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Enhancing Sales Prediction Accuracy: A Hybrid Model of Single Exponential Smoothing and Golden Section Search

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ABSTRACT

Accurate sales forecasting is a component in inventory management, particularly for determining appropriate stock levels for upcoming periods. Forecasting inaccuracies may result in overstocking or understocking, leading to increased operational costs and decreased service quality to customers. In practice, many retail businesses still encounter difficulties in producing reliable sales forecasts due to fluctuating demand patterns and the use of forecasting methods with suboptimal parameter selection. Single Exponential Smoothing (SES) is widely used because of its simplicity and ease of implementation; however, its forecasting performance is highly dependent on the choice of the smoothing parameter (alpha), which is often determined using a trial-and-error approach. This study proposes a hybrid forecasting approach that combines Single Exponential Smoothing with Golden Section Search to enhance sales prediction accuracy. Golden Section Search is employed as a numerical optimization technique to systematically determine the optimal alpha value by minimizing forecasting errors measured using Mean Absolute Percentage Error (MAPE). The proposed approach is applied to sales data from XYZ as a case study using varying lengths of historical data, namely 3 months, 6 months, 12 months, 24 months, and 36 months. The results demonstrate that the proposed hybrid method is capable of producing forecasts with a good level of accuracy, particularly for short-term forecasting. The lowest MAPE value of 7.02% is achieved when using 3 months of historical data, indicating high responsiveness to recent demand changes. As the length of historical data increases, the model tends to become more stable but less responsive to trend fluctuations, resulting in higher error values. Overall, the proposed approach is effective in supporting inventory management decision-making by providing accurate and reliable sales forecasts.

1. Introduction

Forecasting is a commonly used approach to estimate future conditions, especially in the context of sales forecasting. Sales forecasting aims to determine the estimated number of sales[1] , identify market potential, and support strategic decision making, such as inventory planning, procurement, and marketing strategy development. Accurate forecasting information is very important for companies because it can minimize the risk of excess or shortage of stock, optimize resource utilization, and increase customer satisfaction through the availability of products that match market needs.

In practice, many retail businesses still face problems in determining the amount of stock for the next period. Erratic demand fluctuations, limited historical data analysis, and the use of sub-optimal forecasting methods often lead to inefficient stock preparation. This condition can have an impact on the company's operational and financial performance, both in the form of lost sales opportunities due to stock shortages and increased storage costs due to excess stock. Therefore, the application of reliable sales forecasting methods is an important requirement in inventory management.

This problem is also experienced by XYZ, a retail store engaged in the sale of consumer goods. XYZ has difficulty in determining the number of accurate stock items to support the procurement process. Without effective sales forecasting, stock preparation is often not aligned with actual demand conditions[2] . This makes XYZ a relevant case study to evaluate the application of sales forecasting methods in supporting data-driven inventory management decision making.

One method that is widely used for short-term sales forecasting is Single Exponential Smoothing (SES). This method uses exponential weighting by giving greater weight to the most recent data so that it is relatively responsive to changes in data patterns[3], [4] . The simplicity of calculation makes the SES method widely applied in practice. However, the performance of this method is strongly influenced by the selection of the smoothing parameter value (alpha). Determining an inappropriate alpha value can cause the forecasting results to be less accurate[5], [6] . In many implementations, the alpha value is still determined using a trial and error approach, which is subjective and does not guarantee the optimal parameters are obtained.

To overcome these problems, this research proposes a hybrid approach by combining the Single Exponential Smoothing and Golden Section Search methods. Golden Section Search is a numerical optimization method used to determine the optimal alpha value by minimizing the level of forecasting error measured using Mean Absolute Percentage Error (MAPE)[7], [8] . This approach allows the optimization process to be carried out systematically and efficiently. The contributions of this research include the application of a sales forecasting model based on the SES-Golden Section Search hybrid approach, improving forecasting accuracy through alpha parameter optimization, and evaluating model performance using XYZ sales data as a real case study.

2. Method

Single Exponential Smoothing Method

Single exponential smoothing is a forecasting method that uses a data weighting approach that aims as an exponential function. In using this forecasting method, the latest data is needed as a model for a continuous calculation so that the new category of data gets a large weighted value[9] . Forecasting is part of management decision making. The need for forecasting is in line with management's efforts to reduce dependence on things that are uncertain[10] and with this forecasting can estimate how many needs in the future period will be and include quality, quantity, place and time to meet the demand for goods and services. Exponential smoothing is a forecasting method that moves with a sophisticated weighted average, but is still easy to use[11] . Single Exponential Smoothing can forecast data up and down around the Mean value without any consistent trend or pattern of increase. The exponential smoothing equation can be written as follows:

$$F_t = \alpha \, X_{t-1} + (1-\alpha) F_{t-1} \qquad (1)$$

Description:
F_t = Forecasting in period t
X_{t-1} = Real value in period t-1
α = Weight indicates smoothing constant ($0 < \alpha$)
F_{t-1} = Forecasting in period t-1

Golden Section Optimization

Optimization is a term often used to minimize or maximize a function. Golden section is an optimization method that uses the principle of reducing the boundary region x that may produce the optimum objective function price (maximum or minimum) iteratively[12] . The specialty of the golden section is that it can be known how many iterations will be done when the known value ε is known[13] . Golden section is an approach used to find the domain that produces the optimal function in univariate. This approach uses the principle of elimination method, which reduces the area that may contain the optimal function iteratively. This method can also be used for bivariate and multivariate problems by applying the approach to one variable at a time. Determining the optimal forecasting parameters in the exponential smoothing method using the golden section, the objective function is the size of the forecasting error and the problem at hand is the problem of minimizing .[14]

In the golden section method, suppose the minimum value is in the interval [a,b] of length h, it will require the value of R to determine two symmetric points in the interval.[15] . The value of R can be determined by the following formula illustrated in figure 1.

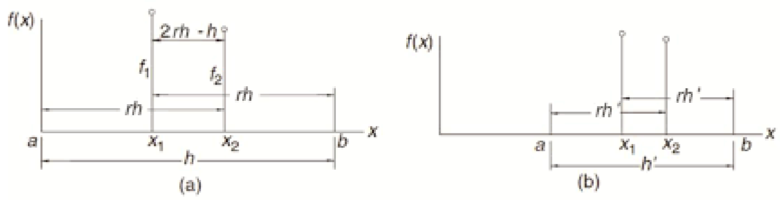

Figure 1. Illustration of *Golden Section*

Assuming that $f_{(1)} > f_{(2)}$ then $a=x_1$ and $x_1 = x_{(2)}$ which will create a new interval (a,b) of length h'=rh. To go to the next stage of operation by calculating the function x_2=a+rh' and repeating the process. From the figure, it can be seen that $x_{(1)} - x_{(2)}$ = 2rh-h and the same distance from the formula after determining the first point is x_1-a=h'-rh' and is explained as follows:

2rh - h = h - rh', Substitute h' = rh

$$2r - 1 = r(1 - r) \quad (2)$$

From the above formula, the equation is obtained:

$$r^2 + r - 1 = 0 \quad (3)$$

By solving the above equation, we get:

$$r1 = \frac{-1+\sqrt{5}}{2} = 0.618 \quad (4)$$

$$r2 = \frac{-1-\sqrt{5}}{2} = -1.618 \quad (5)$$

In order for the interval to be smaller, the condition 0 < r < 1 is required, so the value used is r1, which is 0.618.

The lower limit (a) and upper limit (b) used in this study are a = 0 and b = 9 because the range of alpha values is between 0 and 1. The formula for $alpha_1$ is r*a+(1-r)*b and the formula for $alpha_2$ is (1-r)*a+r*b. After getting the $alpha_1$ and $alpha_2$ values, find the minimum MAPE from the calculation results of the combination of alpha 1 and alpha 2. Reduce the interval limit based on the Golden Section criteria. Repeat the steps above until $|alpha_2 - alpha_1| \leq$ eps (iteration stop tolerance). The eps value used is 0 because the lower bound (a) is 0. Find the minimum MAPE between the combination of a, b, alpha 1, alpha 2. The output alpha is the optimal one.

3. Results and Discussions

Golden Section Calculation

The Golden Section method in this study is used to determine the most optimal alpha value to be used in performing the single exponential smoothing forecasting calculation process. The first thing that needs to be done to calculate the alpha value using the golden section method is to determine the value of r. The following is the calculation of the value of r:

$$r1 = \frac{-1+\sqrt{5}}{2} = 0.618$$

$$r2 = \frac{-1-\sqrt{5}}{2} = -1.618$$

In order for the interval to be smaller, the condition 0 < r < 1 is required, so the value used is r1, which is 0.618. After getting the value of r, the next step is to determine the lower limit (a) and upper limit (b). The lower limit (a) and upper limit (b) used in this study are a = 0 and b = 1 because the range of alpha values is between 0 and 1. After that, we can start determining the alpha1 and alpha2 values which will later be used to calculate the MAPE alpha1 and MAPE alpha2 values.

The calculation of $alpha1_1$is as follows:

$$alpha1_1 = r * a + (1 - r) * b$$
$$alpha1_1 = 0.618 * 0 + (1 - 0.618) * 1$$
$$alpha1_1 = 0 + 0.382 * 1$$
$$alpha1_1 = 0.382$$

The calculation of $alpha2_2$is as follows:

$$alpha2_1 = (1 - r) * a + r * b$$
$$alpha2_1 = (1 - 0.618) * 0 + 0.618 * 1$$
$$alpha2_1 = 0.618$$

The calculation of MAPE $alpha1_1$produces a MAPE value of 12.2846%. The MAPE calculation of $alpha2_1$results in a MAPE value of 13.1653%. Because the MAPE value of $alpha2_1$> MAPE $alpha1_1$, the value of a = 0 and b = 0.618. The iteration stop tolerance value (eps) for the first iteration is 0.618 - 0.382 = 0.236. Next, we calculate alpha1, alpha2, MAPE alpha1 and MAPE alpha2 for the 2nd iteration.

The calculation of $alpha1_2$is as follows:

$$alpha1_2 = r * a + (1 - r) * b$$
$$alpha1_2 = 0.618 * 0 + (1 - 0.618) * 0.618$$
$$alpha1_2 = 0 + 0.382 * 0.618$$
$$alpha1_2 = 0.2361$$

Calculation of $alpha2_2$is as follows:

$$alpha2_2 = (1 - r) * a + r * b$$
$$alpha2_2 = (1 - 0.618) * 0 + 0.618 * 0.618$$
$$alpha2_2 = 0.3819$$

The calculation of MAPE $alpha1_2$results in a MAPE value of 12.3167%. The calculation of MAPE $alpha2_2$results in a MAPE value of 12.2845%. Because the MAPE value of $alpha1_1$> MAPE $alpha2_1$, the value of a = 0.2361 and b = 0.618. The iteration stop tolerance value (eps) for the first iteration is 0.3819 - 0.2361 = 0.1458. After that the calculation process continues until the iteration stop tolerance value (eps) reaches 0.000. Details of the calculation with the Golden Section method can be seen in table 1.

Table 1. Golden Section

Iteration	a	b	alpha1	alpha2
1	0	1	0.3820	0.6180
2	0	0.6180	0.2361	0.3819
3	0.2361	0.6180	0.3820	0.4721
4	0.2361	0.4721	0.3262	0.3819
5	0.2361	0.3819	0.2918	0.3262
6	0.2918	0.3819	0.3262	0.3475
7	0.2918	0.3475	0.3131	0.3262
8	0.2918	0.3262	0.3049	0.3131
9	0.3049	0.3262	0.3131	0.3181
10	0.3049	0.3181	0.3100	0.3131
11	0.3100	0.3181	0.3131	0.3150
12	0.3100	0.3150	0.3119	0.3131
13	0.3119	0.3150	0.3131	0.3138
14	0.3131	0.3150	0.3138	0.3143
15	0.3131	0.3143	0.3135	0.3138
16	0.3135	0.3143	0.3138	0.3140

17	0.3138	0.3143	0.3140	0.3141
18	0.3138	0.3141	0.3139	0.3140
19	0.3138	0.3140	0.3139	0.3139
Iterations	MAPE		EPS	
	f(alpha1)	f(alpha2)		
1	12.2846%	13.1653%	0.2360	
2	12.3167%	12.2845%	0.1458	
3	12.2845%	12.4550%	0.0901	
4	12.2490%	12.2845%	0.0557	
5	12.2525%	12.2490%	0.0344	
6	12.2490%	12.2573%	0.0213	
7	12.2477%	12.2490%	0.0131	
8	12.2484%	12.2477%	0.0081	
9	12.2477%	12.2478%	0.0050	
10	12.2478%	12.2477%	0.0031	
11	12.2477%	12.2477%	0.0019	
12	12.2477%	12.2477%	0.0012	
13	12.2477%	12.2477%	0.0007	
14	12.2477%	12.2477%	0.0005	
15	12.2477%	12.2477%	0.0003	
16	12.2477%	12.2477%	0.0002	
17	12.2477%	12.2477%	0.0001	
18	12.2477%	12.2477%	0.0001	
19	12.2477%	12.2477%	0.0000	

3 Month Data Forecasting

The first forecasting results with 3 months of data using the Single Exponential Smoothing (SES) method with Golden Section optimization show that the model is able to provide fairly accurate predictions of sales data. Based on the forecasting table, the actual sales value in October 2023 was 46, which was used as the initial forecast value. In the following month, November 2023, there was a decrease in sales to 38, while the forecast was still at 46, indicating that the model needed time to adapt to the change in trend. In December 2023, the forecast adjusted to 42, which is closer to the actual value of 42.

Table 2. 3-Month Forecasting Results

Month	Actual Data	Forecast
October 2023	46	46
November 2023	38	46
December 2023	42	42

The forecasting result for January 2024 is then projected to remain at 42. Alpha optimization using Golden Section Search resulted in a value of 0.49999, which shows a balance between maintaining historical trends and adjusting to recent data changes. In the Single Exponential Smoothing method, smaller alpha values tend to maintain historical patterns more stably, while larger alpha is more responsive to recent data changes. With this optimal alpha value, the model can adapt moderately without being too sensitive to random fluctuations. Evaluation of the forecasting error using Mean Absolute Percentage Error (MAPE) resulted in a value of 7.02%, which indicates a fairly low error rate. Based on the evaluation standard, MAPE below 10% is categorized as excellent forecasting.

6 Months Data Forecasting

Based on the second forecasting results using 6 months of data using the Single Exponential Smoothing (SES) method with Golden Section optimization, forecasting for the last six months shows that the model has adapted to changes in sales trends. Actual and forecast data from July to December 2023 show that the model starts to adjust the forecasting results after a few months. In July 2023, the forecast was taken from the actual value of 37, and in August 2023, the model began to respond by increasing the forecast to 37, even though the actual data rose to 39. A significant change was seen in September 2023, where the actual data jumped to 49, and the forecast began to increase to 38,427. The model continued to adjust to these changes, especially when it faced a sharp drop in November 2023, where the actual data dropped to 38 while the forecast was still at 46. By December 2023, the model was finally closer to the actual value with a forecast of 40,271.

Table 3. 6-Month Forecasting Results

Month	Actual Data	Forecast
July 2023	37	37
August 2023	39	37
September 2023	49	38.427
October 2023	46	46
November 2023	38	46
December 2023	42	40.271

The forecasting result for January 2024 is 41,509**.** Alpha optimization using Golden Section Search resulted in a value of 0.7161, which indicates that the model is more responsive to recent data changes. This high alpha value allows the forecast to adjust more quickly to fluctuating sales patterns. This can be seen from how the model adjusted the forecast after significant changes in September and November. Evaluation of the forecasting error with Mean Absolute Percentage Error (MAPE) shows a value of 8.64%, which is still in the good category.

12-Month Data Forecasting

Based on the forecasting results using the Single Exponential Smoothing (SES) method with Golden Section optimization, the forecasting data for the past 12 months shows a fairly stable pattern with some fluctuations in sales trends. In January 2023, the initial forecast was taken from the actual data of 48, but the model began to adjust the prediction after a decline in February and March 2023. In March, the actual data dropped to 40, while the forecast was still at 47,705, indicating that the model needed time to adjust to the change in trend.

In the following months, the model started to be more responsive to the data patterns, with the forecast adjustments getting closer to the actual values. For example, in June 2023, the actual data was 45, and the forecast came close with 43,863. However, in July and August, when there were fluctuations where the actual data dropped to 37 and then rose again to 39, the forecast still experienced delays in adjusting. In September 2023, the spike in actual data to 49 began to be accommodated by the model by raising the forecast to 41.17. By December 2023, the model shows improvement with a forecast of 42,387, which is quite close to the actual data of 42.

Table 4. 12-Month Forecasting Results

Month	Actual Data	Forecast
January 2023	48	48
February 2023	47	48
March 2023	40	47.705
April 2023	47	45.434
May 2023	39	45.896
June 2023	45	43.863
July 2023	37	44.198
August 2023	39	42.007
September 2023	49	41.17
October 2023	46	43.478
November 2023	38	44.221
December 2023	42	42.387

The forecasting result for January 2024 is 42,273. Alpha optimization using the Golden Section Search method resulted in a value of 0.2947, which indicates that the model is more likely to maintain historical patterns and is less reactive to recent data changes. This smaller alpha value makes the model more stable, but also causes a delay in capturing sudden changes in sales trends. Evaluation of the forecasting error using Mean Absolute Percentage Error (MAPE) resulted in a value of 9.25%, which is still in the good category and acceptable in business forecasting. The MAPE being close to 10% indicates that the model has fairly good accuracy.

24-Month Data Forecasting

Based on the results of forecasting for 24 months using the Single Exponential Smoothing (SES) method with Golden Section optimization, the model shows a stable adaptation pattern with a fairly good level of accuracy. In January 2022, the initial forecast was set equal to the actual data of 35. However, when there was a spike in actual data in February 2022 to 46, the model still maintained the forecast at 35, indicating a delay in capturing sudden changes. Over time, the model began to adjust to the pattern of data fluctuations, such as in June 2022, where the forecast remained at 37, even though the actual data increased to 46.

Entering 2023, the model continued to undergo adjustments, with the forecast getting closer to the actual data. For example, in January 2023, the forecast was 41,129, which was still lower than the actual data of 48, but the model began to gradually increase the prediction. This trend continues until the end of 2023, with a December forecast of 42,402, which is quite close to the actual data of 42.

Table 5. 24-Month Forecasting Results

Month	Actual Data	Forecast
January 2022	35	35
February 2022	46	35
March 2022	35	36.911
April 2022	39	36.579
May 2022	37	37
June 2022	46	37
July 2022	39	38.564
August 2022	49	38.639
September 2022	37	40.44
October 2022	49	39.842
November 2022	35	41.433
December 2022	45	40.315
January 2023	48	41.129
February 2023	47	42.323
March 2023	40	43.136
April 2023	47	42.591
May 2023	39	43.357
June 2023	45	42.6
July 2023	37	43.017
August 2023	39	41.972
September 2023	49	41.455
October 2023	46	42.766
November 2023	38	43.328
December 2023	42	42.402

The forecasting result for January 2024 is predicted to be 42,332. Alpha optimization using Golden Section Search resulted in a value of 0.1737, which indicates that the model is more likely to maintain historical patterns than to adjust aggressively to recent changes. This small alpha makes the model more stable and less sensitive to sudden spikes or drops in actual data. However, it also causes a delay in adjusting the forecast to rapidly changing data patterns. Evaluation of the forecasting error using Mean Absolute Percentage Error (MAPE) shows a value of 10.56%, which is still in the good enough category but higher than previous forecasts.

Forecasting 36 Months Data

Based on the results of forecasting for 36 months using the Single Exponential Smoothing (SES) method with Golden Section optimization, the model shows a fairly stable adaptation pattern with some significant fluctuations in actual data.

At the beginning of the period (January 2021), the actual data was 55, which became the initial basis for forecasting. However, when there was a decrease in February and March 2021 to 53 and 43, the model still maintained higher forecasts at 55 and 54, indicating that the model needed time to adjust to the drastic change in data.

Entering the middle of 2021 to 2022, the forecasts started to show better adjustments. For example, in May 2021, actual data 46 started to approach the forecast of 48, and in June 2021, actual data 50 was already quite close to forecast 48. However, a few months later, when large fluctuations occurred (such as September 2021 with actual data 43 and forecast 49), the model still showed delays in capturing the pattern of change.

In 2022, the model was more stable but still experienced some noticeable differences, especially when the actual data experienced sudden spikes or drops. For example, in January 2022, the forecast was still at 47, while the actual data dropped to 35, which caused a considerable forecasting error. However, by the end of 2022, the model started to be more accurate, such as in December 2022, where the actual data was 45 and the forecast was 41, showing smaller differences compared to previous months.

Entering 2023, the model adjusts more and more to the data trend. In January 2023, the actual data was 48 with a forecast of 42, and this pattern continued until December 2023, where the actual data was 42 and the forecast was 42, showing a better level of accuracy compared to previous years.

Table 6. 36-Month Forecasting Results

Month	Actual Data	Forecast
January 2021	55	55
February 2021	53	55
March 2021	43	54
April 2021	43	51
May 2021	46	48
June 2021	50	48
July 2021	44	48
August 2021	53	47
September 2021	43	49
October 2021	40	47
November 2021	54	45
December 2021	44	48
January 2022	35	47
February 2022	46	43
March 2022	35	44
April 2022	39	41
May 2022	37	40
June 2022	46	39
July 2022	39	41
August 2022	49	41

September 2022	37	43
October 2022	49	41
November 2022	35	44
December 2022	45	41
January 2023	48	42
February 2023	47	44
March 2023	40	45
April 2023	47	43
May 2023	39	45
June 2023	45	43
July 2023	37	43
August 2023	39	41
September 2023	49	41
October 2023	46	43
November 2023	38	44
December 2023	42	42

For January 2024, the forecasting result is predicted to be 42,148.Alpha optimization using the Golden Section Search method resulted in a value of 0.3139, which indicates that the model has moderate sensitivity to changes in the data. This alpha allows the model to adjust to changes in trend, but is not too aggressive in responding to sudden spikes or drops. Evaluation of the forecasting error using Mean Absolute Percentage Error (MAPE) shows a value of 12.25%, which is in the good enough category.

Based on the results of forecasting using the Single Exponential Smoothing (SES) method with Golden Section optimization, analysis is carried out on data with a time span of 3 months, 6 months, 12 months, 24 months, and 36 months. The results show that the performance of the model varies depending on the length of the data period used. In forecasting with 3 months of data, an optimal alpha value of 0.4999 was obtained with a MAPE error rate of 7.02%, and the forecasting result for January 2024 was 42,000. This model shows good accuracy with a low error rate, and is more responsive to trend changes due to the relatively high alpha value. Similarly, for 6-month forecasting, where a higher alpha value (0.7161) causes the model to adapt more quickly to changes in the data, but the error rate increases to 8.64%, with a forecast result of 41,509 for January 2024.

As the amount of historical data used increases, the model becomes more stable but experiences an increase in the error value. At 12-month forecasting, a smaller alpha value (0.2947) indicates that the model favors historical patterns over sudden changes, with a MAPE of 9.25% and a January 2024 forecasting result of 42,273. Meanwhile, at 24 months forecasting, the model is more stable with an alpha of 0.1737, but the error rate increases to 10.56%, and the January 2024 forecast result is 42,332. The model tends to maintain historical patterns, making it less responsive to trend changes that have occurred in recent months.

In forecasting with 36 months of data, the model shows the highest MAPE of 12.25%, with an alpha value of 0.3139 and a January 2024 forecasting result of 42,148. With more historical data, the model becomes slower in adjusting to changes in the data, causing the accuracy to decrease. Overall, Single Exponential Smoothing (SES) with Golden Section optimization is more suitable for short to medium term forecasting as it provides lower error rates and is more responsive to recent trend changes.

Table 7. MAPE Testing Results

Timeframe	Alpha Value	MAPE
3 months	0.49999	7.02%
6 months	0.7161	8.64%
12 months	0.2947	9.25%
24 months	0.1737	10.56%
36 months	0.3139	12.25%

Forecasting System Implementation

The forecasting page is designed to assist users in projecting the need for goods based on past sales data. An illustration of this page can be seen in the figure below:

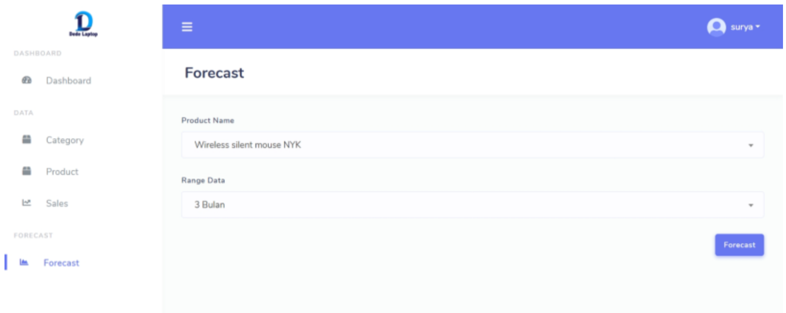

Figure 2. Forecasting Page

There is a form with several main components. The user can select the item to be predicted using the Item List dropdown, for example "Wireless silent mouse NYK". In addition, there is a Data Range dropdown that allows users to specify the time range of historical data to be used for analysis, such as "3 Months". After all options are filled in, the user can press the Forecast button to start the process of predicting the demand for goods. After the Forecast button is pressed, the system will begin to perform prediction calculations according to the goods and time range selected. The forecasting results are displayed in the form of a graph called the Forecasting Graph, which shows the comparison between Actual Data, which is the actual sales data, and Forecasting, which is the result of estimation from the system. This graph provides a clear visual picture of the conformity or difference between historical data and prediction results, making it easier for users to analyze sales patterns.

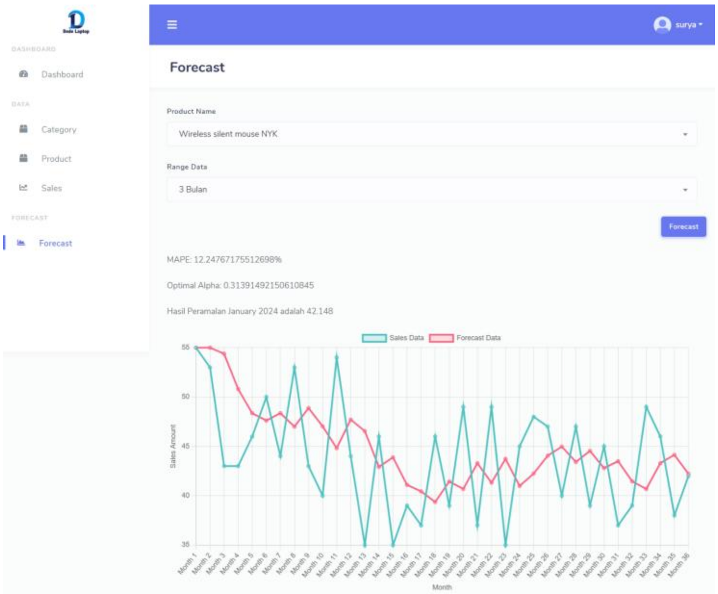

Figure 3. Forecasting Results

Above the graph, there is important information that helps users understand the forecasting results, namely: MAPE shows the prediction error rate in percentage form. Based on the MAPE calculation in chapter 3, the error value was recorded at 12.2477%, which indicates the level of prediction accuracy. Optimal Alpha refers to the parameter value used to produce the best prediction. From the optimization results described in chapter 3, the optimal alpha value obtained is 0.3139. Forecasting Results i.e. Displays sales estimates for a specific period. For example, "The Forecasting Result for January 2024 is 42,148", which describes the estimated number of sales in that month.

4. Conclusion

The conclusion of the research shows that 1. Sales Forecasting System with Single Exponential Smoothing and Golden Section Methods at XYZ is able to record sales data of goods properly. This system can also calculate the optimal alpha value using the Golden Section method accurately, and perform sales forecasting using the Single Exponential Smoothing method by utilizing the alpha value obtained from the Golden Section calculation. The test results using the MAPE method on sales data from January 2021 to December 2023 showed a value of 12.2477%. This value is included in the category of good forecasting accuracy, so the system can be relied upon to predict sales needs effectively.

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