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BATTERY LIFESPAN PREDICTION FOR MOTORCYCLES USING DOUBLE MOVING AVERAGE

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Abstract: The inability to accurately monitor the lifespan of motorcycle batteries can lead to sudden failures, disrupt user activities, and increase maintenance costs. This issue is exacerbated by the absence of a predictive system that can assist users and workshops in planning maintenance and managing battery inventory effectively. This study aims to develop a battery lifespan prediction model for motorcycles using the Double Moving Average (DMA) method. The model is built based on historical data from 12 motorcycle units, including usage frequency, duration, terrain conditions, and maintenance habits. Forecasting is conducted through two stages of moving averages followed by trend parameter calculations. Evaluation results show that the model has a high level of accuracy, with MAPE = 0.10, MAD = 1.68, and RMSE = 2.14, indicating very low prediction errors. In addition, DMA is also used to forecast product demand at PT Anugerah Karya Abiwara Kisaran to prevent stock shortages. The system is developed using Visual Studio 2010 and Microsoft Access and has proven effective in supporting maintenance planning and inventory control. With its high accuracy and efficiency, the results of this study provide tangible contributions to decision-making in battery maintenance and inventory management.

Keywords: battery; double moving average; motorcycle; prediction.

Abstrak: Ketidakmampuan dalam memantau usia pakai aki sepeda motor secara akurat dapat menyebabkan kerusakan mendadak, mengganggu aktivitas pengguna, serta meningkatkan biaya perawatan. Permasalahan ini diperburuk oleh tidak tersedianya sistem prediktif yang membantu pengguna dan bengkel dalam merencanakan perawatan serta mengelola persediaan aki secara efisien. Penelitian ini bertujuan untuk mengembangkan model prediksi usia pemakaian aki sepeda motor dengan menggunakan metode Double Moving Average (DMA)**.** Model dibangun berdasarkan data historis dari 12 unit sepeda motor yang mencakup frekuensi penggunaan, durasi, kondisi medan dan kebiasaan perawatan. Proses peramalan dilakukan melalui dua tahap perataan bergerak, yang kemudian diikuti dengan perhitungan parameter tren. Hasil evaluasi menunjukkan bahwa model ini memiliki tingkat akurasi yang tinggi, dengan nilai MAPE sebesar 0,10, MAD sebesar 1,68, dan RMSE sebesar 2,14, yang mengindikasikan tingkat kesalahan prediksi yang sangat rendah. Selain itu, metode DMA juga diterapkan untuk meramalkan permintaan produk pada PT Anugerah Karya Abiwara Kisaran guna mencegah terjadinya kekurangan stok. Sistem dikembangkan menggunakan Visual Studio 2010 dan Microsoft Access, serta terbukti efektif dalam mendukung perencanaan perawatan dan pengendalian persediaan. Dengan akurasi dan efisiensi yang tinggi, hasil penelitian ini memberikan kontribusi nyata dalam pengambilan keputusan terkait pemeliharaan aki dan manajemen inventori.

Kata kunci: baterai; double moving average; prediksi; sepeda motor.

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INTRODUCTION

The battery is one of the essent\ial components of a motorcycle, functioning as the primary power source for starting the engine and supporting various electronic systems. Its lifespan can vary significantly depending on several factors, including usage patterns, environmental conditions, battery quality, and maintenance practices [1].

However, many motorcycle users face difficulties in determining the optimal time to replace the battery, which often results in sudden declines in vehicle performance. To overcome this issue, a forecasting system is required to accurately predict battery lifespan based on historical usage data. P.T. Anugerah Karya Abiwara Kisaran, a company specializing in motorcycle distribution and after-sales services located at Jalan Sisingamangaraja No. 320, Kisaran, also encounters this challenge [2].

The absence of a reliable prediction mechanism means that customers typically rely on subjective experience [3] or wait until problems arise before replacing the battery. This reactive approach can lead to inconvenience and decreased customer loyalty. To address this problem, the Double Moving Average (DMA) method can be applied [4], [5]. DMA is an advanced time series forecasting technique that analyzes trends more accurately than the standard Moving Average method [6], [7]. Therefore, the purpose of this research is to develop a predictive model for estimating motorcycle battery lifespan based on usage patterns and historical data using the Double Moving Average method.

This model is expected to support P.T. Anugerah Karya Abiwara Kisaran in providing timely and accurate battery replacement recommendations, enhancing service quality, minimizing unexpected battery failures, and improving overall customer satisfaction. The Double Moving Average (DMA) method is chosen due to its ability to accurately capture long-term trends, especially in time-series data such as motorcycle battery lifespan.

Compared to the simple moving average, DMA effectively smooths short-term fluctuations while highlighting gradual performance degradation over time. Research by Hilal and Saha [8] demonstrated that classical statistical methods like DMA can outperform more complex models when data is limited, as they focus more on actual trends rather than short-term noise. Furthermore, DMA is simple, resource-efficient and easy to implement, making it well-suited for companies like P.T. Anugerah Karya Abiwara Kisaran, which may have limited technical infrastructure and historical data.

Wu et al. [9] also proved that DMA yields high forecasting accuracy in datasets with seasonal patterns and long-term trends, such as energy consumption. Therefore, this method is not only academically valid but also practically applicable as a foundation for building a battery lifespan prediction system based on usage data. Its implementation is expected to improve customer service, reduce unexpected battery failures, and optimize replacement schedules through data-driven decision-making.

The lifespan of a motorcycle battery can be influenced by various factors that are often overlooked by users[9]. Common issues affecting battery durability include variations in battery lifespan, users' lack of understanding in battery maintenance[10] differing usage patterns, as well as environmental and weather conditions that can accelerate battery

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degradation. Without an accurate prediction system, users tend to replace batteries based on guesswork or only after a problem arises. This can lead to inconvenience and higher maintenance costs if the battery replacement is not done at the right time1[11].

By applying a prediction system based on the Double Moving Average method, the company can assist customers in better understanding the durability of their batteries. Using this data, the Double Moving Average model will help identify battery life trends and provide an estimated optimal time for battery replacement before problems occur.

The Double Moving Average method[12], offers advantages over the standard Moving Average, as it reduces data fluctuation, detects trend changes, delivers more stable predictions, and is easy to implement and develop. Implementing a battery life prediction system based on This research offers a novel contribution by applying the Double Moving Average (DMA) method to forecast motorcycle battery lifespan based on real-world usage patterns, a rarely studied area.

In contrast from previous studied focused on automotive or industrial batteries using complex models, this study emphasizes a lightweight, interpretable, and practical approach suitable for businesses with limited data, like P.T. Anugerah Karya Abiwara Kisaran. Additionally, the integration of forecasting results into a customer recommendation system provides direct business value, enabling proactive battery maintenance, improving customer satisfaction, and minimizing service failures. This makes the research both scientifically relevant and operationally impactful**.** With more accurate battery lifespan estimates [13], customers can plan battery replacements more efficiently and avoid unexpected breakdowns.

This study applies the Double Moving Average (DMA) method to predict motorcycle battery lifespan using real-world usage data—an area rarely explored. Unlike complex models in prior studies, this approach offers a simple, efficient, and suitable solution for small businesses with limited data, such as P.T. Anugerah Karya Abiwara Kisaran. The model is integrated into a web-based system that provides timely battery replacement recommendations, helping reduce unexpected failures and improve customer satisfaction. It also supports better inventory planning and after-sales service. This research bridges forecasting methods with practical applications to enhance maintenance strategies and business operations.

Motorcycle battery durability is a crucial aspect that affects the overall user experience. Many factors contribute to battery lifespan, and without an accurate prediction system, users often struggle to determine the right time for replacement. At P.T. Anugerah Karya Abiwara Kisaran, a company engaged in motorcycle distribution and maintenance, there is a significant opportunity to enhance service quality by developing a battery life prediction system [14] based on the Double Moving Average method [15].

METHOD

This study uses the Double Moving Average method [16] to predict motorcycle battery lifespan based on vehicle usage patterns.

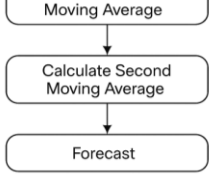

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Image 1. Visualization of The DMA Method

The image shows the flow of the Double Moving Average (DMA) method, starting from inputting actual data, followed by calculating the first moving average (Mt) and the second moving average (Mt'). The results of these calculations are then used to forecast the value for the next period. The data used consists of historical motorcycle battery usage patterns, including frequency of use, duration of usage, terrain conditions, and maintenance habits. These data are obtained from service records at P.T. Anugerah Karya Abiwara Kisaran. The data were collected retrospectively from several customer vehicles.

By collecting data from multiple battery units, the developed DMA model aims to predict the average battery lifespan based on general usage patterns. This approach enables the prediction system to provide accurate battery replacement recommendations for groups of customers with similar usage characteristics.

First Moving Average
The raw data is processed to calculate the moving average over a specific period to obtain Mt. The moving average period is adjusted based on the characteristics of the data and the needs of the prediction[18].

$$Mt = \frac{Y_t + Y_{t-1} + Y_{t-2}}{n} \quad \text{…….……..(1)}$$

Description:
Mt = First moving average value at period t.
Yt = Actual data at period t.
n = Number of periods.

The first Moving Average is then averaged again to obtain *Mt*, which helps to smooth the data trend.

$$Mt' = \frac{Y_t + Y_{t-1} + Y_{t-2}}{n} \quad \text{………..(2)}$$

Description:
Mt = Second moving average value at period t.
Yt = Actual data at period t.
n = Number of periods.

Table 1. Wet Cell Battery Data

No	Motorcycle	Terrain	Maintenance	Battery Lifespan (Months)
1	Honda Beat	Moderate	Rare	15
2	Honda Scorpio	Moderate	Regular	18
3	Honda Genio	Light	Regular	18
4	Honda Beat	Light	Occasionally	15
5	Honda Beat	Heavy	Rare	13
6	Honda Beat	Light	Occasionally	17
7	Honda Genio	Moderate	Occasionally	14
8	Honda Beat	Moderate	Rare	17
9	Honda Scorpio	Light	Regular	15
10	Honda Genio	Heavy	Occasionally	16
11	Honda Beat	Moderate	Occasionally	16
12	Honda Scorpio	Light	Rare	15

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The next step, after obtaining the M value (Double Moving Average), is to sequentially determine the constant value (*at*) using Equation (3), followed by calculating the trend coefficient (*bt*) using the appropriate formula.

The trend parameter is calculated using the following formula:

$$at = 2Mt - Mt' \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$bt = \frac{2}{n-1}(Mt - Mt' \ldots\ldots\ldots\ldots\ldots\ldots..(4)$$

Description:
at = Level component at period t.
bt = Trend component at period t.
Mt = First moving average value at period. t.
Mt′ = Second moving average value at period t.

The predicted value for the next period is calculated using the following formula:

$$Ft + 1 = at - bt \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Description:
F = Forecasting at period t.

MAD, MAPE, MSE, and RMSE are used to measure the accuracy of forecasting results. MAD shows the average error in the original data units, while MAPE expresses the error as a percentage. MSE gives greater weight to large errors because it squares the differences, and RMSE simplifies MSE back into the original units, making it easier to interpret. All four are used to assess how well a forecasting model performs. Mathematically, The Data For The Wet Battery Type Can Be Seen In Table 1.

RESULT AND DISCUSSION

This study uses historical data from 12 motorcycle units, each with different usage pattern characteristics. he data collected includes terrain conditions (average difficulty level of the terrain traveled) and battery maintenance history. All data were obtained from service records at P.T. Anugerah Karya Abiwara Kisaran.

Perform a 3-period moving average calculation, using the following method.

$$M = \frac{18+18+15}{3}$$

$$M = 17$$

Next, perform the Double Moving Average calculation. The Double Moving Average is obtained as follows.

$$M' = \frac{15.33+17+17}{3}$$

$$M' = 16.44$$

Table 2. Battery Lifespan Forecasting Results

No	Motor-cycle	Wet Cell Batter-ies	Mt	Mt’	at	bt	Ft	Err	Ab-sErr	Err^2	Err/Dt
1	Beat	15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
2	Scorpio	18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
3	Genio	18	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
4	Beat	15	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
5	Beat	13	15.33	16.44	14.22	-1.11	0.00	0.00	0.00	0.00	0.000
6	Beat	17	15.00	15.78	14.22	-0.78	13.11	-3.89	3.89	15.1	0.229

No	Motor-cycle	Wet Cell Batter-ies	Mt	Mt’	at	bt	Ft	Err	Ab-sErr	Err^ 2	Err/D t
7	Genio	14	14.67	15.00	14.33	-0.33	13.44	-0.56	0.56	0.31	0.040
8	Beat	17	16.00	15.22	16.78	0.78	14.00	-3.00	3.00	9.00	0.176
9	Scorpio	15	15.33	15.33	15.33	0.00	17.56	2.56	2.56	6.53	0.170
10	Genio	16	16.00	15.78	16.22	0.22	15.33	-0.67	0.67	0.44	0.042
11	Beat	16	15.67	15.67	15.67	0.00	16.44	0.44	0.44	0.20	0.028
12	Scorpio	15	15.67	15.78	15.56	-0.11	15.67	0.67	0.67	0.44	0.044
	Beat						15.44				
	Scorpio						15.23				
	Genio						14.76				
	MAD		1.68								
	MAPE		0.10								
	MSE		4.58								
	RMSE		2.14								

Calculation of the coefficient values *a* and *b*, to be used in the forecasting method.

$$at = 2(15.3316.44)$$

$$at = 14.22$$

$$bt = \frac{2}{3-1}(15.33 - 16.44)$$

$$bt = -1.11$$

After obtaining the coefficient values *a* and *b*, we proceed with the forecasting calculation.

$$F_{t-1} = (14.11 - 1.11)$$

$$F_{t-1} = 13.11$$

The following is the form display for the item type**,** which is an activity where the admin can input the types of items. The form display for item types can be seen in image 2.

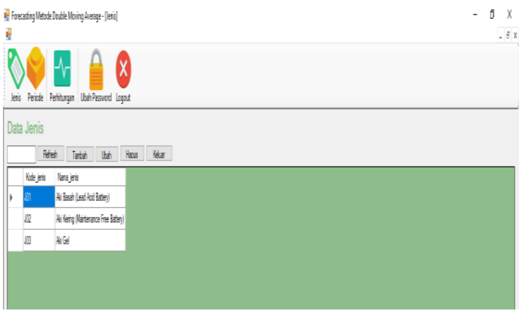

Image 2. Battery Type Data

The following is the form display for the period, which is an activity where the admin can input battery lifespan data per period. The period form display can be seen in image 3.

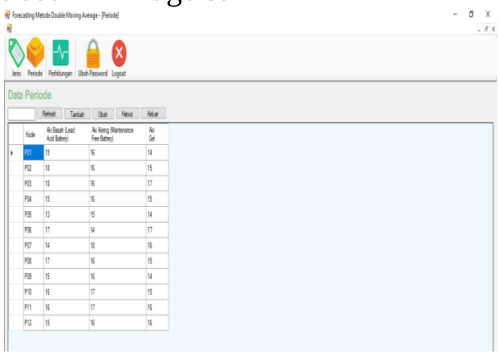

Image 3. Battery Period Data

The calculation (forecasting) form will appear when the admin clicks the calculation menu. This activity allows the admin to input the forecasting period and the moving average period. There is a Calculate button that displays the data entered in the period form, then outputs the forecasting results along with the absolute error results, namely MAD, MAPE, and MSE.

There is also a Print button that generates a forecasting report for printing

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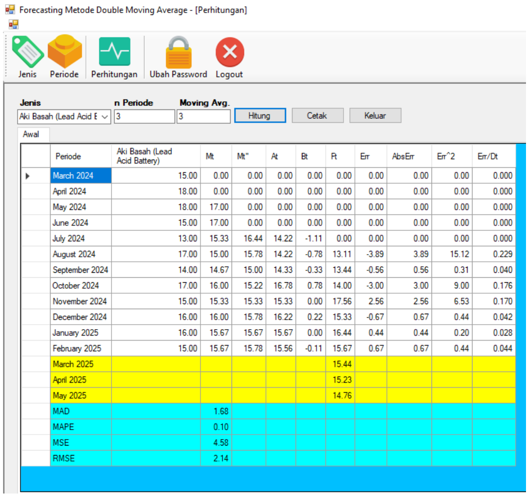
and distribution to the company owner. Additionally, a Close button is available to close the calculation (forecasting) form. The calculation form display can be seen in image 4.



Periode	Aki Basah (Lead Acid Battery)	Mt	Mt"	At	Bt	Ft	Err	AbsErr	Err^2	Err/Dt
March 2024	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
April 2024	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
May 2024	18.00	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
June 2024	15.00	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
July 2024	13.00	15.33	16.44	14.22	-1.11	0.00	0.00	0.00	0.00	0.000
August 2024	17.00	15.00	15.78	14.22	-0.78	13.11	-3.89	3.89	15.12	0.229
September 2024	14.00	14.67	15.00	14.33	-0.33	13.44	-0.56	0.56	0.31	0.040
October 2024	17.00	16.00	15.22	16.78	0.78	14.00	-3.00	3.00	9.00	0.176
November 2024	15.00	15.33	15.33	15.33	0.00	17.56	2.56	2.56	6.53	0.170
December 2024	16.00	16.00	15.78	16.22	0.22	15.33	-0.67	0.67	0.44	0.042
January 2025	16.00	15.67	15.67	15.67	0.00	16.44	0.44	0.44	0.20	0.028
February 2025	15.00	15.67	15.78	15.56	-0.11	15.67	0.67	0.67	0.44	0.044
March 2025						15.44				
April 2025						15.23				
May 2025						14.76				
MAD		1.68								
MAPE		0.10								
MSE		4.58								
RMSE		2.14								

Image 4. Forecasting Results

From image 4, it can be seen that MAD (Mean Absolute Deviation) measures the average of the absolute differences between actual values and predicted values. A low MAD indicates that the average error between the forecast and actual data is minimal, suggesting that the model is accurate and stable. MAPE (Mean Absolute Percentage Error) expresses prediction errors as a percentage of the actual values. When the MAPE value is low (e.g., less than 10%), it signifies that the model's performance is very good because the relative error is small.

RMSE (Root Mean Squared Error) measures the square root of the average squared differences between forecasted and actual values. Battery lifespan prediction using the Double Moving Average (DMA) method is relevant and can be practically implemented across various motorcycle units. With simple integration into the customer service system, the company can gain significant benefits in terms of efficiency, customer satisfaction, and competitive advantage in the local automotive service market.

CONCLUSION

This study successfully developed a motorcycle battery lifespan forecasting model using the Double Moving Average (DMA) method, based on real-world data from 12 units. The model provides accurate and consistent predictions, with very low error rates as indicated by evaluation metrics (MAPE 0.10, MAD 1.68, and RMSE 2.14). This demonstrates that the simple and resource-efficient DMA method is highly suitable for practical applications, offering a data-driven solution to assist both users and service workshops in planning timely battery replacements. Ultimately, this research contributes to the development of accessible predictive maintenance systems, strengthening data-driven decision-making and enhancing customer satisfaction.

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