Forecasting the number of airplane passengers uses the double and the triple exponential smoothing method

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Abstract. Forecasting is needed to increase capacity and infrastructure, and also to improve the quality and quantity of the airport, especially at Aji Pangeran Tumenggung Pranoto Samarinda's airport. The forecasting method is very diverse. It is difficult to forecast the number of passengers in each period. This is very important to compare the accuracy of the forecasting number of passengers and how to find out the best method to produce the forecasting value. This research uses the mean square error to measure the accuracy of double exponential smoothing and the triple exponential smoothing. The results of this research found the accuracy level between double exponential smoothing and triple exponential smoothing that produced the best forecasting value. MSE error calculation uses alpha constant values 0.1, 0.3, 0.5, 0.7 and 0.9. The best result is the double exponential smoothing method of alpha value 0.9 with an error value of 20522138.748.

1. Introduction
Air transport users always experience changes in the number of airplane passengers each year, data from 2010 to 2018 show changes in passenger volume in 2010 with 80,435 passengers, in 2011 there were 96,431 passengers, 98,022 in 2012 126,054, in 2014 there were 116,569 passengers, in 2015 there were 96,172 passengers, in 2016 there were 82,602 passengers, in 2017 there were 48,313 passengers, and in 2018 as many as 100,646 passengers. Data from 2010 to 2013 showed an increase in passenger volume, but from 2014 to 2017 passenger volumes tended to decline then increased again in the year. Changes in passenger increases this make it difficult for managers to make policy decisions, to increase the service and the airport facilities [1-3].

The number of aircraft passengers in the coming year can be predicted using the double exponential smoothing and triple exponential smoothing methods; this method is used the historical data on the number of passengers in the previous period. Forecasting is an important thing that is done by the manager, by knowing the prediction of the number of passengers that will come; the manager can make a comprehensive decision and can do it optimally [1-3].

2. Research method
2.1 Forecasting
Forecasting is knowledge and art to predict what will happen in the future at the present time. In doing forecasting, there must be passed data and information. Past data and information are behaviors that occurred in the past with various conditions at that time [3-4]. The exponential smoothing method is a procedure with repeated calculations that constantly uses the latest observational data. Every data used in this method is given a weight which is symbolized by alpha [4].

2.2 Double exponential smoothing
The Double Exponential Smoothing method is a linear model proposed by Brown. This method performs two smoothing processes; the rationale for the linear exponential smoothing method of Brown is similar to the linear moving average because both smoothing values must be updated from the actual data if there is a trend element [5]. The trend is a smoothed estimate of the average growth at the end of each period. The double exponential smoothing formula, namely [6]:

1) Calculate the value of the first exponential smoothing given the symbol (S’t) with the equation:
\[ S_t = \alpha X_t + (1 - \alpha) S_{t-1} \] (1)
2) Calculating the second exponential smoothing value given symbol (S”t) with the equation:
\[ S''_t = \alpha S'_t + (1 - \alpha) S''_{t-1} \] (2)
3) Calculates the value of a constant and is given a symbol (αt) with the equation:
\[ \alpha_t = 2S' - S''_t \] (3)
4) Determine the number of slopes with the expression:
\[ b_t = \alpha / (1 - \alpha) S_t - S''_t \] (4)
5) Calculate the amount of predictive value with the equation:
\[ F_{t+m} = \alpha_t + b_t \] (5)

where:
- \( S_0 \) = First exponential smoothing value
- \( S''_t \) = Value of second exponential smoothing
- \( S'_t \) = Exponential smoothing value before
- \( \alpha_t \) = The amount of period constant \( t \)
- \( b_t \) = Slope or trend value from the appropriate data
- \( F_{t+m} \) = Predicted value for the future period
- \( m \) = prediction period
- \( X_t \) = Actual value of the period to \( t \)
- \( \alpha \) = Exponential smoothing parameter of magnitude 0 < \( \alpha \) <1

2.3 Triple exponential smoothing
Exponential Triple Technique Quadratic smoothing of one brown parameter is based on quadratic function. The technique is an extension of the Double Linear exponential technique of two Holt Parameters over the season by including a third smoothing to adjust the season component [7]. Forecasting using the Triple Linear Method of Expansion One Brown parameter is required in the following steps [8]:

1) Calculates the value of the first exponential smoothing
\[ S_t = \alpha X_t + (1 - \alpha) S_{t-1} \] (6)
2) Calculating the value of the second exponential smoothing
\[ S''_t = \alpha S'_t + (1 - \alpha) S''_{t-1} \] (7)
3) Calculating the third exponential smoothing value
\[ S'''_t = \alpha S''_t + (1 - \alpha) S ''''_{t-1} \] (8)
4) Calculate the amount of constants \( \alpha_t \)
\[ \alpha_t = 3S'_t - 3S''_t + S'''_t \] (9)
5) Calculate the value of the bt slope
\[ b_t = \alpha / 2 (1-\alpha) (6.5 \alpha) S'_t - (10-8.\alpha) S''_t + (4-3.\alpha) S'''_t \] (10)
6) Calculate the value of \( c_t \)
3) Determine the amount of forecasting value, using the following formula:

\[ F_t + m' = a_t + b_t (m) + 0.5c_t (m) \]  \hspace{1cm} (12)

Where:
- \( S'_t \) = First smoothing period \( t \)
- \( Y_t \) = real value of period \( t \) or actual data
- \( S''_t \) = Smoothing all three periods \( t \)
- \( \alpha_t \) = The value of the constant \( \alpha_t \)
- \( b_t \) = Value of \( b_t \) slope
- \( c_t \) = Value of \( c_t \)
- \( F_t + m' \) = Basic forecasting value

2.4. Forecasting accuracy value

Forecasting is said to be good also the result of the forecast has a small error so that the forecasting data made will be close to the actual request. One way that can be done is to compare errors in the forecast by looking at several factors such as the method used or alpha used [9].

Forecasting requires a method to determine the error rate of forecasting results that have been calculated using the forecasting method. There are many methods for knowing forecasting errors, methods to determine the level of accuracy. Mean Square Error (MSE), The Mean Square Error (MSE) uses the square value for each difference in the calculation that occurs. The MSE value is obtained from the equation [10-11]:

\[ MSE = \frac{\sum (y_t - \hat{y}_t)^2}{n} \]  \hspace{1cm} (13)

where:
- \( y_t \) = actual data in period \( t \)
- \( \hat{y}_t \) = forecasting data in period \( t \)
- \( n \) = amount of data

3. Results and discussion

3.1 Description of the system

Forecasting the number of aircraft passengers in Samarinda using the double exponential smoothing and triple exponential smoothing methods as a smoothing method to predict the number of passengers based on the data of the last 5 years. The existing data is first calculated using the double exponential smoothing and triple exponential smoothing methods, the calculation results of each method will be searched for error values using the mean square error to determine which method is the best.

3.2 Manual calculation of the double exponential smoothing method

The calculation that will be done is a manual calculation using the smoothing method twice, with alpha values 0.1, 0.3, 0.5, 0.7, and 0.9. Examples of data used are 2014 data for February and March.

Calculation of alpha = 0.1 February 2014 forecasting:

\[ S'_1 = (\alpha \times X_1) + (1 - \alpha) \times S'_0 \]
\[ = (0.1 \times 10579) + (1 - 0.1) \times 10579 = 10579.000 \]
\[ S''_1 = (\alpha \times S'_1) + (1 - \alpha) \times S''_0 \]
\[ = (0.1 \times 10579.000) + (1 - 0.1) \times 10579 = 10579.000 \]
\[ \alpha_1 = (2 \times S'_1) - S''_1 \]
\[ = (2 \times 10579.000) - 10579.000 = 10579.000 \]
\[ b_1 = \alpha_1 - 0.1 \times (S'_1 - S''_1) \]
\[ = 0.1/0.1 \times (10579.000 - 10579.000) = 0 \]
\[ F_2 = \alpha_1 + b_1 = 10579.000 + 0 = 10579.000 \]

Calculation of alpha = 0.5 February 2014 forecasting:
$S_1' = (\alpha \times X_1) + (1 - \alpha) \times S_0'$

$S_1'' = (\alpha \times S_1') + (1 - \alpha) \times S_0''$

$\alpha_1 = (2 \times S_1') - S_1''$

$b_1 = \frac{\alpha_1}{1 - \alpha} \times (S_1' - S_1'')$

$F_2 = \alpha_1 + b_1 = 10579.000 + 0 = 10579.000$

Calculation of alpha = 0.9 February 2014 forecasting:

$S_2' = (\alpha \times X_1) + (1 - \alpha) \times S_0'$

$S_2'' = (\alpha \times S_1') + (1 - \alpha) \times S_0''$

$\alpha_2 = (2 \times S_2') - S_2''$

$b_2 = \frac{\alpha_2}{1 - \alpha} \times (S_2' - S_2'')$

$F_3 = \alpha_2 + b_2 = 10579.000 + 0 = 10579.000$

Calculations with constant $\alpha = 0.1, 0.3, 0.5, 0.7$, and 0.9 are continued until January 2019. The result of the calculation and testing the accuracy of forecasting are presented in the following table:

| Month | Forecasting results DES | $\alpha = 0.1$ | $\alpha = 0.3$ | $\alpha = 0.5$ | $\alpha = 0.7$ | $\alpha = 0.9$ |
|-------|-------------------------|----------------|----------------|----------------|----------------|----------------|
| 02/14 | 10579                   | 10579          | 10579          | 10579          | 10579          |
| 03/14 | 10310.4                 | 9773.2         | 9236           | 8698.8         | 8161.599       |
| 04/14 | 10352.29                | 10140.61       | 10251.25       | 10684.21       | 11439.49       |
| 05/14 | 10115.37                | 9541.216       | 9223           | 8902.864       | 8322.952       |
| 06/14 | 9835.718                | 8982.293       | 8571.437       | 8346.8295      | 8310.005       |
| 07/14 | 9939.713                | 9716.245       | 10175.437      | 10916.269      | 11794.041      |
| 08/14 | 9950.453                | 9910.919       | 10268.078      | 10402.447      | 10090.408      |
| 09/14 | 10239.38                | 10861.50       | 11649.468      | 12172.974      | 12613.471      |
| 10/14 | 10091.07                | 10201.40       | 9987.699       | 9248.414       | 8200.240       |
| 11/14 | 9602.107                | 8729.029       | 7645.582       | 6588.691       | 5978.003       |
| 12/14 | 9228.752                | 8042.038       | 7288.657       | 7199.337       | 7749.118       |
| 01/15 | 9467.836                | 9359.339       | 10134.011      | 11497.530      | 12910.234      |
| 02/15 | 9324.727                | 9078.866       | 9243.597       | 9054.568       | 8037.665       |
| 03/15 | 8893.411                | 7995.786       | 7392.344       | 6608.213       | 5933.880       |
| 04/15 | 8242.970                | 6553.395       | 5501.945       | 4775.557       | 4529.459       |
| 05/15 | 8229.634                | 7403.169       | 7828.609       | 8951.745       | 10512.103      |
The calculation that will be done is a manual calculation using the smoothing method three times, with alpha values 0.1, 0.3, 0.5, 0.7, and 0.9. Examples of data used are 2014 data for February.

Forecasting in February 2014 $\alpha = 0.1$
the calculation and testing the accuracy of forecasting are presented in the following table

| Month | Forecasting results TES |
|-------|-------------------------|
|       | α = 0.1                  | α = 0.3                  | α = 0.5                  | α = 0.7                  | α = 0.9                  |
| 02/14 | 10579                    | 10579                    | 10579                    | 10579                    | 10579                    |
| 03/14 | 10176.1                  | 9370.3                   | 8564.5                   | 7758.7                   | 6952.9                   |

Calculations with constant α = 0.1, 0.3, 0.5, 0.7 and 0.9 are continued until January 2019. The result of the calculation and testing the accuracy of forecasting are presented in the following table:

### Table 2. Triple exponential smoothing forecasting result

| Month | Forecasting results TES |
|-------|-------------------------|
|       | α = 0.1                  | α = 0.3                  | α = 0.5                  | α = 0.7                  | α = 0.9                  |
| 02/14 | 10579                    | 10579                    | 10579                    | 10579                    | 10579                    |
| 03/14 | 10176.1                  | 9370.3                   | 8564.5                   | 7758.7                   | 6952.9                   |
| Month   | Forecasting results TES |
|---------|-------------------------|
|         | $a = 0.1$               |
| 04/14   | 10259.08                |
|         | $a = 0.3$               |
| 05/14   | 9918.35                 |
|         | $a = 0.5$               |
| 06/14   | 9529.565                |
|         | $a = 0.7$               |
| 07/14   | 9733.604                |
|         | $a = 0.9$               |
| 08/14   | 9784.283                |
|         |                          |
| 09/14   | 10247.279               |
|         |                          |
| 10/14   | 10029.137               |
|         |                          |
| 11/14   | 9310.467                |
|         |                          |
| 12/14   | 8799.965                |
|         |                          |
| 01/15   | 9230.154                |
|         |                          |
| 02/15   | 9060.528                |
|         |                          |
| 03/15   | 8463.759                |
|         |                          |
| 04/15   | 7564.443                |
|         |                          |
| 05/15   | 7660.263                |
|         |                          |
| 06/15   | 8060.198                |
|         |                          |
| 07/15   | 7898.221                |
|         |                          |
| 08/15   | 8593.646                |
|         |                          |
| 09/15   | 8577.735                |
|         |                          |
| 10/15   | 7321.152                |
|         |                          |
| 11/15   | 6133.131                |
|         |                          |
| 12/15   | 6691.843                |
|         |                          |
| 01/16   | 7577.168                |
|         |                          |
| 02/16   | 7533.299                |
|         |                          |
| 03/16   | 7037.148                |
|         |                          |
| 04/16   | 6768.368                |
|         |                          |
| 05/16   | 6218.311                |
|         |                          |
| 06/16   | 6520.704                |
|         |                          |
| 07/16   | 6471.148                |
|         |                          |
| 08/16   | 6851.388                |
|         |                          |
| 09/16   | 7011.608                |
|         |                          |
| 10/16   | 6988.31                 |
|         |                          |
| 11/16   | 6724.422                |
|         |                          |
| 12/16   | 6062.792                |
|         |                          |
| 01/17   | 6330.425                |
|         |                          |
| 02/17   | 6325.311                |
|         |                          |
| 03/17   | 5457.157                |
|         |                          |
| 04/17   | 4902.07                 |
|         |                          |
| 05/17   | 4631.418                |
|         |                          |
| 06/17   | 4223.049                |
|         |                          |
| 07/17   | 4355.399                |
|         |                          |
| 08/17   | 4591.987                |
|         |                          |
| 09/17   | 4925.835                |
|         |                          |
| 10/17   | 4918.758                |
|         |                          |
| 11/17   | 3546.484                |
|         |                          |
| 12/17   | 2432.524                |
|         |                          |
| 01/18   | 1603.524                |
|         |                          |
| 02/18   | 766.057                 |
|         |                          |
| 03/18   | 231.561                 |
|         |                          |
| 04/18   | 539.729                 |

**Note:** The table presents forecasting results for different values of $a$ (0.1, 0.3, 0.5, 0.7, 0.9) for various months and years.
The process of calculating error values on alpha values using the mean square error method is done by means of actual data minus the forecasting results and squared and then summed up with data errors which are then divided by the amount of data, 59 data. Here is an example of MSE error calculation for forecasting using alpha value 0.9 can be seen in Table 3.

**Table 3. Calculation of MSE data forecasting DES on α = 0.9**

| Years | Month | X<sub>i</sub> (Actual data) | F<sub>i</sub> (Forecasting results) | Σ(X<sub>i</sub> – F<sub>i</sub>)<sup>2</sup>/n |
|-------|-------|-----------------------------|-----------------------------------|------------------------------------------|
| 2014  | Feb   | 9236                        | 10579                             | 1,803,649,000                            |
| 2014  | Mar   | 10587                       | 8161.599                          | 5,882,565,160                            |
| 2014  | Apr   | 9221                        | 11439.49                         | 4,921,697,880                            |
| 2014  | May   | 8827                        | 8322.952                          | 254,064,386                              |
| 2014  | Jun   | 10530                       | 8310.0055                        | 4,928,375,580                            |
| 2014  | Jul   | 10133                       | 11794.041                        | 2,759,059,130                            |
| 2014  | Aug   | 11525                       | 10090.408                        | 2,058,053,458                            |
| 2014  | Sep   | 9549                        | 12613.471                        | 9,390,983,959                            |
| 2014  | Oct   | 7732                        | 8200.240                          | 219,248,852                              |
| 2014  | Nov   | 7939                        | 5978.003                         | 3,845,507,977                            |
| 2014  | Dec   | 10711                       | 7749.118                          | 8,772,743,427                            |
| 2015  | Jan   | 8965                        | 12910.234                        | 15,564,868,311                           |
| 2015  | Feb   | 7406                        | 8037.665                          | 399,001,356                              |
| 2015  | Mar   | 5975                        | 5933.880                          | 1,690,791                                |
| 2015  | Apr   | 8656                        | 4529.459                          | 17,028,336,506                           |
| 2015  | May   | 9679                        | 10512.103                        | 694,060,762                              |
| 2015  | Jun   | 8023                        | 10909.886                        | 8,334,110,912                            |
| 2015  | Jul   | 10735                       | 6936.046                          | 14,432,050,174                           |
| 2015  | Aug   | 8788                        | 12658.34                          | 14,979,534,615                           |
| 2015  | Sep   | 4620                        | 7653.058                          | 9,199,438,485                            |
| 2015  | Oct   | 3990                        | 1019.908                         | 8,821,445,782                            |
| 2015  | Nov   | 8973                        | 2735.651                          | 38,904,521,953                           |
| 2015  | Dec   | 10363                       | 12738.231                        | 5,641,722,913                            |
| 2016  | Jan   | 7801                        | 12290.419                        | 20,154,889,379                           |
| 2016  | Feb   | 6232                        | 6113.131                          | 14,129,689                               |
| 2016  | Mar   | 6628                        | 4594.332                          | 4,135,805,009                            |
| 2016  | Apr   | 5471                        | 6618.455                          | 1,316,653,228                            |
| 2016  | May   | 7902                        | 4563.827                          | 11,143,394,300                           |
| 2016  | Jun   | 6877                        | 9653.890                          | 7,711,123,565                            |
| 2016  | Jul   | 8233                        | 6440.759                          | 3,212,124,501                            |
| 2016  | Aug   | 7711                        | 9202.783                          | 2,225,416,741                            |
| 2016  | Sep   | 7175                        | 7505.279                          | 109,084,228                              |
| 2016  | Oct   | 6332                        | 6690.137                          | 128,262,807                              |
| 2016  | Nov   | 4806                        | 5557.324                          | 564,488,962                              |
| 2016  | Dec   | 7434                        | 3426.683                          | 16,058,584,881                           |
The MSE value for $\alpha = 0.9$ is done by dividing the number of sigma results in table 4.7 with the amount of data that is 59. The process of calculating the MSE value for alpha $\alpha = 0.9$ is:

$$MSE = \frac{\Sigma(X_i - F_i)^2}{n} = \frac{1210806186.1319}{59} = 20522138.748$$

The result of calculating the MSE error value for alpha $\alpha = 0.9$ is 20522138.7480 then the calculation in Table 3 is repeated for other alpha values.

### 3.4. Implementation

Before entering into the home menu the user must enter a username and password on the login page [12-13]. The data page is a page that displays data on the number of aircraft feeders stored in the database can be seen in Figure 1 and Figure 2.
The forecasting page is a page that displays data from the calculation of the triple exponential smoothing method, double exponential smoothing, and the results of error calculations. The display of data pages can be seen in Figure 3.

4. Conclusions
In conclusion, the results of the study have been produced forecasting the number of airplane passengers using a comparison of the double exponential smoothing and triple exponential smoothing methods in Samarinda. The forecasting system is measured using the mean square error method as an error calculation method. It uses α constant values, which results in 5 different forecastings between the double exponential smoothing and triple exponential smoothing methods. Double exponential smoothing method with an error value of 20522138.748 obtained from an alpha value of 0.9. Triple exponential smoothing method with an error value of 21137573.741 obtained from an alpha value of 0.7. This system produces the best forecasting method, namely the double exponential smoothing method of α = 0.9 resulting in an error value 20522138.748

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