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Baby Supplies Sales Prediction System using the Single Exponential Smoothing Method at Little Queen Baby Shop

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Abstract

The increasing demand for baby equipment in Indonesia in recent years has created significant business opportunities for the retail sector, including Little Queen Baby Shop. However, seasonal fluctuations in demand often lead to stock management problems such as overstock and out of stock, which affect storage costs and customer satisfaction. This research aims to design and develop a sales prediction system for baby products using the Single Exponential Smoothing (SES) method as a solution to minimize forecasting errors and support data-driven decision-making. The research method involved collecting secondary sales data from January to November 2024, which was then processed using the SES algorithm with a smoothing parameter (α) to determine the optimal prediction values with the lowest error rate. The system was developed as a web-based application using PHP programming language and MySQL database, equipped with features such as transaction recording, stock management, sales analysis, and prediction reports for upcoming periods. The implementation results show that the SES-based prediction system provides sufficiently accurate forecasts, as indicated by low values of Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE), and Mean Squared Error (MSE). This system enables Little Queen Baby Shop to optimize stock management, reduce the risk of losses due to excessive or insufficient inventory, and improve both operational efficiency and customer satisfaction.

Keywords: *Sales prediction, Single Exponential Smoothing, information system.*

1. Introduction

In recent years, the demand for baby equipment in Indonesia has increased significantly. This is related to changes in people's lifestyles, which increasingly prioritize comfort, safety, and product quality for their children. According to research conducted by [1], the market value of baby equipment products in Indonesia has grown by over 12% per year, demonstrating high consumer interest in high-quality and functional baby products. This situation creates significant opportunities for businesses in this sector, including retail stores like Little Queen Baby Shop. However, high fluctuations in demand and seasonality also pose significant challenges to effective inventory management.

Poor inventory management can lead to two major problems: overstock and out-of-stock. Overstocking leads to additional storage costs and the risk of damaged goods, while out-of-stocking results in lost sales opportunities and can decrease customer satisfaction. In the retail business, particularly the baby supplies sector, which relies heavily on seasonal demand, these two issues can reduce operational efficiency and impact annual revenue by up to 20% [2]. Therefore, accurate sales forecasting is urgently needed to optimize inventory management and improve operational efficiency.

To address inventory management issues, the Single Exponential Smoothing (SES) method can be an appropriate solution. This method is simple yet effective in predicting sales because it places greater weight on recent data[3].With its ability to respond quickly to changing demand patterns, the Single Exponential Smoothing (SES) method is suitable for projecting short-term demand in retail stores like Little Queen Baby Shop, which experience relatively stable demand fluctuations in the short term[4].

Implementing SES in a sales forecasting system helps improve inventory planning accuracy, reduce storage costs, and enhance operational efficiency. This system can be equipped with features such as transaction recording, stock monitoring, sales analysis, and forecasting reports for the next period.

Several previous studies related to this research have been conducted by various researchers.

[5] in their study titled “Prediksi Penjualan Minyak Goreng di PT Tunas Baru Lampung Menggunakan Metode Single Exponential Smoothing” (Prediction of Cooking Oil Sales at PT Tunas Baru Lampung Using the Single Exponential Smoothing Method), aimed to predict cooking oil sales using the Single Exponential Smoothing method and compared it with the Moving Average method. The results showed that the Single Exponential Smoothing method produced better results, with an MSE of 250,570,764.80, MAD of 12,922.32, and MAPE of 33.55. Meanwhile, [6] in his study “Peramalan Jumlah Mahasiswa Baru di AMIK Royal Kisaran dengan Metode Single Exponential Smoothing” (Forecasting the Number of New Students at AMIK Royal Kisaran Using the Single Exponential Smoothing

Method) applied the same method to estimate the number of new students based on 15 years of historical data (2003/2004–2017/2018). The optimal α value was selected by comparing the smallest error, and the results indicated that in the 2018/2019 academic year, there were an estimated 89 new students in the Informatics Management program and 30 in the Computer Engineering program. Another study by [7] entitled "Peramalan Produksi Beras Cap Buah Nipah di Kabupaten Tanjung Jabung Timur Menggunakan Metode Single Exponential Smoothing" (Forecasting Rice Production of Cap Buah Nipah Brand in Tanjung Jabung Timur Regency Using the Single Exponential Smoothing Method) used production data from 2017 to 2022. The smoothing parameter α was evaluated to determine the smallest forecasting error. The findings showed that α = 0.99 yielded a MAPE of 3.83%, indicating high forecasting accuracy. In addition, [8] in his research titled "Sistem Prediksi Penjualan Barang Menggunakan Metode Single Exponential Smoothing (Studi Kasus: Little Queen Baby Shop)" (Sales Prediction System Using the Single Exponential Smoothing Method: A Case Study of Little Queen Baby Shop), developed a sales prediction system based on historical data. The system utilized the smoothing parameter α to produce forecasts with minimal errors, helping the store plan its inventory more accurately.

By relying on historical sales data, this system can provide responsive predictions to changes in demand trends that may occur, so that stores can make stock adjustments more efficiently. In addition, the implementation of this system is also expected to reduce operational costs related to storage and reduce losses due to excess or shortage of stock, which directly contributes to increased profitability and customer satisfaction. Based on the description that has been discussed, the author will conduct a study entitled "Baby Equipment Sales Prediction System Using the Single Exponential Smoothing Method at Little Queen Baby Shop".

2. Methodology

2.1. Analysis Method

2.1.1. Metode Single Exponential Smoothing

The Single Exponential Smoothing (SES) method is a forecasting technique used to predict future values by giving greater weight to the most recent data. Compared to the moving average method, SES is more flexible because it adaptively updates predictions based on changes in the most recent data. Its main goal is to estimate future values by considering historical data patterns to improve prediction accuracy. In this method, the parameter α (alpha) is used to determine the weight of the most recent data with a value range between 0 and 1, where the higher the α value, the greater the influence of the most recent data on the forecast results. For example, the most recent data is given a weight of α, while previous data is given a weight of $\alpha(1-\alpha)$, and so on. A high α value results in predictions that are more responsive to changes in trends, while a low α value makes the model pay more attention to older historical data.

The basic formula for Single Exponential Smoothing (SES) is as follows:

$$\{Y\}_{\{t+1\}} = \alpha Y_t + (1 - \alpha)\backslash hat\{Y\}_t \quad (1)$$

Where:

$\{Y\}_{\{t+1\}}$ = is the predicted value for the next period t+1.
Y_t = actual data in period t.
$\{Y\}_t$ = is the predicted value for period eke-t.
α = is a smoothing parameter that determines how much weight is given to the most recent data.

2.1.2. Mean Absolute Percentage Error (MAPE)

Mean Absolute Percentage Error (MAPE) is a measure of the average absolute percentage error often used in predictive analysis. MAPE is a statistical method useful for assessing the accuracy of forecasting results[9]. The MAPE value provides information on the magnitude of the prediction error compared to the actual value in a certain period[10]. The smaller the percentage error produced by MAPE, the higher the level of accuracy of the prediction. Thus, MAPE is an important tool for researchers or analysts in evaluating the performance of predictive models and making more informed decisions based on historical.[11]. The following is the equation :

$$\frac{1}{n}\sum \frac{|D_t - y_{t|}}{D_t} \times 100\% \quad (2)$$

Where:
Dt = Actual value
Yt = Predicted value
n = Number of data

MAPE values can be interpreted into categories, namely [12]:
<10% = very accurate
10-20% = fairly accurate
20-50% = reasonable
>50% = inaccurate

2.2. Research Stages

2.2.1. Data Collection Techniques

The technique used to collect data is secondary data collection. Secondary data is information that has been created or collected by others. This data contains sales data for baby supplies for one year, from January 2024 to November 2024. The data was obtained from existing sales transaction records at the store, eliminating the need for direct field recording. With this sales data, the author can analyze sales patterns and use it as a basis for designing a sales prediction system. The results of the data collection provided the author with the data used to design a sales prediction system using the single exponential smoothing method, as follows:

Table 1. Sales Data

Year	Month	Number of Sales	
		Mamy Poko	**Happy Nappy**
2024	Januari	231	209
2024	Februari	235	210
2024	Maret	251	258
2024	April	290	339
2024	Mei	268	275
2024	Juni	246	170
2024	Juli	261	360
2024	Agustus	210	222
2024	September	236	194
2024	Oktober	252	228
2024	November	240	269
2024	Desember	?	?

Table 1 presents sales and purchase data at a baby shop in Takeharjo Village, Solokuro District, Lamongan Regency, which was used to predict baby equipment sales using the Single Exponential Smoothing (SES) method.

Mamy Poko products exhibited a fluctuating but relatively stable sales pattern, ranging from 230–290 units. At the beginning of the year (January–March), sales increased from 231 to 251 units, peaking in April (290 units), likely due to promotions or increased consumer demand. After declining in May–June (246 units), sales rose in July (261 units), then declined again in August (210 units), and stabilized in September–November (236–252 units). This pattern indicates stable demand with seasonal spikes, making the SES method suitable for smoothing out short-term fluctuations.

Meanwhile, Happy Nappy exhibited a more volatile pattern. The beginning of the year (January–February) tended to be stable at around 209–210 units, but there was a spike in March–April (258–339 units), followed by a sharp decline in June (170 units) and the highest increase in July (360 units). After that, sales declined again and fluctuated in August–November (194–269 units). This pattern indicates that sales are influenced by promotional factors and consumer preferences, making the SES method suitable for estimating stock requirements more accurately.

The application of the Single Exponential Smoothing (SES) method to Mamy Poko sales data is shown in the following table, which illustrates the monthly forecasting process based on actual data and forecasts from the previous period.

2.2.2. Process Design

This process design is the system design for this research, which uses a process-based approach. Therefore, in the system design, the researcher implemented a Data Flow Diagram (DFD). DFD is used as a tool to model the processes within the system. The process used in this system design includes creating flowcharts and level 0 and 1 diagrams.

1. Flowchart Single Exponential Smoothing
   The flowchart for designing a sales prediction system using the Single Exponential Smoothing method is as follows:

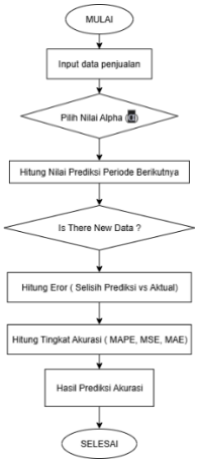


Fig. 1: Flowchart Single Exponential Smoothing

The image above shows a flowchart for the prediction process, which begins with inputting historical sales data as the basis for the calculation. Next, an alpha (α) value is determined, which serves as a weight for the most recent data, with a range between 0 and 1. After that, calculations are performed to obtain the predicted value for the next period. If actual data is available, the system will proceed to the evaluation stage by calculating the error rate and accuracy using metrics such as MAPE, MSE, and MAE. However, if actual data is not yet available, the process proceeds directly to the prediction results display stage. In the final stage, the system displays the predicted results along with their accuracy level, and then the process is declared complete.

2. Data Flow Diagram (DFD)
   The DFD below illustrates the overall sales forecasting system. The primary entity is the Admin, who interacts with the system to manage products, enter sales data, and generate sales forecasts. The system processes the sales data and generates forecasts based on the SES method.

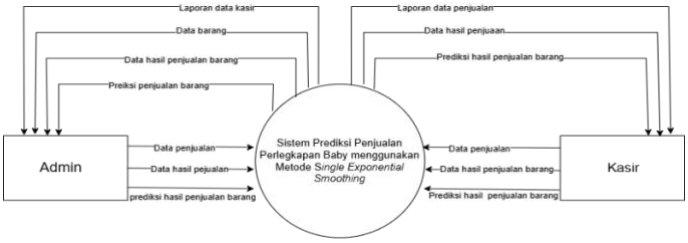


Fig. 2: Data Flow Diagram Level 0

The image below is a Level 1 Flow Diagram or Context Diagram of the Sales Prediction System at the Little Queen Baby Shop in Takeharjo Village using the single exponential smoothing method. Level 1 DFD is the result of a breakdown of the context diagram or Level 0 DFD. It describes the details of each process in the application.

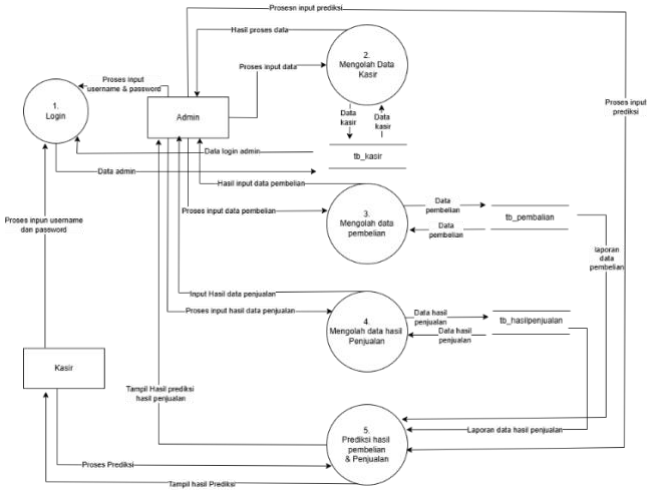


Fig. 3: Data Flow Diagram Level 1

The following is a description of the Level 1 DFD image above. The Login feature is the initial page displayed in the system, which functions to provide access to the application. Each user must have a username and password that have been registered in the prediction system database. Furthermore, the Manage Sales Result Data feature displays the total sales results from each specific period, where the admin can view, add, edit, process, or delete the overall sales result data. Then, the Sales Result Prediction feature functions to display the results of sales and purchases predictions for the next few years, as well as evaluate the level of accuracy using the Mean Absolute Percentage Error (MAPE) method. This feature also has a Calculate button that allows the admin to view the prediction results and print the prediction report.

2.2.3. Entity Relationship Diagram (ERD)

An Entity Relationship Diagram (ERD) is a conceptual model used to illustrate the logical structure of a database. An ERD demonstrates the relationships between entities, attributes, and relationships within a system. An ERD significantly assists in the database design process, making it more structured and efficient. Furthermore, an ERD facilitates implementation into information systems or applications, as it provides a clear overview of the data requirements. Furthermore, an ERD serves as a communication channel between system designers, developers, and users. This diagram ensures a shared understanding among all parties, ensuring a more focused system development process and meeting desired outcomes.

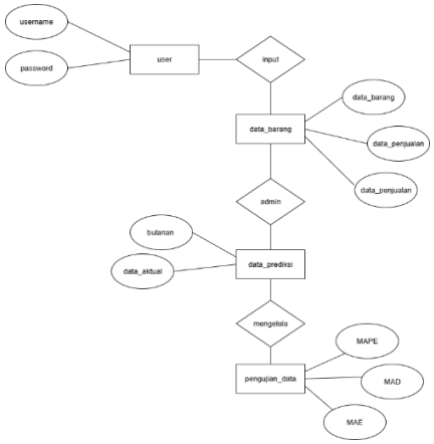


Fig. 4: Data Flow Diagram Level 1

In short, this database is designed as a centralized information system that facilitates the recording of all daily transactions, both sales and purchases. Furthermore, this database serves as the primary infrastructure for managing product data in a comprehensive and integrated manner. Its function extends beyond historical recording to supporting the process of predicting future needs (both demand and supply),

as well as evaluating the accuracy of these predictions. This is essential for supporting more informed and targeted strategic decision-making.

3. Results and Discussion

3.1. Single Exponential Smoothing (SES) Method Calculation

3.1.1. Determining the Initial Value of the Forecast

In the initial stage, the first forecast value is determined based on actual Mamy Popo product sales data from January 2024. This value is used as the basis for calculations for the following period. The Single Exponential Smoothing (SES) method works by giving greater weight to the most recent data, allowing the model to adjust more quickly to changes in sales trends.

Table 2. Initial Forecast Setting

Period	Actual Sales (A_t)	Forecast (F_t)	Remark
January 2024	231	231	Initialized value

In the table above, the January forecast value (F_1) is equated with the actual data because there is no previous data that can be used as a comparison.

3.1.2. Monthly Forecast Calculation Process

At this stage, the forecast for each subsequent month is calculated using the Single Exponential Smoothing (SES) formula. The smoothing constant used is $\alpha = 0.5$. This value indicates that the weighting of the previous month's actual data and the previous forecast have an equal influence on the forecast results.

Table 3. Forecast Calculation Process (Mamy Poko)

Month	Actual (A_t)	Formula Applied	Forecast (F_t)
February	235	0.5(231) + 0.5(231)	231.00
March	251	0.5(235) + 0.5(231.00)	233.00
April	290	0.5(251) + 0.5(233.00)	242.00
May	268	0.5(290) + 0.5(242.00)	266.00
June	246	0.5(268) + 0.5(266.00)	267.00

In the table above, each forecast value is calculated by combining 50% of the previous month's actual data and 50% of the previous forecast results. This allows the system to gradually adjust to new trends without ignoring old patterns.

3.1.3. Determining the Final Prediction Results

After the calculation process is carried out for each month, the final forecast results for December 2024 are obtained. This value is calculated based on the actual data for November and the forecast results for November.

Table 4. Final Sales Forecast Results (Mamy Poko)

Month	Actual (A_t)	Formula	Forecast (F_t)
December	—	0.5(240) + 0.5(243.6)	241.8

Thus, the predicted sales results for December 2024 are 241.8 units, indicating a relatively stable sales trend.

3.2. System Implementation

3.2.1. Login Page

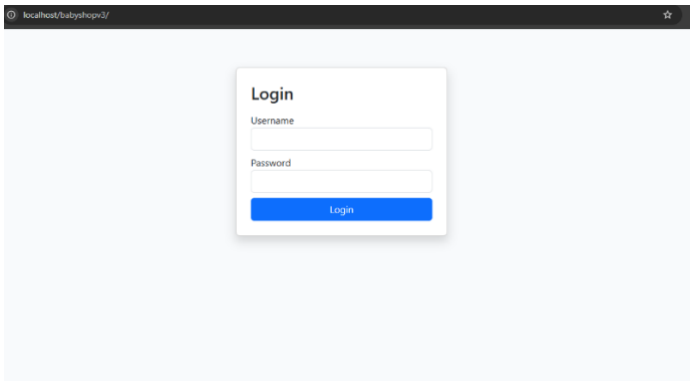


Fig. 5: Login Page

The image above shows the login page, where users are required to enter a valid username and password. Once successful, the user is automatically redirected to the dashboard. The login page acts as the main gateway to access the system, ensuring that only verified users can access and utilize the features available within the dashboard. In addition, the login process helps maintain data security by preventing unauthorized access to sensitive information. The page is designed to be simple and user-friendly, allowing users to log in efficiently. If

users enter incorrect credentials, the system will display an error message, prompting them to recheck and input the correct data before proceeding.

3.2.2. Dashboard Page

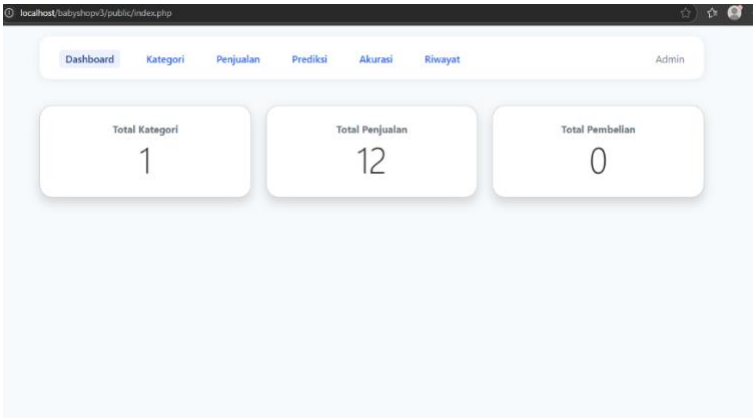


Fig. 6: Dashboard Page

The dashboard is the first display users see after successfully logging into the system. Its function is to present a quick and interactive summary of important information, allowing users to understand the application's status without having to navigate through menus one by one. The dashboard acts as an information center, presenting important data concisely and interactively to users after logging in. With a simple and informative display, the dashboard makes it easy for both admins and cashiers to monitor system activity such as item counts, total sales, revenue, and sales graphs. The responsive and user-friendly interface design makes this page effective as a navigation center and monitoring the performance of baby equipment sales at Little Queen Baby Shop.

3.2.3. Sales Data Page

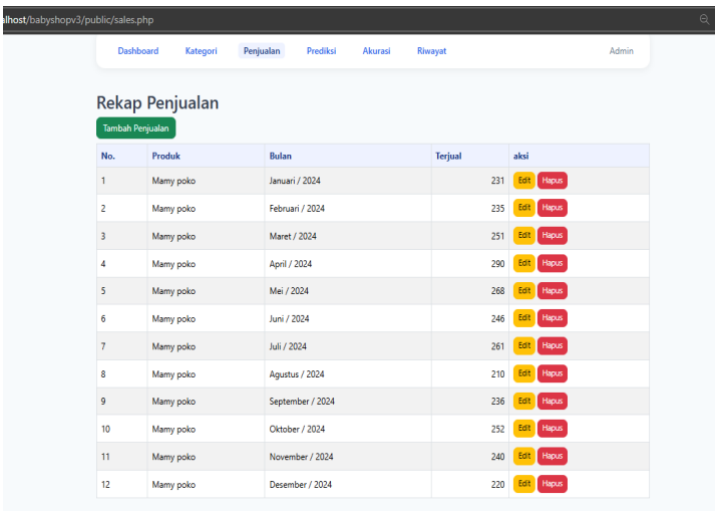


Fig. 7: Sales Data Page

The sales data page is at the heart of any business system, serving as the primary repository for all sales transaction records. This is where every sales detail, from date, item sold, quantity, price, to total revenue, is systematically recorded. This page serves as a comprehensive digital archive that provides an accurate picture of past sales performance. The data collected on this page is a vital input for forecasting models such as Single Exponential Smoothing (SES); by analyzing historical patterns, the system can project future demand. Therefore, the accuracy and completeness of the data on this page directly impact the reliability of predictions and the business's ability to make informed decisions.

3.2.4. Prediction Page

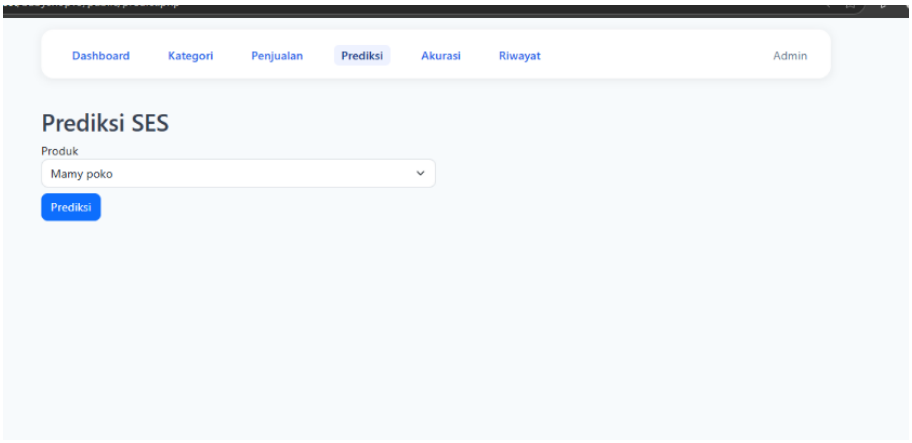


Fig. 8: Prediction Page

The forecast page is a crucial feature in a sales forecasting system, designed to display future sales projections generated by forecasting models, such as Single Exponential Smoothing (SES). Its primary function is to provide users with forward-looking insights, allowing them to view estimated sales or demand for future periods. This page acts as a bridge between historical data analysis and strategic decisions, providing a clear picture of future potential and challenges. In addition to displaying the forecast results, the forecast page also provides an interface that makes it easy for users to determine the product categories to be forecasted. Through a product selection menu directly connected to the database, users can quickly select relevant items according to their analysis needs.

3.2.5. Prediction Results Page

The forecast results page is the core of a sales forecasting system, serving as a visual platform that presents future sales projections generated by forecasting models, such as Single Exponential Smoothing (SES). Its primary purpose is to provide users with proactive insights, allowing them to view estimated demand or sales for the upcoming period. It serves as a vital bridge connecting analyzed historical data with strategic decisions, providing a clear view of future market potential and challenges.

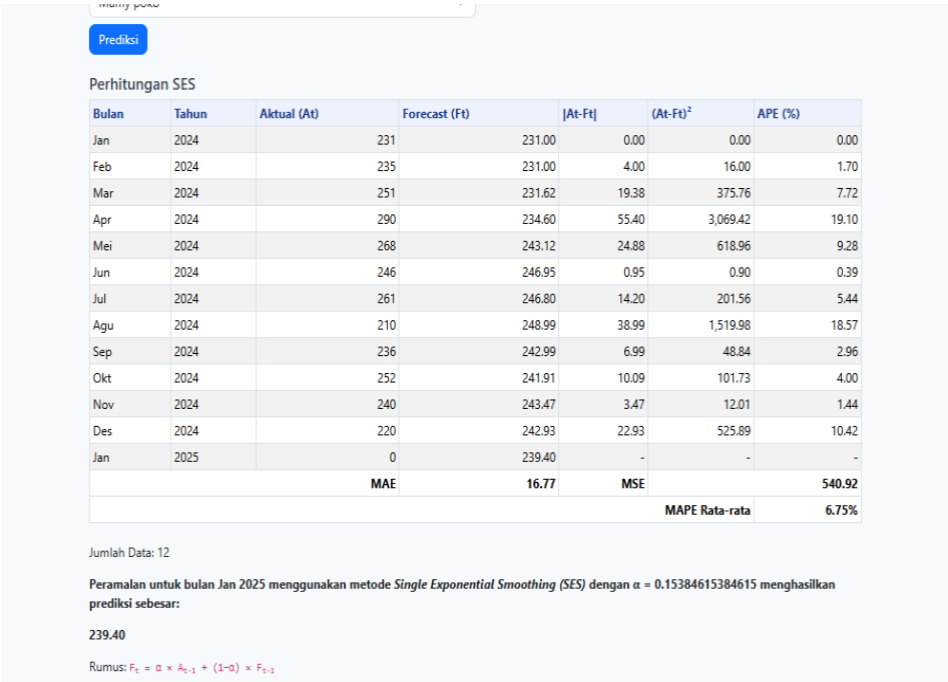
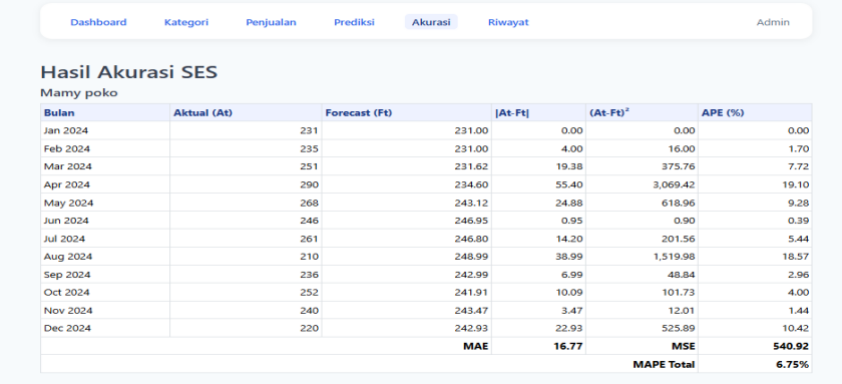


Fig. 9: Prediction Results Page

The image above displays the forecast results page, displaying the results of the baby equipment sales forecast calculation using the Single Exponential Smoothing (SES) method. This method is used to estimate future sales based on previous sales data. By displaying these forecast results, users can not only see estimated figures but also gain insight into sales patterns over time. This helps anticipate demand fluctuations, allowing for more accurate and measurable decisions.

3.2.6. Accuracy Page



Bulan	Aktual (At)	Forecast (Ft)	|At-Ft|	(At-Ft)²	APE (%)
Jan 2024	231	231.00	0.00	0.00	0.00
Feb 2024	235	231.00	4.00	16.00	1.70
Mar 2024	251	231.62	19.38	375.76	7.72
Apr 2024	290	234.60	55.40	3,069.42	19.10
May 2024	268	243.12	24.88	618.96	9.28
Jun 2024	246	246.95	0.95	0.90	0.39
Jul 2024	261	246.80	14.20	201.56	5.44
Aug 2024	210	248.99	38.99	1,519.98	18.57
Sep 2024	236	242.99	6.99	48.84	2.96
Oct 2024	252	241.91	10.09	101.73	4.00
Nov 2024	240	243.47	3.47	12.01	1.44
Dec 2024	220	242.93	22.93	525.89	10.42
		MAE	**16.77**	**MSE**	**540.92**
				MAPE Total	**6.75%**

Fig. 10: Accuracy Page

The image above displays the Prediction History Page, which records and displays all prediction processes that have been performed in the system. This table details each prediction run, providing important information such as Number, Predicted Product (e.g., "pampers"), Description (predicted data type, e.g., "Sales"), Prediction Year and Month, Alpha value used, Prediction Result obtained, Time when the prediction was performed, and a "Delete" action option for each entry. This page is very useful for tracking, reviewing, or deleting old predictions, supporting auditing and management of the prediction process in the system.

4. Conclusion

Based on the system's testing results, the application of the Single Exponential Smoothing (SES) method to predict sales yielded several conclusions. First, the Single Exponential Smoothing method was successfully applied to monthly sales data, utilizing the key parameter, alpha (α), to capture data level patterns and trends. Through a two-stage smoothing process (level and trend), the system was able to generate accurate sales predictions for the following period. The system, built as a web-based application, also facilitates the Littlequeen Baby Shop admin in inputting data and automatically generating predictions. Second, the Single Exponential Smoothing method's accuracy was considered good in predicting sales at Littlequeen Baby Shop in Takeharjo Village. The test results yielded a Mean Absolute Percentage Error (MAPE) of 6.44% and a Mean Squared Error (MSE) of 540.02. A MAPE value below 10% indicates that the predictions produced by this method are highly accurate and can be used as a basis for decision-making regarding sales planning at the store.

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