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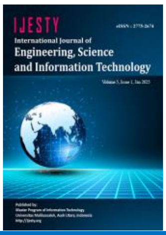

Implementation of Simple Exponential Smoothing and Weighted Moving Average in Predicting Netflix Stock Prices

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Abstract

This study aims to develop a stock price prediction system for Netflix using the Simple Exponential Smoothing and Weighted Moving Average methods and evaluate the accuracy of both methods. The system provides future stock price estimates based on historical data and includes evaluation metrics such as Mean Absolute Error and Mean Absolute Percentage Error. The implementation results show that SES achieved an MAE of 4.40 and a MAPE of 1.08%, while WMA resulted in an MAE of 8.65 and a MAPE of 2.11%. These findings indicate that SES is more effective in predicting stock prices with lower error rates, particularly for stable historical data. In contrast, WMA is more responsive to short-term trends but less accurate overall. Based on the results, SES is recommended as the developed system's primary method for stock price prediction.

Keywords: *Netflix, Prediction, Simple Exponential Smoothing, Stock, Weighted Moving Average.*

1. Introduction

Stocks are one of the most popular forms of investment in the capital market among the public [1]. Stocks are a form of investment traded on the stock exchange, represented by securities as proof of ownership. An example of a company with significant stock movements in the capital market is Netflix, which operates in the media and entertainment industry. Netflix's stock prices are transparent and accessible to the public, making it easier for traders to invest in the stock market. The primary goal for investors is maximizing profits while minimizing potential losses. Therefore, appropriate strategies are essential for trading Netflix stocks, including leveraging data mining concepts. Data mining is a method used to extract valuable information from large datasets, enabling in-depth analysis to identify trends and patterns that can serve as the basis for investment strategies. Generally, stock price predictions are influenced by three main factors: technical, fundamental, and sentiment. Technical analysis plays a crucial role in helping investors and market participants make more informed decisions amidst the fluctuating conditions of the stock market. In volatile and uncertain price situations, technical analysis becomes essential for identifying stock price movement patterns, predicting future trends, and determining the best timing for buying or selling transactions. The primary focus of technical analysis is observing historical data, such as stock prices and trading volumes. Given the many market variables, analysts and investors require a more precise approach to forecast future stock price movements [2].

Determining critical policies requires an effective and accurate method for predicting stock prices, as stated by [3]. One method that can be used to predict stock prices is the Simple Exponential Smoothing method. This method works by smoothing historical data by assigning greater weight to the most recent data, resulting in predictions more responsive to recent changes. SES is beneficial in analyzing dynamic stock price movements, especially for data without trends or seasonality, to provide accurate estimates based on historical patterns. In addition to Exponential Smoothing, the Weighted Moving Average method is also a technique that can be used to predict stock prices. WMA is a form of moving average that assigns greater weight to more recent data, making it more responsive to current price changes than a simple moving average. This method is beneficial for capturing short-term price changes, providing quicker signals for investors to determine the optimal timing for buying or selling stocks. In WMA, historical price data is processed by assigning progressively larger weights to prices closer to the prediction period, resulting in more accurate estimates in volatile markets [4].

The Weighted Moving Average and Simple Exponential Smoothing methods offer unique approaches to analyzing stock price movements. WMA assigns greater weight to the most recent price data, making it more responsive to short-term market changes and capable of generating quick and accurate trading signals. On the other hand, SES smooths historical data by prioritizing recent data, making it practical for capturing price fluctuations without trends or seasonality. By combining these two methods, stock analysis can capture short-term changes while providing stable estimates based on historical patterns. This enables investors to design more balanced, adaptive strategies that are better prepared for market volatility.

This study aims to implement the Simple Exponential Smoothing and Weighted Moving Average methods using a technical analysis approach to predict Netflix stock prices during 2019–2024. The urgency of this research is driven by the growing public interest in stock investment, necessitating reliable prediction tools to support informed decision-making. Netflix, with its dynamic and easily accessible stock movements, serves as a relevant subject for analysis. The Simple Exponential Smoothing method provides predictions by smoothing historical data, assigning greater weight to recent data, making it suitable for capturing short-term price changes. Meanwhile, the WMA method also focuses on recent data, emphasizing current price movements. Combining these two methods will give investors more comprehensive insights, enabling them to maximize profits, minimize risks, and make more informed and strategic investment decisions.

2. Literature Review

2.1. Netflix

Netflix is an online subscription-based service that allows users to watch TV shows and movies without ad interruptions on internet-connected devices. In other words, Netflix will enable users to enjoy their favourite content anytime and anywhere through various devices such as smartphones, smart TVs, tablets, PCs, and laptops [5]. Netflix was founded in Los Angeles, California, United States, by Marc Randolph and Reed Hastings, who initially planned to start a DVD rental service by mail. The service was officially launched in 1998 and had approximately 30 employees. In its early stages, Netflix offered around 925 movies that could be rented online for a fee of approximately Rp.40,000 per rental, with an additional Rp.20,000 for delivery. In 1999, they introduced a monthly subscription model and began distributing content digitally. Netflix subsequently launched its initial public offering on May 29, 2002.

The year 2013 marked a significant milestone for Netflix with the launch of its original series, followed by a Primetime Emmy Award for its streaming service. By 2017, Netflix had reached 100 million subscribers and earned its first Oscar for the film *"The White Helmets."* Today, Netflix has over 200 million subscribers and has won numerous prestigious awards, including Oscars and Primetime Emmy Awards [6].

2.2. Data Mining

Data Mining is the process of uncovering hidden knowledge within a database using statistics, mathematics, artificial intelligence, and machine learning techniques. Its primary goal is to extract useful information and actionable knowledge from large databases. Although Data Mining is often associated with Knowledge Discovery in databases, the two interconnected concepts are distinct. Data mining is a core component of the KDD process, which serves as the method for discovering unknown information or knowledge within a database. By integrating disciplines such as statistics, artificial intelligence, and machine learning, Data Mining becomes a highly effective tool for analyzing data and extracting valuable insights from large datasets [7].

2.3. Forecasting

Forecasting is a method used to predict what is likely to happen in the future based on current situations and historical data. Approaches to forecasting vary depending on the perspective of each scientific method applied for decision-making. This technique produces future projections, a foundation for more intelligent business planning and decision-making. Since every organization must contend with future uncertainties, the need for accurate predictions becomes critically essential [8].

2.4. Simple Exponential Smoothing

The Simple Exponential Smoothing method is a forecasting technique that continuously updates predictions based on recent data by assigning greater weight to the most current data and exponentially decreasing the weight of older data. This method employs a smoothing parameter that determines how much previous observations influence the forecast. The predictions' accuracy depends on the data's reliability, the relevance of the variables being forecasted, and the chosen analytical preferences. As a result, this approach produces forecasts more responsive to changes than relying solely on historical patterns, which seldom repeat entirely in the future [9].

As an extension of the moving averages method, Single Exponential Smoothing offers a more dynamic approach to refining predictions based on recent observations. This method continuously recalculates forecasts using the most recent data to produce more accurate predictions. Each data point is assigned a weight in this process, with newer data receiving greater weight than older data. These weights are controlled by the smoothing parameter known as alpha (α). The α parameter ranges between 0 and 1 and determines the influence of the latest data on the forecast outcome. The value of α is typically determined experimentally (through trial and error) to find the value that minimizes forecast error, thereby enhancing prediction accuracy [10].

The Single Exponential Smoothing method is a simple yet effective forecasting technique for data that does not exhibit trend or seasonal patterns. This method assigns greater weight to the most recent data while gradually reducing the weight of earlier data exponentially. Forecast calculations are performed using the following formula:

$$S\_t = \alpha \cdot X\_t + (1-\alpha) \cdot S\_(t-1) \quad \text{……………………………………………………………………………………………………(1)}$$

Where :
S_t: Smoothed value (forecast) for the current period
X_t: Actual data value in the current period
S_{t-1}: Smoothed value (forecast) from the previous period
α : Smoothing parameter $(0 < \alpha < 1)$

2.5. Weighted Moving Average (WMA)

The Weighted Moving Average method, often called the weighted moving average approach, involves assigning specific weights to each historical data point used in the analysis. These weights are typically determined by management or data analysts and are generally subjective. The assignment of weights is based on experience, intuition, and established policies, with no fixed rules governing how weights should be allocated. The primary goal of assigning weights is to emphasize data that is considered more significant in the forecasting process.

Each historical data point is assigned a different weight in this method, with the highest weight typically given to the most recent data. This is based on the assumption that newer data is more relevant for predicting future conditions than older data. Therefore, the WMA method emphasizes the importance of recent data in the forecasting process, as it is more likely to reflect current conditions that are more relevant and accurate than data from the distant past [11]. The formula used in the Weighted Moving Average method is as follows :

$$WMA = \frac{(P_t \times n) + (P_{t-1} \times (n-1)) + (P_{t-2} \times (n-2))}{n + (n-1) + (n-2)} \quad \text{...(2)}$$

Where :
P_t : Price on day *t*
P_{t-1} : Price on day *t - 1*
P_{t-2} : Price on day *t - 2*
n : WMA Period

2.6. Evaluation Metrics

Evaluation metrics are measures or parameters used to assess the performance or accuracy of a model or algorithm in predicting or classifying data. These metrics help us understand how well or poorly the model handles a specific task. By using evaluation metrics, we can gain insight into how closely the model's predictions align with the actual values in the data, enabling us to assess the model's reliability and accuracy.

Using appropriate evaluation metrics is crucial to ensure the developed model performs adequately and is dependable for the intended task. In addition to RMSE (Root Mean Square Error) and MAPE (Mean Absolute Percentage Error), various other evaluation metrics are available, which can be selected based on the specific characteristics and requirements of the task or data being analyzed.

1. Mean Absolute Error (MAE)

   Mean Absolute Error is a metric used to evaluate the performance of a model in various machine learning and statistical applications, particularly in regression contexts. MAE calculates the average of the absolute differences between the values predicted by the model and the actual observed values. It provides a measure of how far, on average, the model's predictions deviate from the exact values without considering the direction of the error (whether the projections are higher or lower than the actual values). MAE is often used because it is easy to interpret: the smaller the MAE, the better the model's performance, as it indicates that the predictions are closer to the actual values. The formula for MAE is as follows :

   $$MAE = \frac{\sum |Y_i - \hat{Y}_i|}{n} \quad \text{...(3)}$$

   Where :
   Y_i : Price actual on period *i*
   $\hat{Y}_i$: Price prediction on period *i*
   n : Number of data points

2. Mean Absolute Percentage Error (MAPE)

   Mean Absolute Percentage Error is an evaluation metric that measures the average percentage error of predictions relative to actual values by calculating the mean of the absolute percentage errors between predicted and actual values. The formula for MAPE is as follows:

   $$100 \times \frac{1}{n} \sum_{i=1}^{n} \left| \frac{\tilde{y}i - yi}{yi} \right| \quad \text{...(4)}$$

   Where :
   $\tilde{y}i$: Prediction Price
   yi : Actual Price
   n : Number of data points

3. Research Method

The research process for predicting Netflix stock prices using the Simple Exponential Smoothing and Weighted Moving Average methods involves six main steps. First, a literature study explores theories and methodologies related to stock price forecasting and historical data analysis. Next, the requirement analysis phase identifies the data and tools needed, such as the Netflix stock dataset from 2019 to 2024. The system design stage outlines the forecasting models and computational frameworks for SES and WMA. The methods are applied to the dataset in the system implementation phase, and predictions are generated. The system testing step evaluates the accuracy and performance of both methods using metrics such as MAE, RMSE, and MAPE. Finally, the research concludes with a summary of findings, highlighting the effectiveness of the SES and WMA methods in predicting Netflix stock price movements.

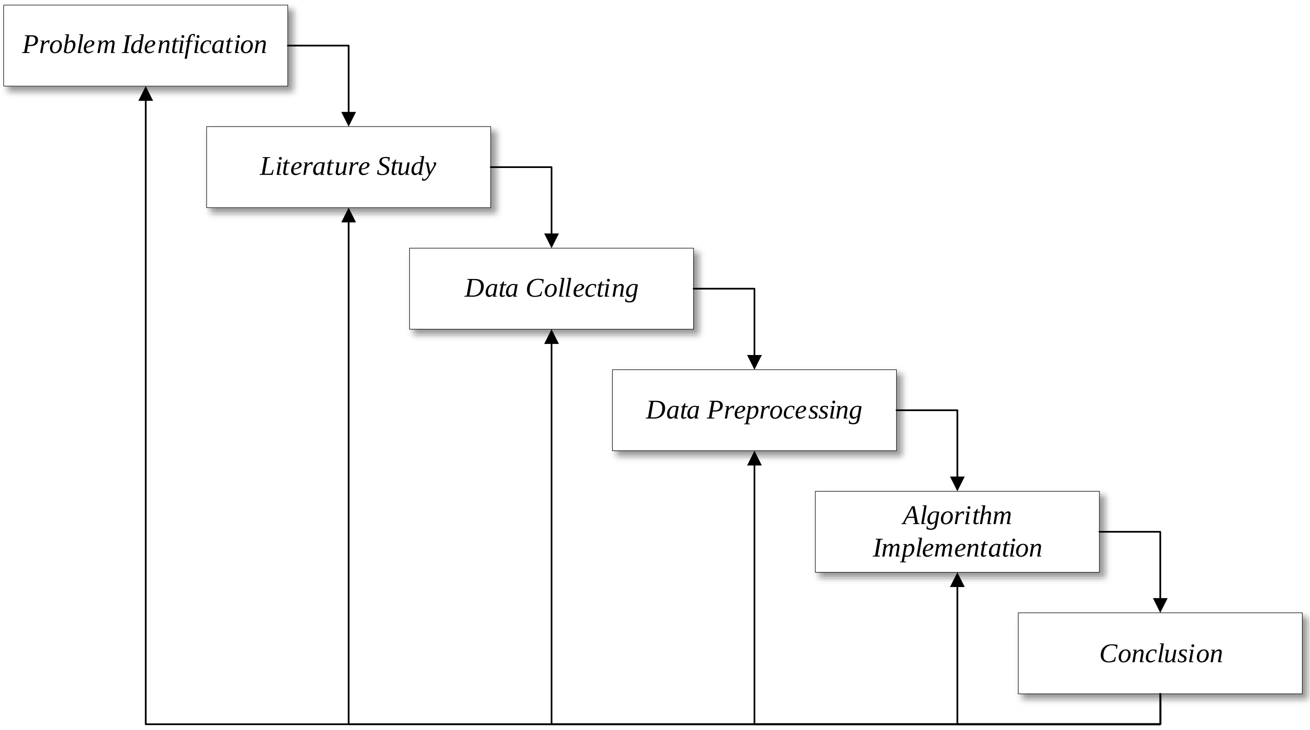


Fig 1. Research Flow Diagram

3.1. Problem Analysis

Predicting stock price movements is often a complex challenge due to unexpected price fluctuations and the influence of various external factors. To address this complexity, practical methods for data analysis are required. The Simple Exponential Smoothing (SES) and Weighted Moving Average methods are two algorithms that can be utilized to predict stock price movements. These methods offer a more straightforward yet practical approach to understanding stock price trends, such as those of Netflix stock, by leveraging historical data from 2019–2024.

3.2. Dataset

This study's dataset or historical data was obtained from a stock data platform, finance.yahoo.com. The data focuses on Netflix stock, identified by the ticker symbol NFLX. Netflix stock was selected due to its status as a leading technology stock with intriguing volatility, making it an interesting subject for analysis. The dataset covers Netflix stock prices from 2019 to 2024, which will be utilized to apply the Simple Exponential Smoothing (SES) and Weighted Moving Average methods to predict its price movements. The timeframe spans the past six years, specifically from 2019-01-01 to 2024-11-30.

Table 1. Research Dataset

No	*Date*	*Close*
1	2019-01-02	267.66
2	2019-01-03	271.2
3	2019-01-04	297.57
4	2019-01-07	315.34
5	2019-01-08	320.27
…	…	…
1485	2024-11-22	897.79

1486	2024-11-25	865.59
1487	2024-11-26	872.6
1488	2024-11-27	877.34
1489	2014-11-29	886.81

The dataset used in this study consists of daily stock prices of Netflix (ticker: NFLX) retrieved from the platform finance.yahoo.com, covering 6 years from January 1, 2019, to November 30, 2024. This dataset comprises 1,489 entries, recording the daily closing prices of Netflix stock, which reflect the stock's value at the end of each trading day. During this period, Netflix stock exhibited significant price variations, starting at $267.66 in early 2019 and reaching $886.81 by the end of November 2024.

4. Result and Discussion

4.1. Prediction Results Analysis SES

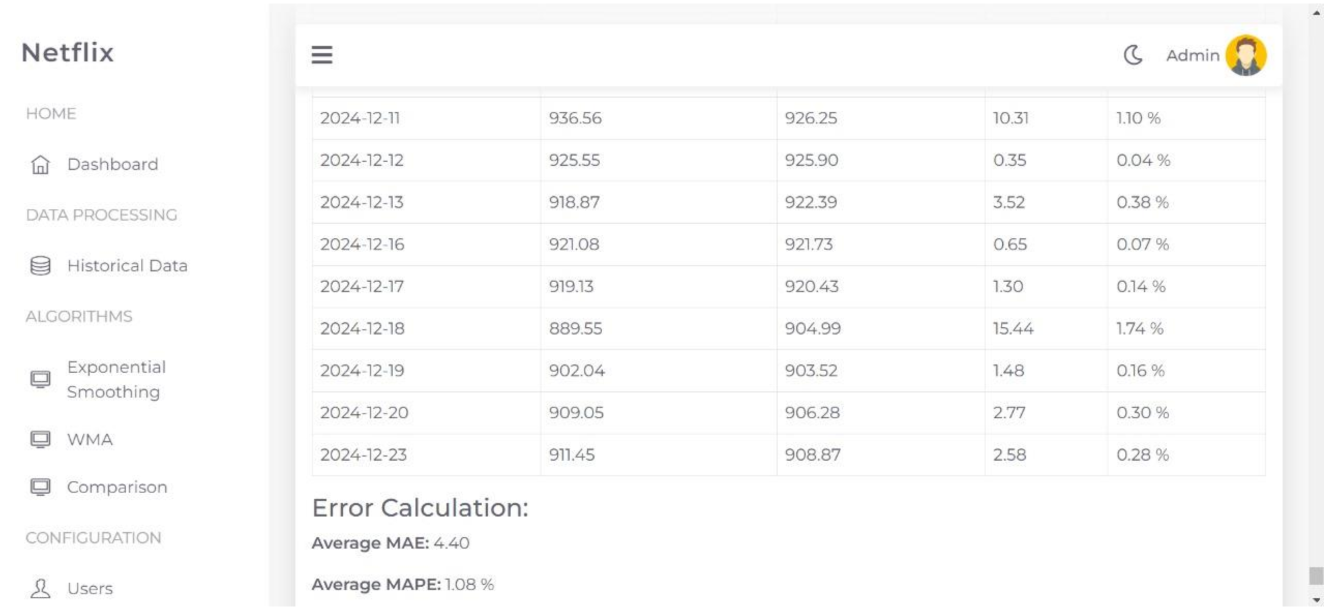


Fig 2. Prediction Result Simple Exponential Smoothing

The prediction results using the Simple Exponential Smoothing method with a smoothing factor (α=0.5) demonstrate a relatively high level of accuracy. The average Mean Absolute Error of 4.40 and Mean Absolute Percentage Error of 1.08% indicate that the predictions exhibit relatively small errors compared to the actual values. The predicted data closely aligns with the exact values, with very low percentage error fluctuations, highlighting that this method effectively captures historical data patterns to forecast Netflix stock prices accurately.

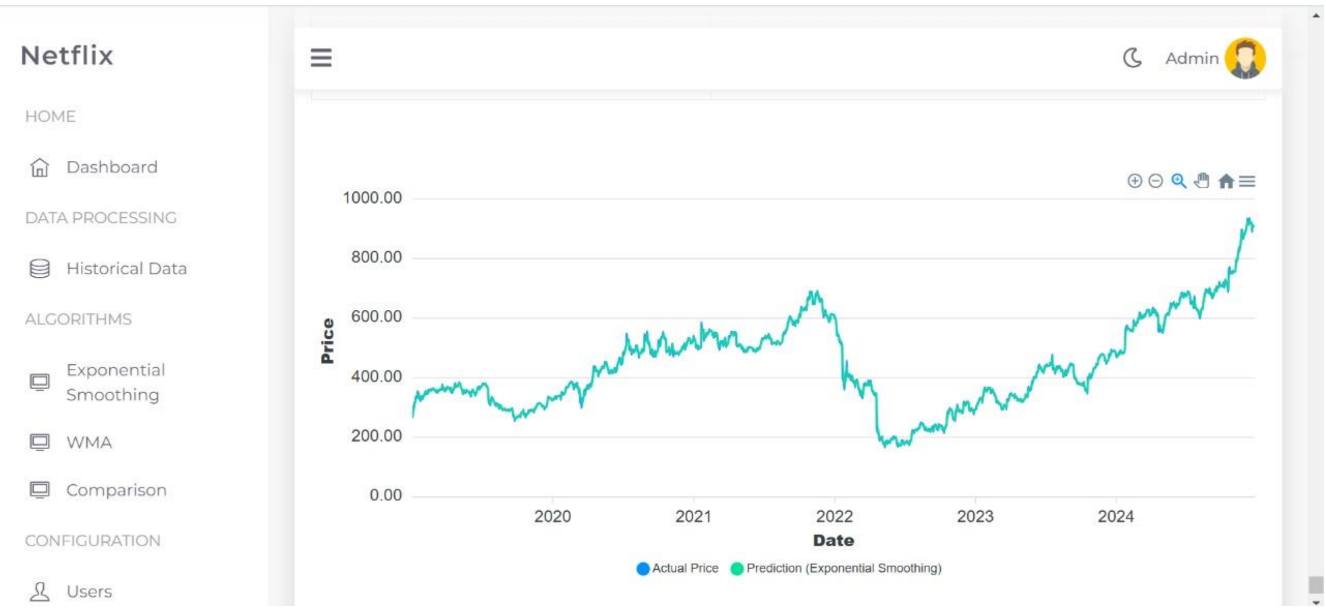


Fig 3. Graph Prediction of SES

The prediction graph compares the actual Netflix stock prices and the predicted results using the Simple Exponential Smoothing (SES) method. The blue curve represents the exact prices, while the green curve reflects the expected values. Overall, the graph demonstrates that SES predictions successfully follow the general pattern of stock price movements, including the fluctuations observed during the analysis period. These results indicate that the SES method can provide reasonably accurate estimates for historical data, although minor deviations are evident at the peaks of extreme fluctuations. This visualization facilitates understanding the method's effectiveness in capturing trends and movements in Netflix's stock prices.

4.2. Prediction Results Analysis WMA

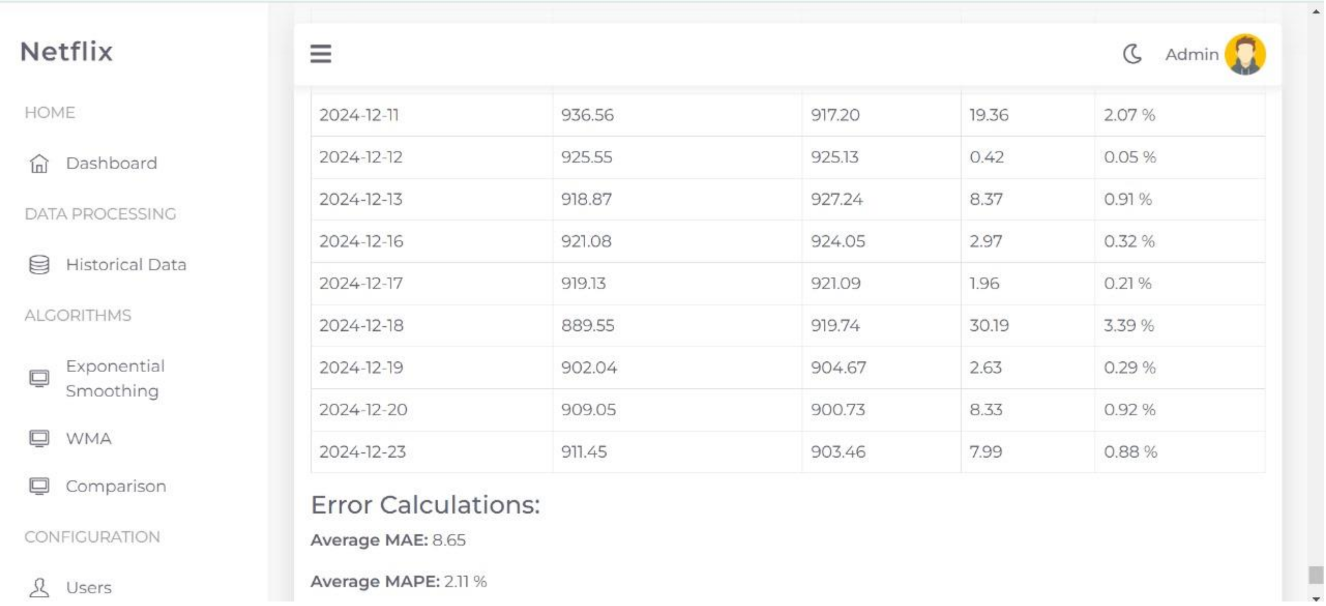


Fig 4. Prediction Result Weighted Moving Average

The prediction results using the Weighted Moving Average method with a moving period of 3 show an average Mean Absolute Error (MAE) of 8.65 and a Mean Absolute Percentage Error of 2.11%. These results indicate that WMA provides reasonably good estimates with slightly higher deviations than other methods. WMA tends to assign greater weight to recent data, making it more responsive to recent price changes. However, for data with large fluctuations, the percentage error tends to be higher, as observed on specific dates, such as December 18, 2024, with a MAPE of 3.39%. Overall, WMA effectively captures Netflix stock price movements, particularly for short-term pattern changes.

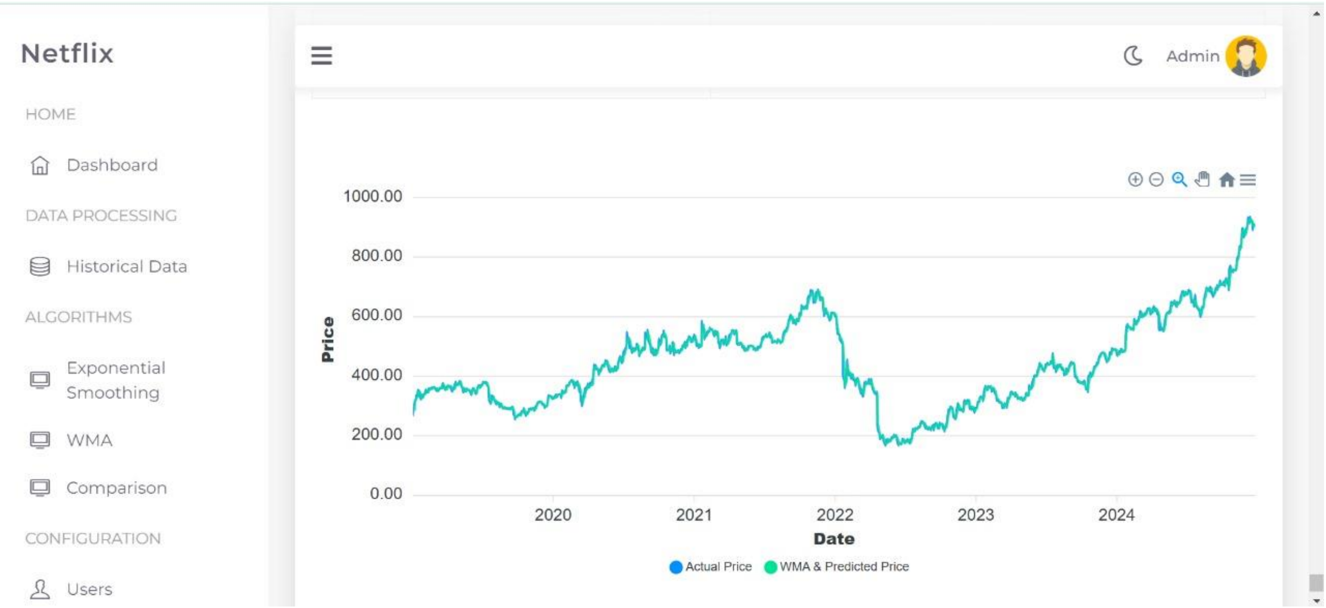
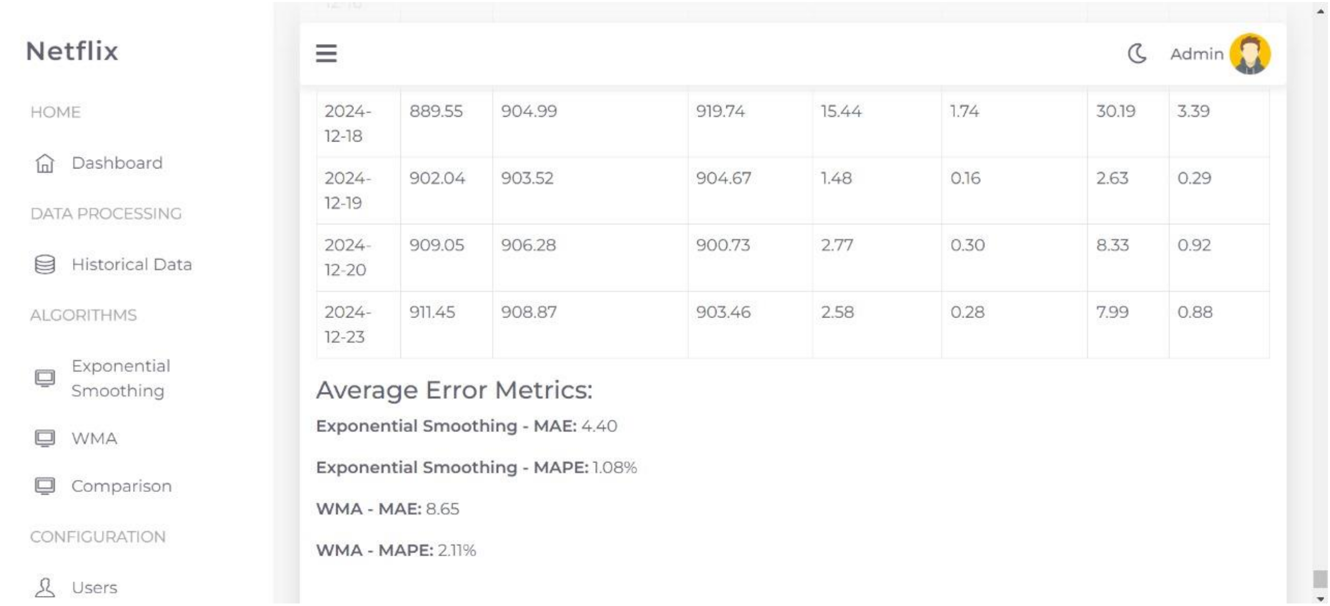


Fig 5. Graph Prediction of WMA

The graph compares Netflix stock prices and the predicted results using the Weighted Moving Average method with a moving period of 3. The blue curve represents the exact prices, while the green curve shows the WMA predictions. The graph demonstrates that the WMA predictions generally succeed in following the pattern of actual price movements, particularly for more stable trend changes. However, slight discrepancies are observed at points with extreme fluctuations, where the WMA predictions require time to adjust to significant changes. These results confirm that WMA is more effective in capturing short-term trends by assigning greater weight to recent data. This graph clearly visualizes WMA's effectiveness in analyzing stock price movements.

4.3. Result Prediction Comparison SES & WMA



2024-12-18	889.55	904.99	919.74	15.44	1.74	30.19	3.39
2024-12-19	902.04	903.52	904.67	1.48	0.16	2.63	0.29
2024-12-20	909.05	906.28	900.73	2.77	0.30	8.33	0.92
2024-12-23	911.45	908.87	903.46	2.58	0.28	7.99	0.88

Average Error Metrics:
Exponential Smoothing - MAE: 4.40
Exponential Smoothing - MAPE: 1.08%
WMA - MAE: 8.65
WMA - MAPE: 2.11%

Fig 6. Result Prediction WMA & SES

The comparison of the two methods reveals that Simple Exponential Smoothing achieves better accuracy than Weighted Moving Average. Based on the average error values, SES produces a Mean Absolute Error of 4.40 and a Mean Absolute Percentage Error (MAPE) of 1.08%, indicating highly accurate predictions with minimal error. Meanwhile, WMA shows an MAE of 8.65 and a MAPE of 2.11%, which, although still reasonably accurate, are higher than those of SES. These results demonstrate that SES is superior in capturing historical data patterns by assigning greater weight to recent data. In contrast, WMA remains a good option for capturing short-term changes but is less optimal for data with large fluctuations. This comparison highlights the advantage of SES in delivering predictions with lower error rates.

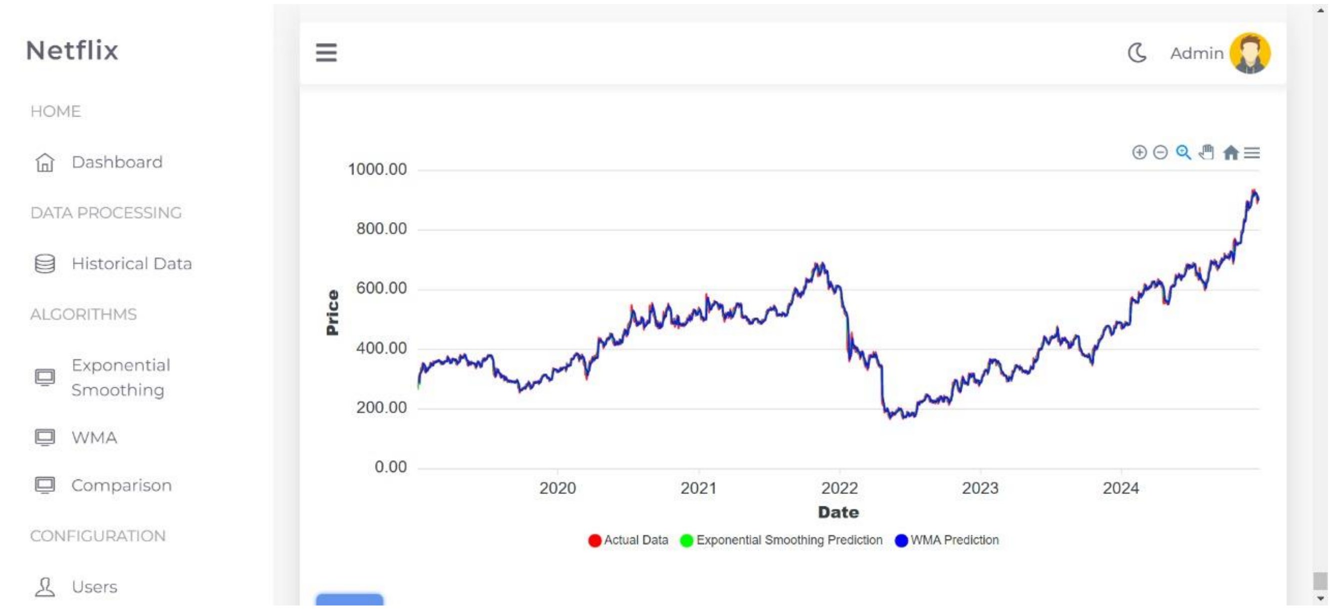


Fig 7. Graph Prediction SES vs SES

This graph compares the Netflix stock prices and the predicted results using the Simple Exponential Smoothing and Weighted Moving Average methods. The red curve represents the actual stock prices, the green curve shows the SES predictions, and the blue curve reflects the WMA predictions. Visually, both SES and WMA successfully follow the general pattern of stock price movements. However, SES predictions appear closer to the actual data compared to WMA, particularly at points with more extreme price fluctuations. This aligns with the error metrics, where SES achieved a lower MAPE (1.08%) than WMA (2.11%), indicating that SES is more accurate for this dataset. This graph provides a clear depiction of the performance of each method in forecasting stock prices based on historical data.

5. Conclusion

Several conclusions can be drawn based on implementing and comparing two prediction methods, Simple Exponential Smoothing and Weighted Moving Average, in forecasting Netflix stock prices from 2019 to 2024. The developed stock prediction system, utilizing SES and WMA, successfully provides future stock price estimates based on historical data with satisfactory performance. The system can display predictions, accuracy evaluations, and interactive data visualizations, facilitating user analysis of stock price patterns. Error metrics calculations indicate that SES outperforms WMA in prediction accuracy, with SES achieving a Mean Absolute Error of 4.40 and a Mean Absolute Percentage Error of 1.08%, compared to WMA's MAE of 8.65 and MAPE of 2.11%. These results demonstrate that SES is more effective for predicting Netflix stock prices due to its lower error rates, particularly for historical data with less volatile patterns.

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