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Rainfall Prediction Analysis Using the Fuzzy Time Series Method in Medan City

Syaftial Zikri[1]*, Wilda Rina Hasibuan[2]

[1,2]Universitas Muhammadiyah Sumatera Utara
syaftial08jr@gmail.com[1], wildarinahasibuan77@gmail.com[2]

Abstract

The increasingly significant climate change causes high rainfall variability, thus requiring an accurate prediction method for disaster mitigation planning and water resource managment. This study aim to analyze rainfal prediction in Medan City using Fuzzy Time Series (FTS) methode. Historical rainfall data for Medan City for a certain period is collected and processed to build an FTS model. The fuzzification process is carried out to convert numerical data into fuzzy values, then the time series relationship is identified to predict the next rainfall value. Based on Chen's fuzzy time series with the detemination of the average-based interval, the Medan City rainfall forecast based on January 2019-December 2023 data obtained the forecast results for January 2024 is 386.7 mm. From the result of tests that have caried out, the best number of sampels be used in the Medan City rainfall case is 60 data, namely the period January 2019 - December 2023.

Keywords: *rainfall, fuzzy time series, Chen method, forecasting.*

1. Introduction

Weather changes are a natural phenomenon that occurs dynamically and is influenced by various atmospheric factors. Over the last few decades, global climate change has accelerated weather variations in many regions of the world, including Indonesia. One important component in weather changes is rainfall patterns, which play a major role in the sustainability of ecosystems, agriculture, and the availability of water resources [1]. Precipitation varies significantly between different regions and over time, influenced by features such as topography, climate, and wind patterns. In tropical places, rainfall tends to be higher, while in desert areas, rainfall can be very low [2]

Rain that falls on the surface of the earth is influenced by several factors so that its distribution is uneven in a river area. This can be known by properly placing rain stations, both in location, quantity and distribution pattern [3]. Rain carries out an important function in the hydrological cycle, providing fluids needed for plant growth, filling water sources, and maintaining ecosystem balance. Apart from that, rain also has a significant impact on human activities, agriculture and water resource management [4].

For example, in the city of Medan, the rainfall is unpredictable, because every day of the week there can be rain with different intensities, or even during the week there is no rain at all [5]. Every province in Indonesia currently has a source of weather information from the BMKG (Meteorology, Climatology and Geophysics Agency). The Medan City Meteorology, Climatology and Geophysics Agency (BMKG) is a government agency responsible for providing information services related to weather, climate and geophysics in the Medan area and its surroundings. BMKG Medan City plays an important role in monitoring and predicting weather conditions, including rainfall, temperature, humidity, as well as potential natural disasters such as floods or strong winds. However, BMKG experts still consider that the accuracy of these predictions is not optimal.To find the most suitable approach in providing weather predictions, especially rainfall forecasting with a high level of accuracy, the selection of the appropriate method for prediction is still being carried out [6].

Fuzzy time series are based on fuzzy logic and are used to handle the uncertainty and ambiguity inherent in weather data. The fuzzy time series model uses the concept of fuzzy logic to handle the uncertainty and inaccuracy of time series data [7]. Several journals regarding forecasting activities apply various methods to determine the most accurate and optimal analysis. Fuzzy Time Series (FTS) is a method used to analyze and predict time series data that has uncertainty or ambiguity. In contrast to conventional time series methods, FTS utilizes the fuzzy set concept introduced by Lotfi A. Zadeh, where the data analyzed does not have to be exact numbers, but can be represented by fuzzy values. This allows FTS to handle data that is uncertain in nature, such as fluctuations in weather, economics and other natural phenomena. The main processes in FTS include fuzzification of historical data, establishment of fuzzy relations, and defuzzification to produce predictions [8].

2. TheoreticalBasis

2.1. Fuzzy Time Series

This system is a time series forecasting system based on a fuzzy set design. This design is used to predict issues using historical data in the form of real numbers represented by linguistic values. This system of course is very dependent on the formation of accurate linguistic intervals. An average-based design (Average Based) in determining interval lengths is more suitable to be applied in the forecasting process [2].
The steps for carrying out average-based Fuzzy Time Series forecasting are:

1. Determine the universal set. The set of universes (Universe of Discourse) is defined as: \(U = [X_{min} - D_1, X_{max} + D_2] \), where \(max} \) is the maximum data, and \(D_1 \) and \(D_2 \) are positive numbers.
2. Create an interval and divide the universe set \(U \) into several parts, starting from:
   a) Calculate the absolute numerical distance from the time series data, namely \(|X_{i+1} - X_i|\) for \(i = 1,…, n - 1\), and then calculate the average of all the distances that absolute.
   b) Determine half of the average absolute difference to be used as the interval length.
   c) Determine the fuzzy set \(A \) for the universal set \(U \).
3. Fuzzification, namely the process of determining the appropriate fuzzy set value for each historical data, where the middle value is taken from each interval, namely \(A_i = \frac{LL_i + UL_i}{2} \), and \(LL_i \) as the bottom line of the ith interval, and \(UL_i \) as the top line of the ith interval.

3. Results and discussion

3.1. Interface Implementation

Admin Login Form This page is a login form interface to access the main page by entering the user name and password. The following is the login form interface below. below this.

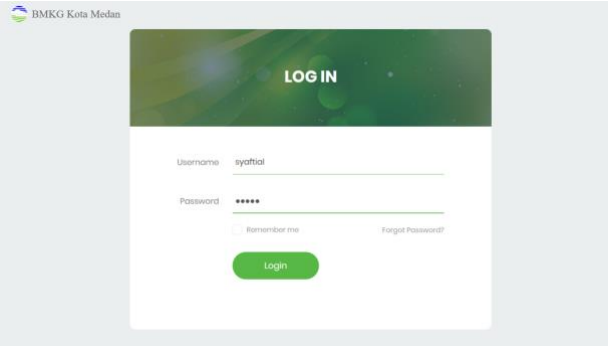


Fig. 1: Admin Login Form

3.2. Home Page

This page is the main form display that can be used after entering the user name and password data. The following is a display of the main form.

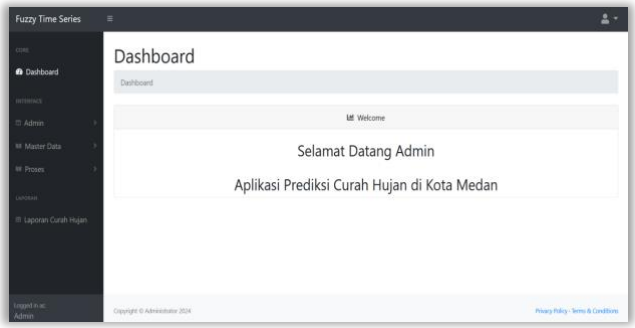


Fig. 2: Main View

3.3. Rainfall Form

This display presents information regarding rainfall data which functions as a medium for entering new rainfall data, as well as editing and deleting existing rainfall data. Here is what the page looks like:

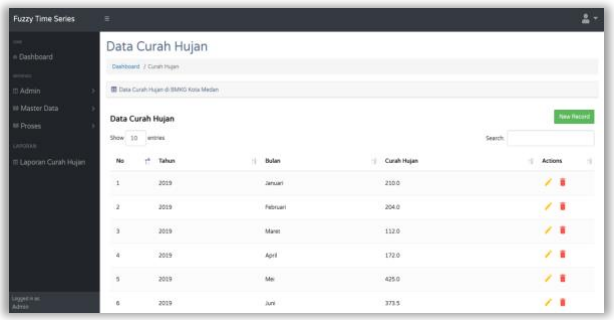


Fig. 3: Display Precipitation Form

To add rainfall data, you can do this by clicking the add button on the form. The following is the rainfall data input page interface:

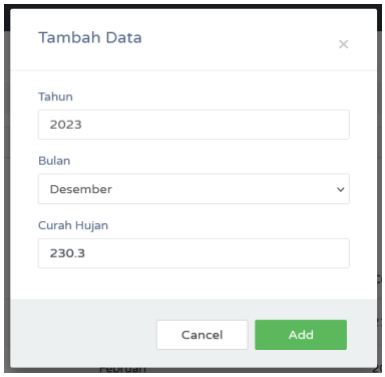


Fig. 4: Rainfall Data Input Display

3.4. Region Form

This regional form display contains data on sub-districts in Medan City. The display of the sub-district area form is shown in the following image.

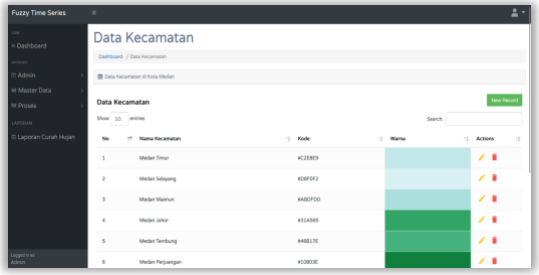


Fig. 5: Region Form Display

3.5. Interval Process Form

The interval process page is an interface page for calculating existing interval processes. Thus, this form will produce values and classes for each interval.

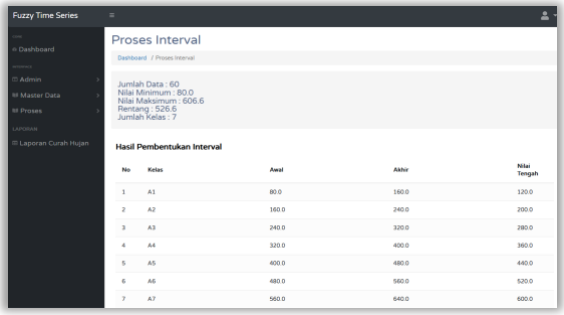


Fig. 6: Display Process Interval Calculation

3.6. Result Form Display

On the results page, is the interface used to view the process results of the rainfall predictions entered into this system. The following is an illustration of the results of the design on the results page interface:

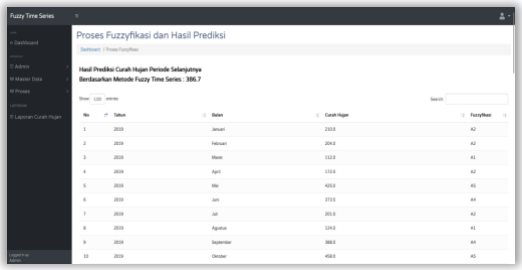
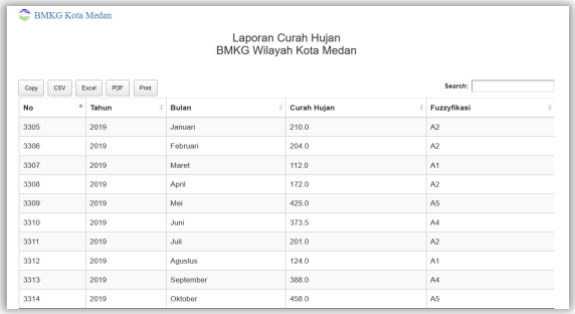


Fig. 7: Result Display

After completing the implementation stage, the next step is to carry out trials to ensure that the system that has been built meets the desired needs. After the test is carried out, a report will be generated, namely a prediction results report as shown in the image below:


BMKG Kota Medan

Laporan Curah Hujan
BMKG Wilayah Kota Medan

Copy CSV Excel PDF Print Search:

No	Tahun	Bulan	Curah Hujan	Fuzzyfikasi
3305	2019	Januari	210.0	A2
3306	2019	Februari	204.0	A2
3307	2019	Maret	112.0	A1
3308	2019	April	172.0	A2
3309	2019	Mei	425.0	A5
3310	2019	Juni	373.5	A4
3311	2019	Juli	201.0	A2
3312	2019	Agustus	124.0	A1
3313	2019	September	388.0	A4
3314	2019	Oktober	458.0	A5

Fig. 8: Display Prediction Results Report

3.7. Home Page Form Display

On the home page form, there is an interface for visitors to access this rainfall prediction application. The following is an illustration of the implementation results of the home page interface for visitors:

Fig. 9: Visitor Home View

3.8. Display the Rainfall List Page Form

On the rainfall list page form, there is an interface for visitors to access this rainfall prediction data. The following is an illustration of the implementation results on the rainfall page:

Fig. 10: Rainfall List Page Display

4. Conclusion

Based on the points discussed previously, the conclusion of this research is that the Fuzzy Time Series has shown good ability in predicting rainfall in Medan City. Fuzzy time series has also proven effective in predicting rainfall in Medan City. Using this approach, the model can capture the short range and variability of rainfall data that is often difficult to predict with other conventional methods. The fuzzy time series method also provides good accuracy in predicting monthly rainfall. Examination of historical data shows that the mean error (RMSE) values are within acceptable limits, indicating that this model can be used for rainfall forecasting.

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