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INVENTORY FORECASTING INFORMATION SYSTEM USING THE WEIGHTED MOVING AVERAGE METHOD AT TITA'S STORE

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Abstract

Inventory management is a crucial factor in retail operations as it influences cost efficiency, sales continuity, and customer satisfaction. In small-scale retail businesses, inventory planning is often performed manually, increasing the risk of overstock and stockout conditions. This study aims to develop a web-based inventory forecasting information system using the Weighted Moving Average (WMA) method to support effective inventory planning. The system integrates item data management, sales transaction recording, and demand forecasting within a single platform. The WMA method is applied to 12 months of historical monthly sales data using a three-period forecasting window with an optimized weight configuration of 5–1–7 to emphasize recent demand patterns. Forecasting accuracy is evaluated using Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE). A case study conducted at Toko Tita shows that the WMA method outperforms the Simple Moving Average method by producing lower MAD and MAPE values, indicating better responsiveness to short-term demand fluctuations. The results demonstrate that the proposed system provides reliable quantitative information to support inventory procurement decisions, reduces manual calculation errors, and improves operational efficiency. Although forecasting errors increase during extreme demand changes, the system is practical and effective for daily inventory management in small retail businesses.

Keywords: inventory management; weighted moving average; demand forecasting; web-based information system; retail business.

1. INTRODUCTION

Inventory management is a critical component of retail business operations, as it directly affects sales continuity, cost efficiency, and customer satisfaction. Inefficient inventory management can lead to overstock or stockout conditions, resulting in increased holding costs and lost sales opportunities. To address these issues, various inventory control approaches such as the Economic Order Quantity (EOQ), Reorder Point (ROP), and perpetual inventory systems have been developed to optimize stock levels and minimize inventory imbalances in retail environments [1], [2]. Furthermore, the implementation of web-based inventory management information systems that integrate real-time stock monitoring and automatic low-stock alerts has been proven to improve data accuracy and operational efficiency in inventory planning [3], [4].

The advancement of information technology has accelerated the adoption of information systems in inventory management to enhance the quality of managerial decision-making. Inventory information systems enable structured processing of historical sales data and provide timely and accurate information to support inventory planning for future periods [1], [5]. One of the core functions of an inventory information system is demand forecasting, which plays a crucial role in determining optimal inventory levels.

Demand forecasting is essential for reducing uncertainty in inventory planning. One widely used time series forecasting technique is the Weighted Moving Average (WMA) method, which assigns different weights to historical data periods, giving greater emphasis to more recent observations. Compared to the simple Moving Average method, WMA is considered more responsive to demand fluctuations and capable of producing higher forecasting accuracy, particularly for retail sales data characterized by variability [2], [6].

Previous studies have demonstrated that the application of the WMA method within inventory information systems can improve forecasting accuracy and enhance inventory management efficiency. Amelianti et al. [7] applied the WMA method to forecast motorcycle spare-parts demand and reported low forecasting errors based on MAD, MSE, and MAPE evaluations. Similarly, Suroso et al. [8] found that a WMA-based forecasting system effectively supports inventory planning in the automotive spare-parts sector. Other studies also confirm that integrating forecasting methods into computerized inventory systems contributes to better inventory control and decision support in retail and small-scale businesses [3], [4].

However, most existing studies primarily focus on forecasting calculations without fully integrating forecasting functionality into sales transaction systems, particularly in small-scale retail environments. To address this research gap, this study proposes a web-based inventory forecasting information system that integrates historical sales transaction data with the Weighted Moving Average method. Unlike previous studies, the proposed system not only performs demand forecasting but also provides practical decision-support features for inventory procurement, making it directly applicable to daily retail operations.

The novelty of this research lies in its end-to-end system implementation, which combines sales data management, inventory control, and demand forecasting within a single web-based platform tailored for small retail businesses. In addition, forecasting accuracy is evaluated using MAD, MSE, and MAPE metrics through a case study conducted at Toko Tita. This integrated approach is expected to improve inventory planning accuracy and support more effective inventory management decisions in small-scale retail operations.The novelty of this research lies in its end-to-end system implementation, which combines sales data management, inventory control, and demand forecasting within a single web-based platform tailored for small retail businesses. In addition, forecasting accuracy is evaluated using MAD, MSE, and MAPE metrics through a case study conducted at Toko Tita. This integrated approach is expected to improve inventory planning accuracy and support more effective inventory management decisions in small-scale retail operations.

2. RESEARCH METHODOLOGY

2.1. Weighted Moving Average Method

The Weighted Moving Average (WMA) method is a forecasting technique that applies different weights to the available data. In this method, the most recent data are considered the most relevant for forecasting purposes and are therefore assigned higher weights [9]. In general, the calculation of the WMA method is formulated as shown in Equation (1).

$$WMA = \frac{\sum(Dt \; x \; Wt)}{\sum Wt} \qquad (1)$$

where Dt represents sales data in period t, and $W_t$denotes the weight assigned to period t. The results of the Weighted Moving Average (WMA) calculation are used as the basis for determining the required inventory level for the subsequent period.

In this study, forecasting accuracy is evaluated using Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE). These error measurements indicate the magnitude of the difference between the forecasted values and the actual data. MAD represents the average of the absolute forecasting errors over a specific period. The use of absolute values prevents positive and negative deviations from canceling each other out. The MAD calculation is formulated as shown in Equation (2).

$$MAD = \frac{1}{n}\sum_{t-1}^{n} | \, e_t \, | \qquad (2)$$

where e_t represents the forecasting error in period t, and n denotes the number of observation periods. Mean Squared Error (MSE) is a forecasting accuracy measure defined as the average of the squared forecasting errors. A smaller MSE value indicates a higher level of forecasting accuracy. The MSE calculation is formulated as shown in Equation (3).

$$MSE = \frac{1}{n}\sum_{t-1}^{n}(\, e_t \,)^2 \qquad (3)$$

Mean Absolute Percentage Error (MAPE) is a relative accuracy measure used to determine the percentage deviation of forecasting results. A smaller MAPE value indicates a lower level of forecasting error, whereas a larger MAPE value reflects a higher forecasting error. A forecasting method is considered to have very good forecasting performance when the MAPE value is less than 10%, and good forecasting performance when the MAPE value ranges between 10% and 20%. The MAPE calculation is formulated as shown in Equation (4).

$$MAPE = \frac{1}{n}\sum_{t-1}^{n}\left|\frac{e_t}{x_t}\right| \; x \; 100\% \qquad (4)$$

The forecasting process in this study utilizes historical monthly sales data covering a period of 12 months (January–December). The selected data period is considered sufficient to represent recent demand patterns in the case study object and is commonly used in short-term inventory forecasting for small-scale retail businesses.

In this study, the Weighted Moving Average method applies a weighting scheme of 5:1:7 for the three most recent periods, where the highest weight is assigned to the most recent data. This weighting configuration is adopted to emphasize recent demand patterns and is consistent with common practices in short-term demand forecasting literature. The selected weighting scheme was determined based on the characteristics of sales data that exhibit short-term fluctuations and the objective of improving responsiveness to recent demand changes.

2.2. System Development Life Cycle (SDLC) and Waterfall Model

The stages of the Waterfall model applied in this study include requirements analysis, system design, implementation, testing, and maintenance [10]. The flow of the SDLC Waterfall model used in this study is illustrated in Figure 1.

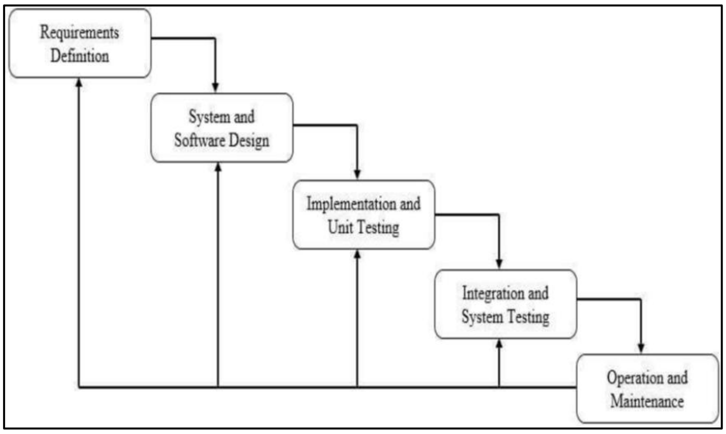

Figure 1. Stages of the SDLC Waterfall Model

This study employs a software engineering research method using the System Development Life Cycle (SDLC) approach with the Waterfall model. The Waterfall model is selected due to its structured and systematic development stages, which facilitate the design and development process of the inventory forecasting information system. Each stage in the Waterfall model is completed sequentially before proceeding to the next stage, ensuring that the system development process is well controlled and properly documented [11].

The stages of the Waterfall model applied in this study are described as follows.

1. Requirements Analysis
   The requirements analysis stage aims to identify system requirements through observation and interviews conducted at Toko Tita. The output of this stage is a system requirements specification, including inventory data management, sales data processing, and inventory forecasting using the Weighted Moving Average method.
2. System Design
   The system design stage is carried out based on the results of the requirements analysis. This stage includes system modeling using Unified Modeling Language (UML) diagrams, such as use case diagrams and flowcharts, as well as database and user interface design.
3. Implementation and Testing
   The implementation stage involves translating the system design into an application. The inventory forecasting information system is developed in a computerized environment according to the predefined design. Subsequently, system testing is performed to ensure that all system functions operate as required. The testing method used is black box testing, which focuses on verifying system functionality.
4. Maintenance
   The maintenance stage is conducted after the system has been implemented. This stage aims to correct errors, improve system performance, and adapt the system to future user requirements.

2.3. Database Management System (DBMS) MySQL

A Database Management System (DBMS) is software used to manage, store, and manipulate data in a structured manner, enabling data to be accessed and processed effectively and efficiently. DBMS plays an important role in the development of information systems by ensuring data consistency, security, and ease of data management and processing [12]. One widely used example of a DBMS is MySQL, which is an open-source relational database management system that supports Structured Query Language (SQL). MySQL is commonly utilized in web-based application development due to its good performance, ease of use, and ability to handle large volumes of data.

MySQL is one of the most widely used Database Management Systems (DBMS) based on the Relational Database Management System (RDBMS) concept in web-based information system development. MySQL utilizes Structured Query Language (SQL) as the standard language for data management and supports various database operations, including table creation, data storage, data retrieval, and the management of relationships among tables [13]. The main advantages of MySQL include its open-source nature, high performance, and capability to handle large volumes of data. In addition, MySQL supports table relationships, data integrity, and user access security, making it well suited for information systems that require structured and sustainable data management [14].

In this study, MySQL is used as the DBMS to store and manage inventory data, sales data, and the results of inventory forecasting calculations. The use of MySQL enables the inventory forecasting information system to operate efficiently, remain well integrated, and be easily extended in the future. Furthermore, MySQL supports the processing of historical sales data required for the implementation of the Weighted Moving Average (WMA) method [15].

3. RESULTS AND DISCUSSION

The proposed system design in this study is represented using several Unified Modeling Language (UML) diagrams. The UML diagrams employed include use case diagrams, class diagrams, and activity diagrams. The use case diagram is used to illustrate the interactions between users and the system, the class diagram models the class structure and the relationships among classes within the system, while the activity diagram describes the process flow and the sequence of activities in the system dynamically.

3.1. Use Case Diagram

The use case diagram design of the system developed in this study is presented in Figure 2.

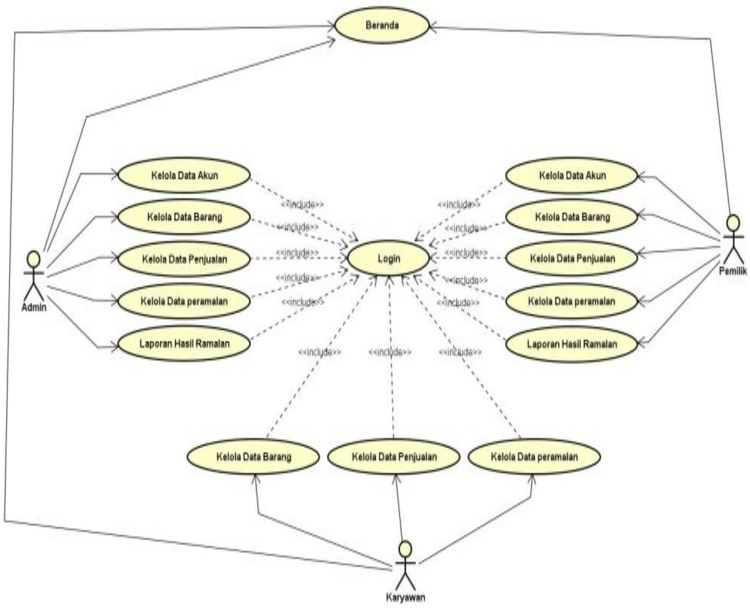

Figure 2. Use Case Diagram

3.2. Activity Diagram

The business processes previously represented in the use case diagram are further elaborated in detail using activity diagrams.

a. Login Activity diagram

Figure 3 illustrates the authentication process flow for administrators or users within the system. The process begins when an administrator or user logs in through the login form on the main page by entering a username and password. The system then performs a verification process by matching the entered login credentials with the data stored in the database. If the username and password are valid, the system redirects the user to the dashboard page. Conversely, if the login credentials are invalid, the system redirects the user back to the login page. The dashboard page provides several main menus, including account management, inventory data, sales data, and forecasting data. The login activity diagram design is shown in Figure 3.

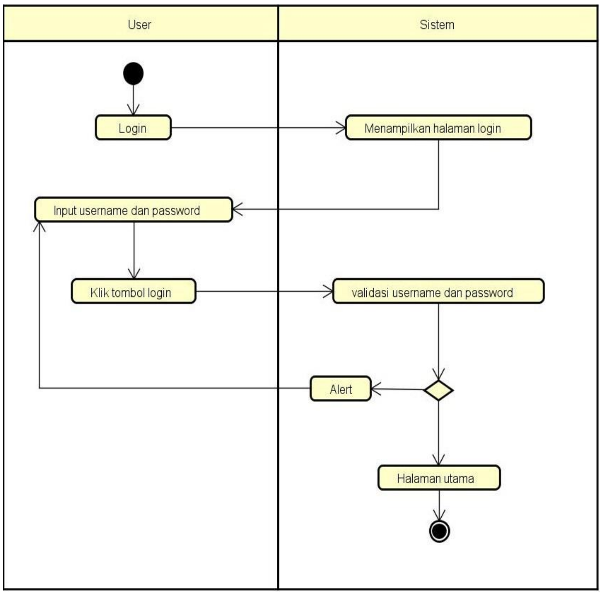

Figure 3. Login Activity Diagram

b. Inventory Data Management Activity Diagram

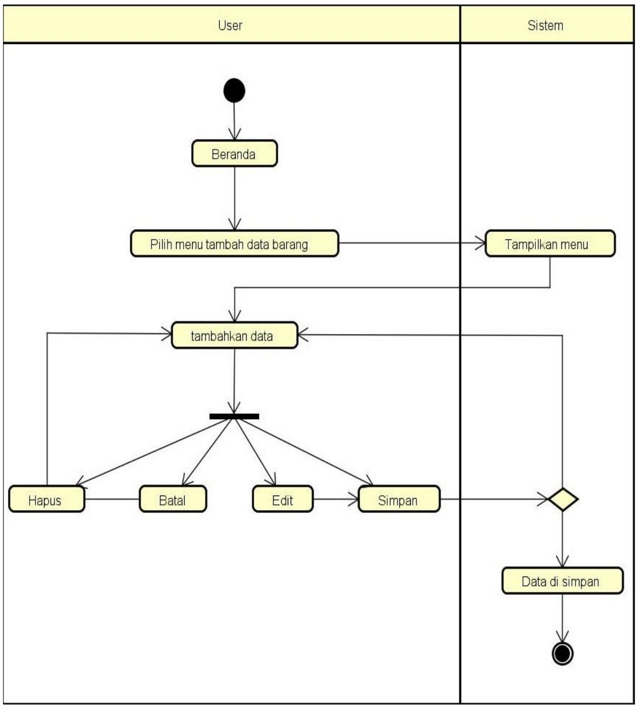

Figure 4. Inventory Data Management Activity Diagram

In addition to adding inventory data, the system also provides inventory data management features in the form of edit and delete processes. The edit process begins when the user selects an inventory item to be modified from the inventory list. The system then displays an edit form containing the existing data. The user updates the data as required and clicks the save button, after which the system processes and updates the inventory data in the database. The delete process is performed by selecting an inventory item to be removed from the inventory list. After the user confirms the deletion action, the system deletes the selected inventory data from the database. Through the implementation of the edit and delete processes, the system enables comprehensive and structured inventory data management.

c. Sales Activity Diagram

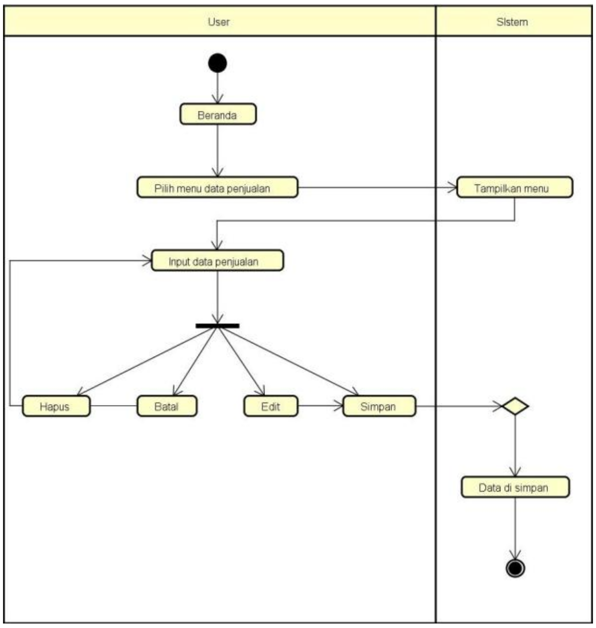

Figure 5. Sales Activity Diagram

Figure 5 illustrates the workflow of sales data management in the system. The process begins when the user logs in through the login form on the main page by entering a username and password. After successfully accessing the system, the user selects the sales data management menu, and the system displays the sales data management page. The user then enters the sales data and clicks the save button. The system processes and stores the sales data in the database. After completing the sales data management process, the user can exit the system by logging out.

d. Forecasting Activity Diagram

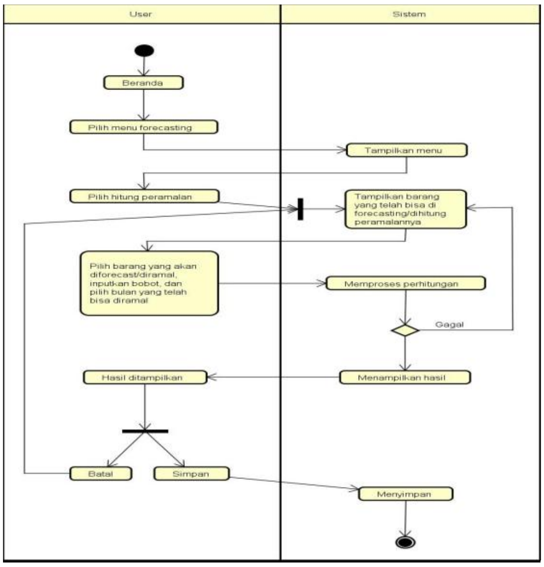

Figure 6. Forecasting Activity Diagram

Figure 6 illustrates the workflow of inventory forecasting in the system. The process begins when the user logs in through the login form on the main page by entering a username and password. After successfully accessing the system, the user selects the forecasting menu, and the system displays a list of items for which forecasting calculations can be performed. The user then selects the item to be forecasted and enters the weight values and the forecasting period in months. Next, the user clicks the calculate forecasting button, and the system processes the sales data and displays the inventory forecasting results. The forecasting results can then be saved by the user into the database. After completing the forecasting process, the user can exit the system by logging out.

3.3. Class Diagram

A class diagram is used to describe the static structure of a system by illustrating the main classes along with their attributes, operations (methods), and relationships between classes. The class diagram of the developed system represents the main components involved in managing item data, sales data, and the inventory forecasting process. The class diagram for the inventory forecasting system is presented in Figure 7.

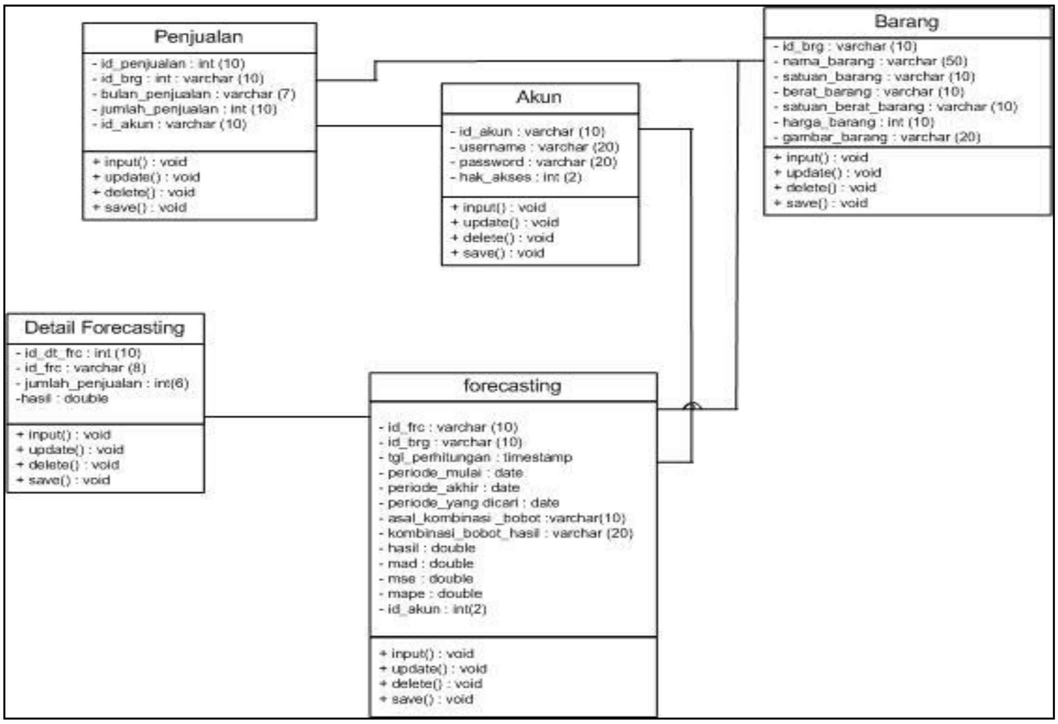

Figure 7. Class Diagram Forecasting

The class diagram of the inventory forecasting system consists of several main classes, namely User, Item, Sales, and Forecasting. Each class contains attributes and methods that are interconnected to support data management and inventory forecasting processes. The User class is responsible for managing user information with access rights to the system, such as administrators or general users. This class is related to the Item, Sales, and Forecasting classes, as all data management and forecasting activities are performed by authenticated users. The Item class stores item-related information, including item code, item name, and unit. This class is associated with the Sales class because each sales record is linked to a specific item. The Sales class records historical sales data for each item within a certain period. This sales data serves as the primary input for the inventory forecasting process. Therefore, the Sales class has a direct relationship with the Forecasting class. The Forecasting class stores the results of inventory forecasting calculations using the Weighted Moving Average (WMA) method. This class processes sales data based on specified weights and forecasting periods, then generates forecasting values that are saved in the database. The relationships among classes in this class diagram illustrate an integrated data flow, starting from item and sales data management to a systematic inventory forecasting process.

3.4. Implementation System

This section presents the implementation results of the Inventory Forecasting Information System using the Weighted Moving Average (WMA) method at Toko Tita. In addition to describing the main system functionalities, this section also discusses the forecasting results and their implications for inventory decision-making.

1. User Authentication and Dashboard Module

   The login module functions as the system's security gateway by authenticating user credentials against the database. Only registered users with valid usernames and passwords are granted access to the system. After successful authentication, users are redirected to the dashboard according to their access privileges. The login form interface is shown in Figure 8.

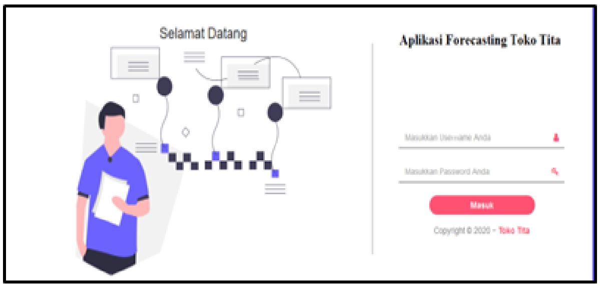

Figure 8. The Login Form Interface

The dashboard interface provides a concise overview of system information, including the total number of items, sales transactions, and quick access to the forecasting module. This design allows users to monitor inventory conditions efficiently without navigating through multiple menus, thereby improving operational usability. The dashboard interface is shown in figure 9.

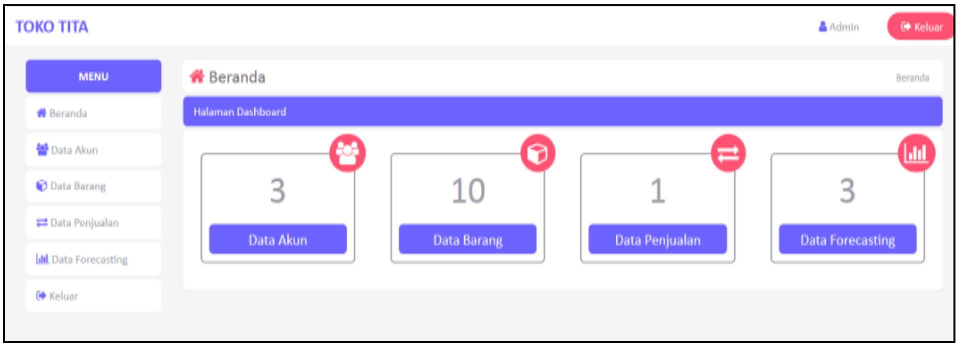

Figure 9. Dashboard Interface

2. Item and Sales Data Management Module

The item and sales data management module functions as the core data foundation of the proposed inventory forecasting information system. This module is responsible for managing all master item data and sales transaction records used in the forecasting process. The item data page allows users to perform Create, Read, Update, and Delete (CRUD) operations on item information, including item code, item name, and unit of measurement. Maintaining accurate and consistent item data is essential to ensure the reliability of sales records and forecasting results. All item data are stored in a relational database and serve as reference data for sales transactions and inventory forecasting calculations. The item input form interface is illustrated in Figure 10. In addition to item management, the sales data management component records all sales transactions associated with each item. These transaction records are automatically stored in the database and structured according to transaction date, item, and quantity sold. The availability of well-organized and historical sales data enables the system to perform demand forecasting using the Weighted Moving Average (WMA) method accurately. By integrating item data management with sales transaction processing, this module ensures data consistency and traceability throughout the system. As a result, the forecasting module can utilize valid and up-to-date data, supporting more accurate inventory planning and data-driven decision-making at Toko Tita.

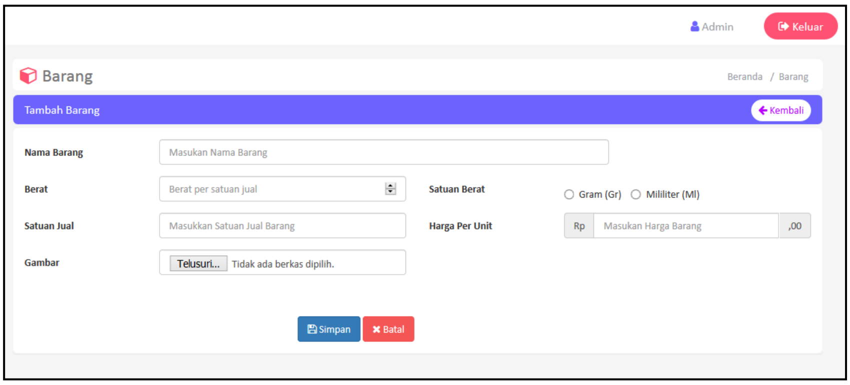

Figure 10. Item and Sales Data Management Module

3. Inventory Forecasting Module Using WMA

The inventory forecasting module represents the main analytical component of the proposed system. Through this module, users can select a specific item, define the forecasting period, and assign weights to historical sales data in accordance with the Weighted Moving Average (WMA) method. The forecasting result interface is shown in Figure 11.

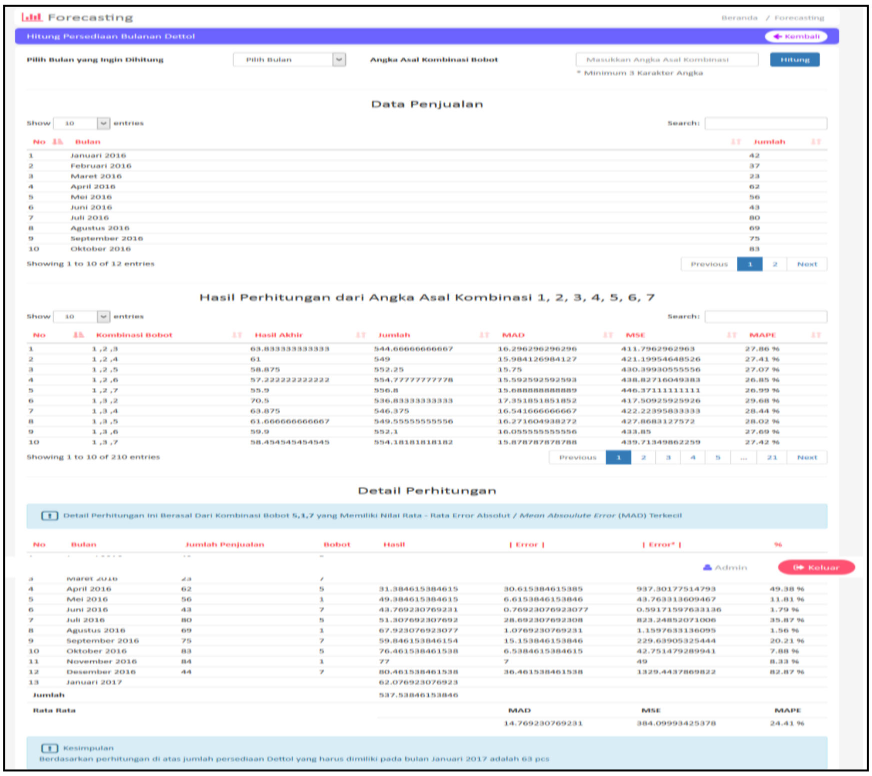

Figure 11. Forecasting Result Interface

Once the forecasting parameters are defined, the system automatically processes historical sales data and generates the predicted demand for the subsequent period. The forecasting results are presented in a structured format, displaying historical sales values, the assigned weights, and the resulting forecast value. These outputs provide users with a clear quantitative basis for evaluating future inventory requirements.

Furthermore, the forecasting results can be stored in the database, allowing users to maintain historical forecasting records for further analysis and comparison. The availability of stored forecasting data supports continuous evaluation of forecasting performance and facilitates more informed inventory procurement decisions. By utilizing the forecasting results generated by the system, users can estimate optimal inventory quantities, thereby reducing the risk of overstock and stockout conditions. Consequently, this module plays a significant role in enhancing the effectiveness and efficiency of inventory management at Toko Tita. The detail forecasting result is shown in figure 12.

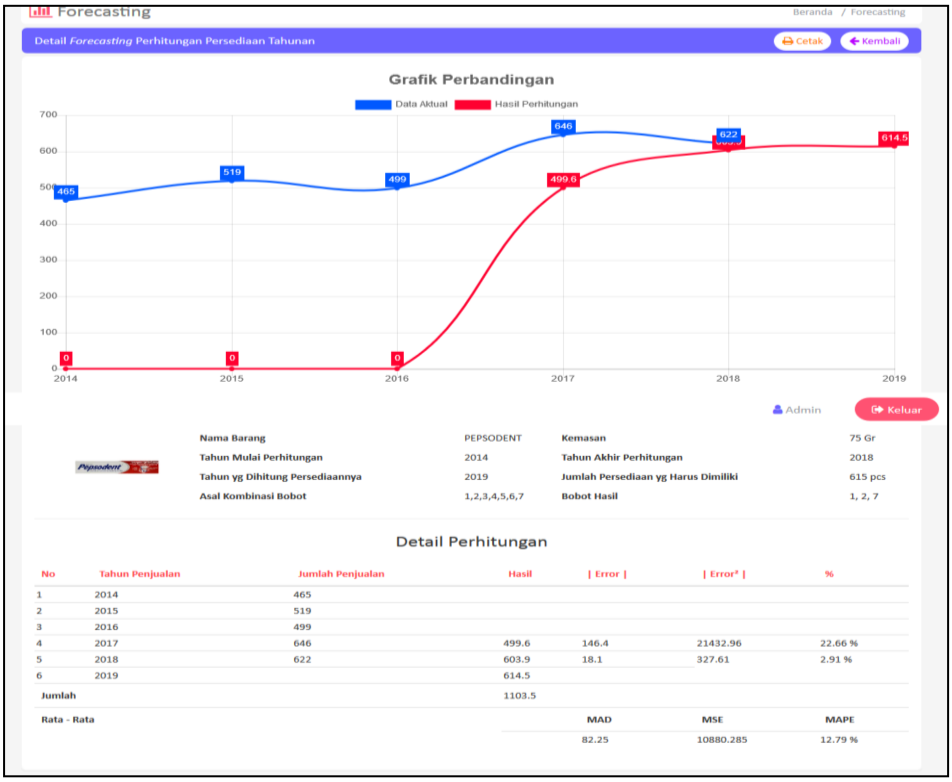

Figure 12. Detail Forecasting Result Interface

3.5. Forecasting Accuracy Evaluation (MAD, MSE, and MAPE)

To evaluate the reliability of the forecasting results, the system automatically computes three commonly used forecasting error metrics: Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE).

1. Weighted Moving Average (WMA) Configuration

The Weighted Moving Average (WMA) method applied in this study uses a forecasting period of three months. Different weights are assigned to each historical period to reflect their relative importance in influencing future demand. The weight configuration consists of 5 for the third previous period (t−3), 1 for the second previous period (t−2), and 7 for the most recent period (t−1), resulting in a total weight of 13. The actual sales data used in the forecasting process are as follows:

$$A = \{42,37,23,62,56,43,80,69,75,83,84,44\}$$

These data represent monthly sales records and serve as the basis for generating inventory demand forecasts using the WMA method. Table 1 presents the WMA Forecasting Results with Weights (5,1,7) for selected items at Toko Tita.

Table 1. WMA Forecasting Results with Weights (5,1,7)

Month	Actual (A)	Forecast (F)	|A−F|	(A−F)²	|(A−F)/A| (%)
Apr	62	31.38	30.62	937.60	49.39
May	56	49.38	6.62	43.82	11.82
Jun	43	43.77	0.77	0.59	1.79
Jul	80	51.31	28.69	823.19	35.86
Aug	69	67.92	1.08	1.17	1.56
Sep	75	59.85	15.15	229.52	20.20
Oct	83	76.46	6.54	42.77	7.88
Nov	84	77.00	7.00	49.00	8.33
Dec	44	80.46	36.46	1329.30	82.86

Month	Actual (A)	Forecast (F)	|A−F|	(A−F)²	|(A−F)/A| (%)
Total	–	–	**132.93**	**3456.00**	**219.69**

2. Evaluation of Forecasting Accuracy Using MAD, MSE, and MAPE

$$MAD = \frac{132,93}{9} = 14,77$$

$$MSE = \frac{3456}{9} = 384.00$$

$$MAPE = \frac{219,69}{9} = 24,41\%$$

The forecasting accuracy of the Weighted Moving Average (WMA) method was evaluated using MAD, MSE, and MAPE metrics. The obtained MAD value of 14.77 indicates that the forecasted demand deviates from actual sales by approximately 15 units per period, which is considered acceptable for small-scale retail inventory planning.

The MSE value of 384.00 suggests that large forecasting errors are relatively limited and do not significantly affect overall forecasting performance. In addition, the MAPE value of 24.41% falls within the range commonly classified as acceptable forecasting accuracy for practical applications. These quantitative results confirm that the WMA method provides a reliable forecasting performance and can effectively support inventory planning decisions at Toko Tita, despite demand fluctuations in monthly sales data.

3. Comparison of Forecasting Methods for Moving Average (MA)

Table 2. Comparison of Forecasting Accuracy

Method	Weight Configuration	MAD	MSE	MAPE (%)	Accuracy Level
Moving Average (MA)	Equal (1–1–1)	16.36	379.77	27.34	Moderate
WMA	0.5 – 0.3 – 0.2	15.77	423.15	26.71	Moderate
WMA (Optimized)	**5 – 1 – 7**	**14.77**	**384.00**	**24.41**	**Better**

The comparison results indicate that the Weighted Moving Average (WMA) method consistently outperforms the Simple Moving Average (MA) method in terms of MAD and MAPE values. The optimized WMA configuration with weights 5–1–7 produces the lowest MAD and MAPE values, demonstrating improved responsiveness to recent demand fluctuations. Although the MSE value of the optimized WMA method is slightly higher than that of MA, the overall reduction in absolute and percentage errors confirms that WMA provides better forecasting performance for inventory planning at Toko Tita.

3.6. Discussion

The evaluation results indicate that the Weighted Moving Average (WMA) method performs effectively in capturing short-term demand patterns at Toko Tita, particularly by assigning greater weights to recent sales data. This weighting strategy enhances the responsiveness of the forecasting model to demand fluctuations that commonly occur in small-scale retail environments. The lower MAD and MAPE values obtained by the WMA method compared to the Simple Moving Average (MA) method confirm that WMA is more suitable for inventory planning scenarios where recent sales trends play a significant role in influencing future demand.

From an operational perspective, the integration of the WMA-based forecasting module into a web-based inventory information system provides tangible benefits for managerial decision-making. The availability of automated forecasting results, supported by quantitative accuracy indicators, allows store managers to determine procurement quantities more objectively rather than relying solely on intuition or past experience. This data-driven approach contributes to minimizing the risk of overstock, which increases holding costs, as well as stockout conditions that can lead to lost sales and reduced customer satisfaction. Consequently, the system supports improved cost efficiency and service level performance in daily retail operations.

The integration of historical sales data, inventory records, and forecasting calculations within a single platform also enhances operational efficiency. By automating data processing and forecasting computations, the system reduces the likelihood of manual calculation errors and improves data consistency. This integration ensures that forecasting results are based on accurate and up-to-date transaction data, thereby increasing the reliability of inventory planning outcomes.

Nevertheless, the results also reveal limitations of the WMA approach, particularly during periods characterized by extreme or sudden changes in demand. In such cases, forecasting errors tend to increase, indicating that WMA, as a linear time-series method, may not fully capture complex demand dynamics influenced by external factors such as seasonal events, promotions, or unexpected market changes. These findings suggest that while WMA is effective for stable or moderately fluctuating demand patterns, its performance may decline under highly volatile conditions.

Therefore, future research is recommended to explore adaptive or hybrid forecasting approaches that combine WMA with other methods, such as exponential smoothing or machine learning-based models. Such approaches may enhance forecasting accuracy by dynamically adjusting to changing demand patterns and capturing non-linear relationships in sales data. Additionally, incorporating external variables, such as promotional activities or seasonal indicators, may further improve the robustness of inventory forecasting systems for small-scale retail businesses.

4. CONCLUSION

Based on the results of this study, it can be concluded that the implementation of a web-based inventory forecasting information system using the Weighted Moving Average (WMA) method has been successfully carried out and effectively supports inventory management at Toko Tita. The developed system is able to integrate item data management, sales transaction processing, and demand forecasting within a single platform, thereby improving data accuracy, operational efficiency, and decision-making quality in inventory planning.

The application of the WMA method with an optimized weight configuration of 5–1–7 demonstrates better forecasting performance compared to the Simple Moving Average (MA) method. This is indicated by lower MAD and MAPE values, which confirm that giving greater emphasis to recent sales data enhances the system's responsiveness to short-term demand fluctuations. Although some forecasting deviations still occur during periods of extreme demand changes, the overall forecasting accuracy achieved is considered acceptable and practical for small-scale retail operations.

Furthermore, the evaluation results show that the forecasting outputs generated by the system provide a reliable quantitative basis for inventory procurement decisions. By utilizing MAD, MSE, and MAPE as evaluation metrics, the system enables continuous monitoring of forecasting accuracy and supports more informed inventory control strategies. As a result, the risk of overstock and stockout conditions can be reduced, leading to improved cost efficiency and customer service levels.

In conclusion, this study confirms that the integration of the Weighted Moving Average method into a web-based inventory information system can effectively enhance inventory planning and management in small retail businesses. The proposed system not only performs demand forecasting but also functions as a practical decision-support tool that is directly applicable to daily retail operations. Future research is recommended to explore adaptive or hybrid forecasting methods to further improve accuracy under highly volatile demand conditions.

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