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Optimising Double Exponential Smoothing for Sales Forecasting Using The Golden Section Method

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ABSTRACT

To achieve maximum profits and a satisfying impression on consumers, companies are required to have the right strategy in selling their products. In determining the right strategy, it requires the availability of accurate information that can be analyzed to determine a sales strategy so that it can increase the number of sales and generate large profits, namely by forecasting. In the Double Exponential Smoothing method, the problem that arises is determining the optimum α parameter value to provide the smallest size of forecasting error, which is sought using the trial and error method, so it requires quite a lot of time. To overcome this problem, a non-linear optimization algorithm using the Golden Section algorithm is used. The Golden Section algorithm is an algorithm that uses the principle of reducing the boundary area α which might produce a minimum objective function value. It is hoped that this forecasting design will be able to provide information that will help the company take decisions or steps in providing stock of goods for sale so that there will be no overstock in the warehouse and can increase Dewaayu Shop's profits. based on the test results, the value of MAPE value is obtained of 21.59579369% and RMSE value of 2.42465034.

1. Introduction

Companies involved in sales services or product distribution always want their business to be successful in the future. This shows that every company is always trying to develop its business in the future. To make profits. In order to achieve maximum profits and a satisfactory impression for consumers, companies need to have the right strategy in selling their products. Determining the right strategy requires the availability of accurate information that can be analysed to determine a sales strategy that can increase the number of sales and generate large profits, namely through forecasting (Boone et al., 2019; Suryadana & Sarasvananda, 2024; Swari et al., 2022). In the Double Exponential Smoothing method, the problem that arises is to determine the optimum α parameter value to provide the smallest forecast error size, which is sought by the trial and error method, so it takes quite a lot of time (Asana et al., 2022; Cui et al., 2024). To overcome this problem, a non-linear optimisation algorithm using the Golden Section algorithm is used.

The Golden Section algorithm is an algorithm that uses the principle of reducing the boundary area α that could produce a minimum value of the objective function (Hani'Ah et al., 2021). It is hoped that this forecasting design will be able to provide information that will help the company to make decisions or steps in providing stock of goods for sale so that there is no overstock in the warehouse and can increase the profits of the Dewaayu shop.

In order to achieve maximum and satisfactory impressions for consumers, companies are required to have the right strategy in selling their products. Determining the right strategy requires the availability of accurate information that can be analysed to determine a sales strategy that can increase the number of sales and generate large profits (Chen et al., 2019; Radhitya et al., 2024). One way to do this is through forecasting. Through forecasting, companies can carry out more mature planning (Atmaja et al., 2022; Qi et al., 2019).

There are 2 methods of forecasting, namely the informal approach and the formal approach. In the Dewaayu Shop case study, the method often used in the company is an informal approach method, namely the company only relies on personal value intuition, experience and estimates to make forecasts. Forecasting the amount of inventory can be calculated using the Double Exponential Smoothing method. method, Double Exponential Smoothing is used on data that has a trend pattern. Dewaayu Shop is a company or retail business that focuses on the fashion and lifestyle industry. Dewaayu Shop has been in business since 2019, initially selling online and now with 3 branches. The shop operates in the clothing and accessories industry, which includes selling clothing, shoes, sandals and beauty products such as skincare, as well as various accessories and other equipment that focus on meeting consumers' needs in terms of personal style, appearance and self-care. Dewaayu Shop's accounting system is still manual, with each transaction being recorded daily in a sales ledger and reported monthly.

The problem this business faces is how to predict or forecast sales transaction data for the coming month. As a result, Dewaayu Shop is unable to predict the rise and fall of sales each month. In order to achieve the expected target, it is necessary for this company to have a sales forecast as a tool to help in effective and efficient planning. One use of data mining using the Double Exponential Smoothing method for general sales data is to predict the number of sales each month and create sales targets so that sales data management is more organised and there is no accumulation of goods that will affect the quality of sales. Problems can be overcome by creating a forecasting method for the company (Griva et al., 2022).

From the informal forecasting approach, namely using personal intuition, it has been improved by adding an approach. Forecasting is the art or science of predicting future events by taking historical data and projecting it into the future using some form of systematic model. Forecasting using the Double Exponential Smoothing method is a process that continuously improves the forecast by averaging (smoothing) past values of time series data in a decreasing (exponential) manner (Lyu & Choi, 2020).

2. Literatur Review

Double Exponential Smoothing (DES) is a powerful forecasting technique particularly suited for time series data exhibiting trends. This method enhances the accuracy of predictions by incorporating both the level and trend components of the data, thereby addressing the limitations of simpler models such as Single Exponential Smoothing (SES) (Mentari & Iftadi, 2023). The application of DES is critical in various fields, including sales forecasting, where understanding trends can significantly influence inventory management and strategic planning.

The foundational principle of DES lies in its ability to smooth out data while simultaneously accounting for trends. As noted by , the method utilizes parameters that optimize forecasting accuracy, selecting those that minimize error values (Ramadhan et al., 2023). This is echoed in the findings of , who demonstrated that Holt's Double Exponential Smoothing outperformed other methods in forecasting accuracy across multiple products, indicating its robustness in practical applications (Mentari & Iftadi, 2023). Furthermore, the research by highlights the effectiveness of Brown's Double Exponential Smoothing in handling both linear and non-stationary trends, which is particularly relevant for sales data that may not follow a consistent pattern (Dharmawan & Indradewi, 2021). Further research was carried out by (Hani'ah & Kurniawan, 2023)The sustainability of automotive companies is very important for Indonesia because they can become one of the absorbers of labor in Indonesia. Sales prediction is an important aspect for company sustainability because it can be used to estimate production quantities. One method that has good performance in sales prediction is Holt–Winters exponential smoothing, but this method is very dependent on the parameters α, β, γ. If you determine the parameters incorrectly, the prediction results could be inaccurate. One way to overcome this is to use parameter optimization. In this research, the integration of Holt–Winters exponential smoothing with multivariable golden section is proposed to produce optimal parameters for predicting car sales in Indonesia. Based on trials, the proposed method can be used to make predictions with an average MAPE of 9% which is included in the high accuracy scale. Apart from that, the proposed method was compared with previous research and the results showed that the proposed method was superior to previous research.

The optimization of DES parameters can be approached through various methods, including the Golden Section Method, which is a technique for finding the extremum (minimum or maximum) of a unimodal function. This method can be particularly beneficial in determining the optimal smoothing constants (α and β) that govern the level and trend components of the DES model (Liantoni & Agusti, 2020; Pérez-Albornoz et al., 2023). By systematically narrowing down the range of possible values, the Golden Section Method facilitates the identification of parameters that yield the lowest forecast error, thereby enhancing the accuracy of sales predictions. However, specific references supporting the use of the Golden Section Method in the context of DES were not identified in the provided references.

Moreover, the comparative studies conducted by et al. and others reinforce the notion that DES is superior to SES when dealing with data that exhibit clear trends. Their analyses consistently show that DES provides more accurate forecasts, as it integrates trend adjustments into the smoothing process (Ahmar, 2024; Dewi & Idayani, 2023). This is crucial for sales forecasting, where understanding the trajectory of sales data can lead to more informed decision-making regarding stock levels and marketing strategies.

Optimizing Double Exponential Smoothing for sales forecasting through methods like the Golden Section Method can significantly enhance forecasting accuracy. The integration of trend components into the smoothing process allows businesses to make better-informed decisions based on reliable predictions. The empirical evidence supporting the efficacy of DES across various studies underscores its importance as a forecasting tool in dynamic market environments.

3. Research methods

Research methods are the steps that researchers have and carry out in order to collect information or data and carry out investigations on the data that has been obtained. The research method provides an overview of the research design which includes, among other things: procedures and steps that must be taken, research time, data sources, and with what steps the data was obtained and what follows.

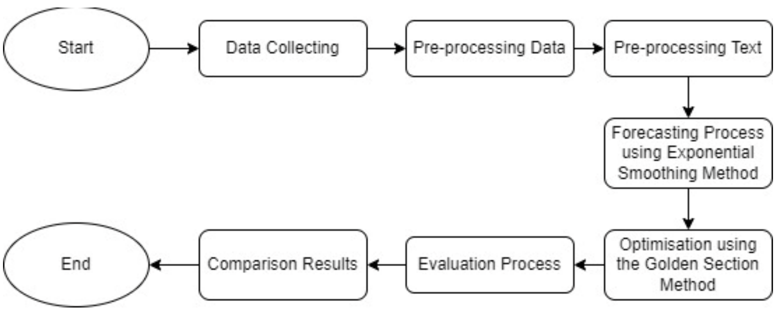

Fig.1. Research Methods

System Overview

The general of the system is an outline of the system workflow and business processes that will be created in the design. In the system that will be built, there are two main processes, namely the training and testing process. Where the first step is to divide the dataset into two, namely training and testing data. From training data, the training process goes through data preprocessing and converting raw data into data that is easy to understand. This process is very important because raw data often does not have a regular format and is difficult for the system to recognize. Meanwhile, data that has gone through preprocessing will go through a data training process. Next, the data that has been trained from training will then go through the testing process stage to produce the best model. After getting the model, the Double Exponential Smoothing model will be used on the test data obtained from the training data. The results of the test data process will go through an evaluation and validation process to determine the best accuracy.

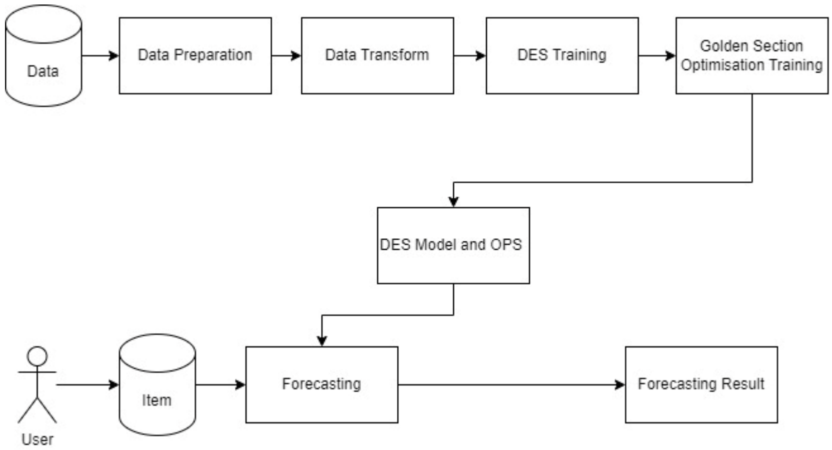

Fig.2. System Overview

Alpha Calculation

This method requires an alpha (α) value as the smoothing parameter value. A higher α value is given to newer data, so that the appropriate α parameter value will provide an optimal forecast with the smallest error value. To get the right α value, it is generally done by trial and error to determine the lowest error value. The α value is carried out by comparing using a smoothing interval between $0 < \alpha < 1$, namely α (0.1 to 0.9). In this forecasting, the alpha (α) used for each product is different because of the large number of different sales data in this research. Here are some of the alphas used are ($\alpha = 0.031$), ($\alpha = 0.186$), ($\alpha = 0.247$), ($\alpha = 0.498$), ($\alpha = 0.560$), ($\alpha = 0.604$), ($\alpha = 0.740$), ($\alpha = 0.854$), and ($\alpha = 1$).

Calculation of the Double Exponential Smoothing Method

The data for forecasting is sales data for three years, namely 2021-2023, taken from the Dewaayu Shop. The data used is weekly data for each product category.

Table 1. Dewayu Shop Sales Data

Years	Month	Week	Id	Item	Total
2021	1	1	A01	Hoodie	8
2021	1	2	A01	Hoodie	7
2021	1	3	A02	Jeans Jacket	3
2021	1	4	A02	Jeans Jacket	2
…….	……..	……	…..	…..	…..
2023	3	4	W01	Jeans Jacket Crop	9
2023	3	4	W02	Cotton Knit sweaters	7

Based on Dewaayu Shop sales data, the results of forecasting sales of goods can be found as follows:

a. Stage 1
   At this stage, alpha and beta values are determined. So the constant value is $\alpha = 0.031477066$
b. Stage 2

This stage determines the actual sale xt value. Xt actual sale is the highest year and highest month. So the actual sale value is the number of mushrooms sold. Xt (actual sale) 2021 January Week 2 Hodie Products = 7.

c. Stage 3
At this stage, the double exponential smoothing method is calculated as follows:
a) Determining First Smoothing:
$S'\text{t} = \alpha \text{Xt} + (1 - \alpha) S'\text{t-1}$ (1)
= (0.031477066) 9 + (1 - 0.031477066) 8
= 8.031477066
b) Determining the second smoothing:
$S''\text{t} = \alpha S'\text{t} + (1 - \alpha) S''\text{t-1}$ (2)
= (0.031477066) 8.031 + (1 - 0.031477066) 0.464
= 0.702454504
c) Determining constants:
at=S't+ (S't−S''t) = 2S't – S"t (3)
= (2 x 8.0314) - 0.702454504
= 14.65804512
d) Determining slope:
bt = $(\frac{\alpha}{1-\alpha} S'\text{t} - S''\text{t})$ (4)
(4)
= $(8.0314 - 0.702454504)\frac{0.4}{1-0.4}$
= 0.230696128
e) Determining forecasting:
Ft-m = at + btm (5)
= 14.65804512 + 0.230696128
= 14.7163087

Based on the data above, the Double Exponential smoothing method calculation has been obtained as follows:

Table 2. Double Exponential Smoothing Method Calculation

Years	Month	Week	Hoodie	S't	S"t	at	bt	Forecast	Absolute Error	Square Error	Absolute Percentage
2021	1	1	8								
		2	7	7,96	0,25	15,43	0,24	15,19	8,19	67,11	1,17
		3	8	7,03	0,46	13,13	0,20	12,92	4,92	24,28	0,61
		4	9	8,03	0,70	14,65	0,230	14,42	5,42	29,45	0,60
2021	2	1	6	8,90	0,96	15,88	0,25	15,63	9,63	92,92	1,60
		2	7	6,03	1,12	9,82	0,15	9,66	2,66	7,11	0,38
		3	8	7,03	1,30	11,45	0,18	11,27	3,27	10,69	0,40
		4	9	8,03	1,51	13,02	0,20	12,82	3,82	14,60	0,42
…	…	…	…	…	…	…	…	…	…	…	…
2023	10	1	9	10,93	9,69	2,48	0,03	2,44	6,55	42,99	0,72
		2	7	8,93	9,67	-1,47	-0,02	-1,44	8,44	71,35	1,20
		3	8	7,03	9,58	-5,11	-0,08	-5,03	13,03	169,90	1,62
		4	10	8,06	9,54	-2,95	-0,04	-2,90	12,90	166,66	1,29
									7,001	67,237	0,738

Calculations Using the Golden Section Method

a. Determine the first uncertainty interval [a,d] = [0,1] which is the constraint of optimization, namely the limit value of α, namely
$0 < \alpha < 1$
b. Calculating the Golden Ratio value.
c. Determines the initial value
alpha1 = r*a + (1-r)*b
gamma1 = r*a2 + (1-r)*b2

alpha2 = a+b - alpha1
gamma2 = a2+b2-gamma1

d. Find the maximum f(x) between the combinations x= alpha1, alpha2, gamma1 and gamma2.
e. Reducing interval limits based on Golden Section criteria.
f. Repeat steps 5 and 6 until |alpha2-alpha1| ≤ eps and |gamma2-gamma1| ≤ eps
g. Find the minimum f(x) with the combination x=alpha1, alpha2, gamma1, gamma2, a, a2, b, b2.
h. Determining the results xmin=x and f(xmin)=f(x)

The following is a parameter optimization calculation using the Golden Section method

a. Determine the lower limit and upper limit
Limit value (a,b) = (1,0)
(a,a2) = 1 (lower limit)
(b,b2) = 0 (upper limit)
r = 0.6180339

From the data above, the parameter iteration calculation has been obtained using the Golden section method as follows:

Table 3. Parameter Optimization Results

Alpha1	Alpha2	Gamma1	Gamma2
0,6180339	0,3819661	0,6180339	0,381966
0,763932002	0,618034038	0,3819661	1
0,854101974	0,763952124	0,61834098	1
0,99830074	0,85410205	0,763932124	1
0,944271929	0,909830121	0,85410205	1
0,965558163	0,944271958	0,909830121	1
0,978713	0,965558181	0,944271958	1
0,986844395	0,978713788	0,965558181	1
0,9918389	0,9868444	0,978713788	1
0,994975007	0,991869393	0,9868444	1
0,996894384	0,994975009	0,991869593	1
0,9980624	0,996894385	0,994975009	1
0,99881376	0,99625	0,996894385	1
0,999266864	0,998813761	0,99825	1
0,999546897	0,999266864	0,998813761	1
...	...	...	...
0,999996316	0,999994039	0,999990355	1

From the results of the optimization calculations above, the optimum parameter values obtained in the 26th iteration have obtained an alpha value of 0.999996316 and a gamma of 0.999990355.

4. Results and Discussion

The optimization result value has been repeated many times then it can be said to be convergent. The results of the Forecasting calculations before Optimization produced a MAPE value of 73.8524529% and after Optimization was carried out using the Golden Section method, the MAPE value was obtained at21.59579369%. So it can be said that this research obtained very good forecasting results.

a) Calculation Results After Parameter Optimization

Following Double Exponential Smoothing calculations using optimization result parameters.

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Tahun	Bulan	Minggu	Hoodie	S't	S"t	at	bt	forcase	Absolute Error	Square Error	Absolute Percentage Error
2021	1	1	8								
		2	7	14,9998971	14,99984179	0,000110519	5,52594E-05	5,52598E-05	6,99994474	48,99922637	0,999992106
		3	8	14,999903	29,99954487	-29,99928372	-14,9995866	-14,99969712	22,99969712	528,9860675	2,87496214
		4	9	16,9998897	46,99908258	-59,9983858	-29,99908238	-29,99930342	38,99930342	1520,945667	4,333255935
2021	2	1	6	14,9998911	61,99846511	-93,99714803	-46,99840087	-46,99874716	52,99874716	2808,867201	8,833124527
		2	7	12,9999163	74,99773558	-123,9956385	-61,99759084	-61,99804764	68,99804764	4760,730578	9,856863949
		3	8	14,999903	89,99685998	-149,9939139	-74,99668068	-74,99723326	82,99723326	6888,540729	10,37465416
		4	9	16,9998897	106,995819	-179,9918587	-89,99559779	-89,99626088	98,99626088	9800,259668	10,99958454
2021	3	1	9	17,99988	124,9946008	-213,9894415	-106,9943266	-106,9951149	115,9951149	13454,86668	12,8883461
		2	12	20,999869	145,9931868	-249,9866357	-124,9928574	-124,9937783	136,9937783	18767,2953	11,41614819
		3	13	24,9998364	170,991523	-291,9833732	-145,9911488	-145,9922245	158,9922245	25278,52744	12,23017111
		4	10	22,9998378	193,9896268	-341,9795781	-170,9891591	-170,990419	180,990419	32757,53176	18,0990419
2021	4	1	8	17,9998741	211,9875636	-387,975379	-193,9869748	-193,9884041	201,9884041	40799,3154	25,24855052
		2	9	16,9998897	228,985346	-423,9709126	-211,9846754	-211,9862373	220,9862373	48834,91706	24,55402636
		3	13	21,9998653	250,9829217	-457,9661128	-228,9822128	-228,9839	241,9839	58556,20784	18,61414615
		4	8	20,9998451	271,9802687	-501,9608472	-250,979499	-250,9813482	258,9813482	67071,33872	32,37266853
2021	5	1	10	17,999886	289,9774652	-543,9551583	-271,9765772	-271,9785811	281,9785811	79511,92022	28,19785811
		2	7	16,9998778	306,9744835	-579,9492114	-289,9735374	-289,975674	296,975674	88194,55093	42,42509628
		3	9	15,9998993	322,9713631	-613,9429275	-306,9703329	-306,9725946	315,9725946	99838,68057	35,10806607
		4	8	16,9998837	339,9680691	-645,9363708	-322,9669956	-322,9693752	330,9693752	109540,7273	41,3711719
2021	6	1	10	17,999886	357,9646098	-679,9294476	-339,9634714	-339,9659763	349,9659763	122476,1845	34,99659763
		2	8	17,9998741	375,960965	-715,9221819	-357,9597722	-357,9624097	365,9624097	133928,4853	45,74530121
		3	12	19,9998786	395,9571438	-751,9145304	-375,9558802	-375,9586502	387,9586502	150511,9143	32,32988752
		4	9	20,9998511	416,9530986	-791,9064949	-395,9517888	-395,9547062	404,9547062	163988,314	44,99496735
2021	7	1	11	19,9998727	436,948876	-833,8980067	-416,9474673	-416,9505394	427,9505394	183141,6642	38,90459449
		2	7	17,9998681	454,9444635	-873,8891907	-436,9429857	-436,9462051	443,9462051	197088,233	63,42088644
		3	6	12,9999104	467,939938	-909,8800553	-454,9383516	-454,9417036	460,9417036	212467,2542	76,82361727
		4	9	14,999909	482,9352785	-935,870739	-467,9336456	-467,9370934	476,9370934	227468,991	52,99301037
2021	8	1	10	18,9998764	501,9304269	-965,8611011	-482,9287714	-482,9323297	492,9323297	242982,2816	49,29323297
		2	8	17,9998741	519,9253936	-1003,851039	-501,9236704	-501,9273686	509,9273686	260025,9212	63,74092107
		3	7	14,9998971	534,9202207	-1039,840647	-519,9184082	-519,922239	526,922239	277647,046	75,27460557
		4	2	8,99992512	543,9149533	-1069,830056	-534,9130576	-534,9169988	536,9169988	288279,8636	268,4584994
2021	9	1	11	12,9999402	556,9095996	-1087,819319	-543,9076556	-543,9116631	554,9116631	307926,9539	50,44651483
		2	14	24,9998423	581,9039784	-1113,808272	-556,9020844	-556,9061877	570,9061877	325933,8752	40,77901341
		3	12	25,9998208	607,8980909	-1163,79654	-581,8961264	-581,9004139	593,9004139	352717,7016	49,49170115
		4	10	21,9998474	629,8919941	-1215,784293	-607,8899072	-607,8943862	617,8943862	381793,4724	61,78943862

Fig.3. Calculations After Parameter Optimization

b) Calculation Results After Optimization

2023	1	1	7	5,52158348	1,307233229	8,428700506	0,453502798	7,975197708	0,975197708	0,951010571	0,139313958
		2	6	4,35434781	1,161157297	6,386381029	0,34361663	6,042764399	0,042764399	0,001828794	0,0071274
		3	12	4,47018968	1,096229983	6,747919396	0,363069055	6,384850341	5,615149659	31,52990569	0,467929138
		4	14	7,86428751	1,427066734	12,87444155	0,692704084	12,18173746	1,818262536	3,306078651	0,129875895
2023	2	1	9	8,38586807	1,658475285	13,45478556	0,723929257	12,73085631	3,730856305	13,91928877	0,414539589
		2	10	5,84441104	1,50759448	8,673633117	0,466681297	8,20695182	1,79304818	3,215021776	0,179304818
		3	12	6,58944265	1,507828076	10,16322915	0,546828405	9,616400747	2,383599253	5,6815454	0,198633271
		4	10	7,43385077	1,598817908	11,67006572	0,627903133	11,04216259	1,042162585	1,086102854	0,104216259
2023	3	1	11	6,48183347	1,544579719	9,874507494	0,531293854	9,343213641	1,656786359	2,744941041	0,150616942
		2	8	6,68881915	1,53811717	10,30140397	0,554262845	9,747141122	1,747141122	3,052502099	0,21839264
		3	9	5,20698861	1,375234648	7,663507924	0,412331922	7,251176002	1,748823998	3,058385377	0,194313778
		4	12	6,05962941	1,380689313	9,357880192	0,503496932	8,85438326	3,14561674	9,894904673	0,262134728
2023	4	1	11	7,54145995	1,543037844	11,99684422	0,645485317	11,3513589	0,351358899	0,123453076	0,031941718
		2	10	6,90403752	1,560459738	10,68715557	0,575018053	10,11213752	0,11213752	0,012574823	0,011213752
		3	9	6,2666151	1,501097579	9,531035033	0,512813458	9,018221575	0,018221575	0,000332026	0,002024619
		4	11	5,95202022	1,435793424	9,0324536	0,485987487	8,546466113	2,453533887	6,019828535	0,223048535
2023	5	1	13	7,22686508	1,538379434	11,37697129	0,612133306	10,76483799	2,235162014	4,99594923	0,17193554
		2	9	7,85605482	1,660437456	12,39123474	0,666705338	11,7245294	2,724529397	7,423060436	0,302725489
		3	8	5,62919267	1,48547459	8,287436154	0,445902127	7,841534028	0,158465972	0,025111464	0,019808247
		4	10	5,3145978	1,358923649	7,911348293	0,425666873	7,48568142	2,51431858	6,32179792	0,251431858
2023	6	1	8	6,15900591	1,382741354	9,552529113	0,513969938	9,038559175	1,038559175	1,078605159	0,129819897
		2	7	4,99177024	1,26975501	7,44403046	0,400523027	7,043507433	0,043507433	0,001892897	0,006215348
		3	8	4,56956618	1,164460314	6,810211737	0,366420669	6,443791068	1,556208932	2,421786239	0,194526116
		4	13	5,63742535	1,223585245	8,827680215	0,474969738	8,352710476	4,647289524	21,59729992	0,35748381
2023	7	1	12	8,17888238	1,528394536	13,30097569	0,715653579	12,58532211	0,585322108	0,34260197	0,048776842
		2	10	7,43385077	1,609714291	11,64827295	0,626730582	11,02154237	1,02154237	1,043548813	0,102154237
		3	8	6,15900591	1,515613557	9,286784707	0,499671669	8,787113038	0,787113038	0,619546935	0,09838913
		4	11	5,42220698	1,38647141	8,071471143	0,434282217	7,637188926	3,362811074	11,30849832	0,305710098
2023	8	1	10	6,90403752	1,477508767	10,85305751	0,583944339	10,26911317	0,269113174	0,072421901	0,026911317
		2	8	6,15900591	1,44556932	9,426873181	0,507209072	8,919664109	0,919664109	0,845782073	0,114958014
		3	13	5,63742535	1,372520519	8,529809666	0,458942935	8,070866731	4,929133269	24,29635478	0,379164098
		4	10	7,96366401	1,584142943	12,75904213	0,686495065	12,07254707	2,072547067	4,295451343	0,207254707
2023	9	1	13	6,69705184	1,559964202	10,27417527	0,552797816	9,721377454	3,278622546	10,7493658	0,252201734
		2	7	7,64083645	1,648713879	11,98424515	0,644807429	11,33943772	4,339437719	18,83071972	0,619919674
		3	8	4,56956618	1,365237741	6,408656882	0,344815173	6,063841709	1,936158291	3,748708928	0,242019786
		4	11	5,42220698	1,306800311	8,23081334	0,442855559	7,787957781	3,212042219	10,31721522	0,292003838
2023	10	1	9	6,79642834	1,423718227	10,74542022	0,578152958	10,16726726	1,167267264	1,362512865	0,129696363
		2	7	5,52158348	1,348477871	8,346211222	0,449064495	7,897146727	0,897146727	0,804872249	0,128163818
		3	8	4,56956618	1,206168728	6,726794908	0,36193246	6,364862448	1,635137552	2,673674814	0,204392194
		4	10	5,3145978	1,210943705	8,207308182	0,441590874	7,765717308	2,234282692	4,992019146	0,223428269
									2,028707716	5,878929295	0,2159579

Fig.4. Calculations After Optimization

From the results of the calculation above, a MAPE value is obtained of 21.59579369% and RMSE value of 2.42465034.

User Interface Implementation

1. Sales Forecast User Interface
   On this page, sales forecast data is displayed, where this page displays sales estimates based on data obtained from previous sales evaluations. Here's what it looks like:

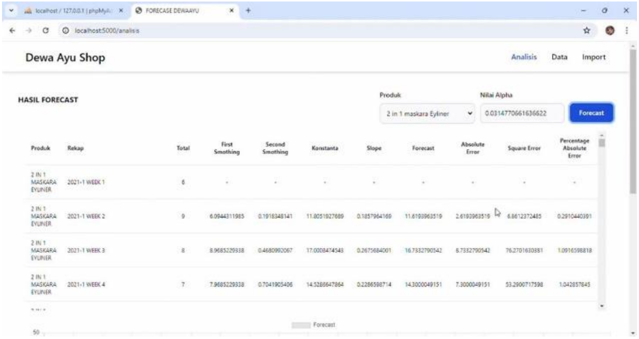

Fig. 5. Sales Forecast

2. Item Data User Interface
   On this page, data on goods sold in the shop is displayed and grouped based on the categories of these goods. Here's what it looks like:

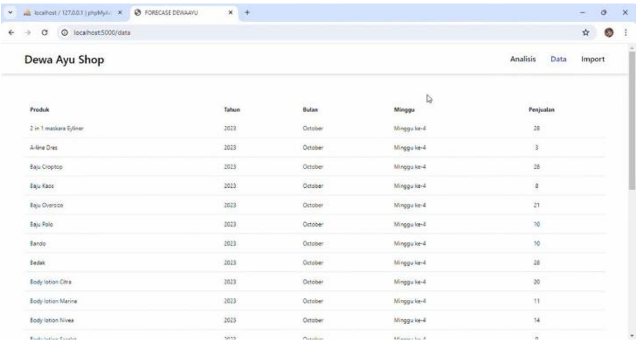

Fig.6. Item Data User Interface

3. User Interface Upload Files
   This page is the page where you can upload item data files. Here's what it looks like:

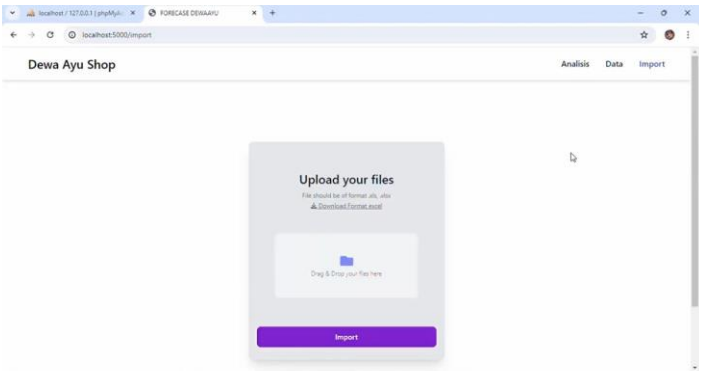

Fig.7. Upload File

4. Sales Forecasting Chart
   This graph shows the sales forecast results for the shop, where this graph can be used as evaluation material for the marketing and sales strategy at the shop. Here's what it looks like:

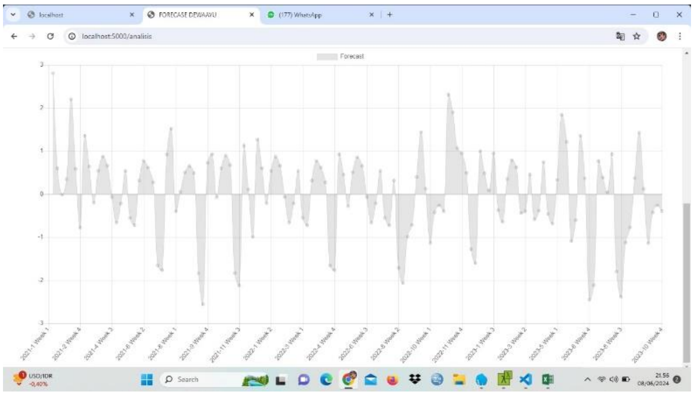

Fig.8. Sales Forecasting Graphic Image

5. Conclusion

This research focuses on the optimisation of sales forecasting using the Double Exponential Smoothing method integrated with the Golden Section optimisation method. The main objective of this research is to improve the accuracy of sales forecasting at Dewaayu Shop, a fashion and lifestyle retailer. Dewaayu Shop is experiencing difficulties in forecasting sales, resulting in sub-optimal inventory management, which can lead to overstocking or understocking. The Double Exponential Smoothing method is used to predict sales data with trend patterns. However, one of the main challenges of this method is determining the optimal value of the smoothing parameter α, which is usually achieved by trial and error, a process that is time consuming and less efficient. To overcome this challenge, this research applies the golden section optimisation method to find the optimal α parameter value more efficiently. The research results show that by using the Golden Section method, the α parameter value can be optimised to provide forecast results with a lower error rate. This is demonstrated by comparing the MAPE (Mean Absolute Percentage Error) values before and after optimisation, which shows a significant reduction after optimisation. In conclusion, this research has shown that the integration of Double Exponential Smoothing with Golden Section Optimisation can increase the accuracy of sales forecasting at the Dewaayu shop. This approach not only reduces forecasting errors, but also provides management with more accurate information to make decisions about inventory management and sales strategies. As a result, companies can plan sales more effectively, avoid overstocking and understocking, and maximise profits. This research also opens up opportunities for further development in the use of other optimisation methods for various more complex forecasting models.

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