output, weights and bias. These derivatives are then used to update their respective variables. This backpropagation aims to reduce the error between the predicted and the actual values.

#### Weight Update Rules

The weights are then updated using the following functions to minimize the value obtained from the loss function.

#### Bias Update Rules

Lastly, the biases are updated.

# Results and Discussion

## Time Series Analysis

## Neural Networks

### Training

### Testing

|  |  |
| --- | --- |
| Company | MSE |
| AMD | 0.005859265 |
| Alphabet | 0.000862567 |
| Amazon | 0.000831416 |
| Apple | 0.007479319 |
| BHP Group Limited | 0.001295159 |
| Coca Cola | 0.006657724 |
| East Africa Metals | 0.003050332 |
| HSBC Holdings | 0.000289854 |
| Intel | 0.001157845 |
| Johnson and Johnson | 0.077928339 |
| L’Oreal | 0.026000365 |
| Meta | 0.123486883 |
| Microsoft | 0.041602214 |
| Nestle | 0.000945337 |
| Novartis AG | 0.007599726 |
| Proctor and Gamble | 0.001207186 |
| Samsung Electronics | 0.000384859 |
| Siemens AG | 0.021622344 |
| Tencent Holdings Limited | 0.000328486 |
| Toyota Motor Corporation | 0.156136595 |

### Validation

|  |  |
| --- | --- |
| Company | MSE |
| AMD | 0.011286 |
| Alphabet | 0.036998 |
| Amazon | 0.041988 |
| Apple | 0.044326 |
| BHP Group Limited | 0.015347 |
| Coca Cola | 0.051388 |
| East Africa Metals | 0.483313 |
| HSBC Holdings | 0.102384 |
| Intel | 0.072831 |
| Johnson and Johnson | 0.049414 |
| L'Oreal | 0.174741 |
| Meta | 0.028277 |
| Microsoft | 0.024886 |
| Nestle | 0.049855 |
| Novartis AG | 0.028158 |
| Proctor and Gamble | 0.126288 |
| Samsung Electronics | 0.020738 |
| Siemens AG | 0.154387 |
| Tencent Holdings Limited | 0.01493 |
| Toyota Motor Corporation | 0.017593 |

# Conclusion and Recommendations

## Time Series Analysis

## Neural Networks

# References

# Appendices

|  |  |  |
| --- | --- | --- |
| Company | Testing MSE | Validation MSE |
| AMD | 0.005859265 | 0.011285854 |
| Alphabet | 0.000862567 | 0.03699829 |
| Amazon | 0.000831416 | 0.041988428 |
| Apple | 0.007479319 | 0.044326173 |
| BHP Group Limited | 0.001295159 | 0.015347291 |
| Coca Cola | 0.006657724 | 0.051387616 |
| East Africa Metals | 0.003050332 | 0.483313323 |
| HSBC Holdings | 0.000289854 | 0.102384032 |
| Intel | 0.001157845 | 0.072831488 |
| Johnson and Johnson | 0.077928339 | 0.049413927 |
| L'Oreal | 0.026000365 | 0.174740765 |
| Meta | 0.123486883 | 0.028276792 |
| Microsoft | 0.041602214 | 0.024885528 |
| Nestle | 0.000945337 | 0.049855178 |
| Novartis AG | 0.007599726 | 0.028157622 |
| Proctor and Gamble | 0.001207186 | 0.126287847 |
| Samsung Electronics | 0.000384859 | 0.020737847 |
| Siemens AG | 0.021622344 | 0.154387357 |
| Tencent Holdings Limited | 0.000328486 | 0.014930324 |
| Toyota Motor Corporation | 0.156136595 | 0.017593062 |

*Fig 1.1: Testing and Validation MSE’s*