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Temperature Prediction Analysis Using Forecasting Models In Chennai

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ABSTRACT

Time series forecasting is an essential tool for planning and decision-making. Various methods, ranging from traditional statistical models to soft computing and artificial intelligence approaches, have been developed to produce increasingly accurate forecasts. Recently, several techniques based on fuzzy and stochastic methods have been proposed for forecasting. In this paper, we discuss and compare the Song and Chissom model, Improved Hwang, Chen and Lee model, Auto Regressive Integrated Moving Average (ARIMA) and Artificial Neural Networks (ANN) on predicting temperature fluctuations in the Chennai district over a period from the year 2006 to 2024.

Keywords: *Fuzzy Time Series, Neural Network, Fuzzy Logic, Inverse Fuzzy Number.*

1. INTRODUCTION

Weather forecasting is a challenging and exciting task. It involves analyzing various atmospheric factors such as wind speed, humidity, pressure and temperature. Temperature is a complex atmospheric process influenced by many weather-related features. Accurate and timely predictions of temperature can be beneficial in several ways including the management of water resources, agriculture, regulating transportation and construction activities. The accuracy of temperature predictions has become more complicated in recent times due to climate variations.

Time series data is a crucial aspect of modern research within the realm of knowledge discovery. It is collected over specific intervals, such as yearly. Forecasting serves as a powerful tool for making inferences about future events based on the past and present information. It is one of the primary objectives of time series analysis and the literature reveals a diverse array of forecasting algorithms, ranging from statistical methods to soft computing techniques. Overall, forecasting plays an essential role in determining the future conditions and values of various phenomena based on historical data.

Fuzzy Time Series (FTS) model was first introduced by Song and Chissom [10], based on the fuzzy set theory proposed by Zadeh. Chen later developed the FTS model by incorporating fuzzy logic group relations tables to reduce the computational complexity of the model. Chen [4] developed a more efficient method for forecasting university enrollment compared to the approach suggested by Song and Chissom. Velusamy [11] developed a fuzzy time series (FTS) forecasting model to predict wheat production by utilizing historical data and fuzzy logic, which helps address uncertainty and nonlinearity.

The current temperature data was transformed into a time series using the forecasting technique ARIMA, which was then utilized to anticipate future values to successfully estimate the temperature in the future. When it comes to predicting, the accuracy of fuzzy time series is crucial. Nowadays, artificial neural networks (ANN) are increasingly being applied in various aspects of hydrology. Geetha. A [5] developed and evaluated a rainfall-forecasting model for a coastal region in India using the ARIMA approach. M.H. Masum [8] analysed rainfall and temperature trends in Chattogram and Bangladesh, using seasonal ARIMA models, projecting these trends up to 2070 and capturing seasonal variations.

The ANN approach is faster than traditional methods, robust in noisy environments, flexible in the range of problems it can address and highly adaptable to new situations. Time-series prediction model has been applied in many fields by many researchers, Lakshminarayana [7] utilised artificial neural networks (ANNs) for rainfall forecasting, specifically employing

Back-Propagation Networks (BPN), Multilayer Perceptron (MLP) and Feed-Forward Neural Networks (FFNN) due to their effectiveness in modeling chaotic and nonlinear rainfall patterns. Al-Saedi [2] proposed a hybrid forecasting model that combines the nonlinearities of ARIMA and ANN models in air temperature data for Baghdad to improve prediction accuracy. This research focuses on the development of a fuzzy logic model to predict temperature in the Chennai district.

2. METHODOLOGY

The present study was conducted using time series and stochastic models to predict and analyze the temperature data from the year 2006 to 2024. The actual temperature data is illustrated in Figure 2.1.

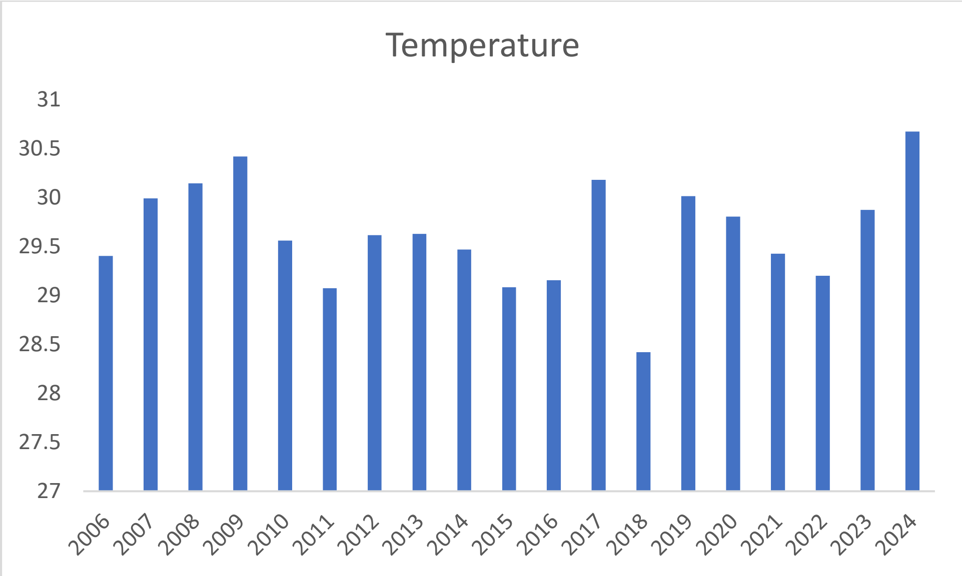

Figure 2.1: Actual Temperature Data in Kanyakumari District

2.1 Improved Hwang and Chen and Lee Method

Step 1: List the historical data of annual temperature.

Step 2: Find the yearly difference of actual temperature data.

Step 3: Establish inverse fuzzy number.

Step 4: Establish a forecasting formula to forecast.

2.2 Song and Chissom Method

Step 1: Define the universe of discourse U. The universe of discourse is

$$U = [A_{min} - V_1, A_{max} + V_2]$$

where A_{max} and A_{min} are maximum and minimum values of the data and V_1 and V_2 are positive real numbers.

Step 2: Define the fuzzy number (m).

$$m = \frac{(A_{max}+V_2-A_{min}-V_1)}{l}$$

Step 3: Fuzzify historical data

Step 4: Identify fuzzy logical relationship.

Step 5: Establish fuzzy logical relationship groups.

Step 6: Defuzzify the forecasted output.

Rule 1: If A_i is empty, then the middle value of the interval u_i is considered.

Rule 2: If A_i is one-one, then the middle value of the interval u_j is considered.

Rule 3: If A_i is one-many, then the average of the middle values is considered.

2.3 ARIMA

The Auto Regressive Integrated Moving Average (ARIMA) model was introduced by Box and Jenkins [3] in 1970. This model describes time series data based on observed values and can be used to forecast future values. The ARIMA model is characterized by three key parameters: p, d and q, where p indicates the number of autoregressive terms, d represents the degree of differencing required to make the time series stationary and q corresponds to the number of lagged forecast errors incorporated into the prediction formula.

Essentially, the ARIMA model combines elements of both moving average and autoregressive models, which can be represented generally in the following form:

$$Y_t = C + \emptyset_t Y_{t-1} + \emptyset_2 Y_{t-2} + \cdots + \emptyset_p Y_{t-p} + e_t - \varphi_t \theta_{t-1} - \varphi_2 \theta_{t-2} + \cdots - \varphi_q \theta_{t-q}$$

To apply this model, the autocorrelation function and the partial autocorrelation function are calculated for the relevant variables. Future trend values are predicted using the chosen (p, d, q) model, and model assessment is conducted to estimate the parameters effectively.

2.4 ANN

Artificial Neural Networks (ANN) are data-driven artificial intelligent models inspired by the human nervous system. ANN function is massively parallel distributed processors, naturally storing information learned from experiences and making it accessible for future use. An artificial neuron is a mathematical function where inputs are individually weighted and their sum is passed through a transfer function to produce an output. Artificial Neural Networks (ANN) utilize this process to perform complex mathematical calculations, allowing them to generate optimal results for various datasets or problem segments. In essence, neural networks employ nonlinear modeling techniques to accurately approximate various functions. The ANN structure includes nodes, organized into three types of layers: input, hidden and output. The complexity of the data determines the number and arrangement of hidden layers and the number of nodes within them.

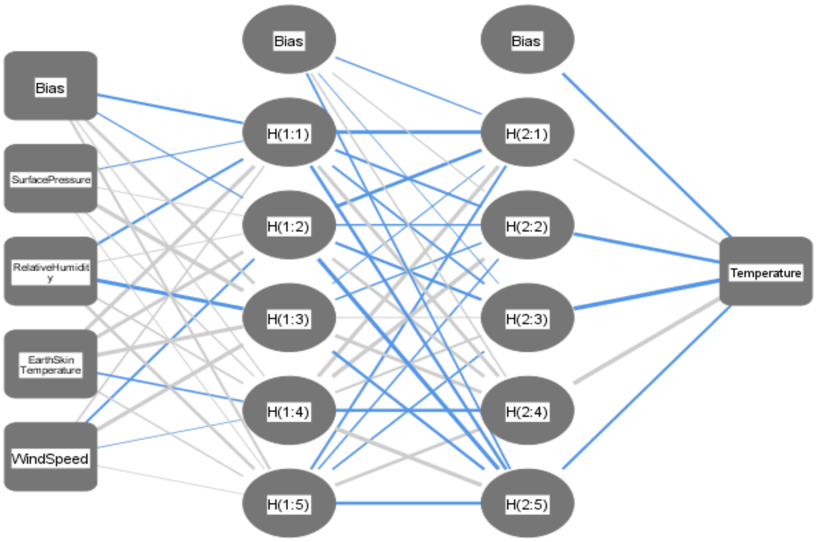

Figure 2.2 ANN model

2.4 Model Evaluation

Mean Absolute Error (MAE) = $\frac{\sum_{i=1}^{n}|X_i - \widehat{X_i}|}{n}$

Mean Square Error (MSE) = $\frac{\sum_{i=1}^{n}(X_i - \widehat{X_i})^2}{n}$

Root Mean Square Error (RMSE) = $\sqrt{\frac{\sum_{i=1}^{n}(X_i - \widehat{X_i})^2}{n}}$

3. RESULTS AND DISCUSSION

The temperature data for the Chennai district from the years 2006 to 2024 has been utilized for model building, specifically for Song and Chissom model, Improved Hwang, Chen and Lee model, Auto Regressive Integrated Moving Average (ARIMA) and the Artificial Neural Network (ANN) model. The primary objective is to identify a more accurate forecasting model. The results are presented in Table 3.1.

YEAR	Actual Temperature	Forecasted Temperature			
		Song and Chissom Method	Improved Hwang, Chen and Lee Method	ARIMA	ANN
2005	28.915	-	-	-	-
2006	29.405	29.5	29.4088187	-	29.60800259
2007	29.99	29.7	29.92045832	29.21848069	29.64441725
2008	30.145	29.7	30.15371725	29.37064448	29.60670404
2009	30.42	29.7	30.42699309	30.20019147	29.66576004
2010	29.56	29.6	29.40530098	30.53747344	29.65606737
2011	29.075	29.567	29.01743386	29.70656021	29.64559014
2012	29.615	29.6	29.29144628	29.13933936	29.64185917
2013	29.63	29.6	29.63155461	29.29196039	29.69803329
2014	29.47	29.5	29.26893428	29.58059334	29.65119714
2015	29.085	29.567	28.96900185	29.44503212	29.59315407
2016	29.155	29.567	29.16243957	29.36692406	29.62127008
2017	30.18	29.7	29.81705779	29.43520132	29.65555614
2018	28.42	30.1	27.92614812	29.88540306	29.62429034
2019	30.015	29.7	31.47169924	29.64067225	29.68794895
2020	29.805	29.6	29.78876197	29.68187342	29.62919076
2021	29.425	29.5	29.44923129	29.82807025	29.59910251
2022	29.2	29.5	29.1806614	29.51026854	29.61565727
2023	29.875	29.6	30.03222417	29.29082448	29.61456193
2024	30.675	29.7	30.66800699	30.18602526	29.70559999
MAE		0.387158	0.183603	0.520284	0.411026
MSE		0.303854	0.142865	0.378961	0.260093
RMSE		0.55123	0.377975	0.615598	0.509993

Table 3.1: Comparison of Different Forecasting Model

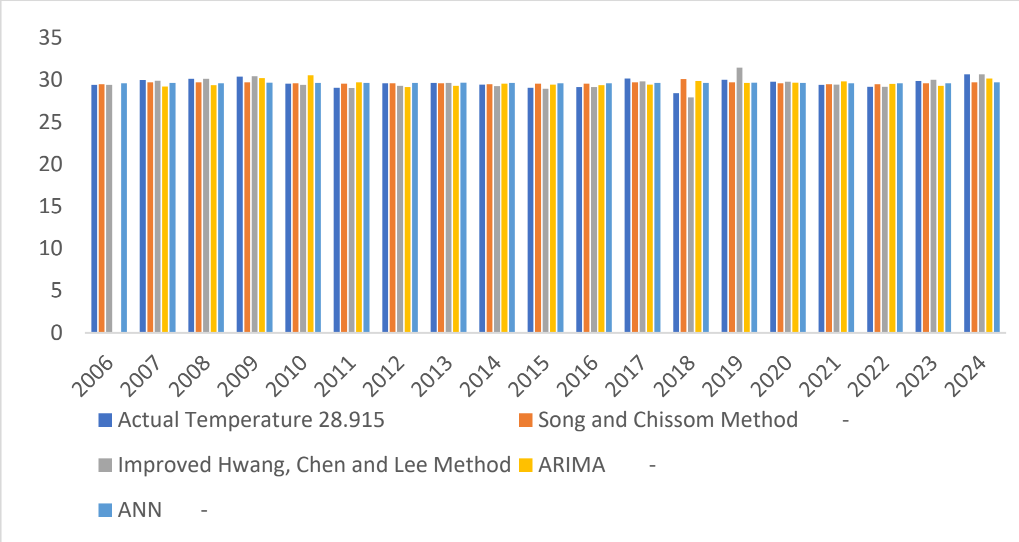

Figure 3.3: Forecasting Observation.

4. CONCLUSION

This study examined the application of the fuzzy time series model and compared it with the ARIMA stochastic model and artificial neural network (ANN) model. The fuzzy time series approach is deemed a suitable method for predicting temperature data. The error rates of all the models were compared from table 3.1, we see that Improved Hwang, Chen and Lee Method achieved low values for the Mean Absolute Error (MAE), Mean Square Error (MSE) and Root Mean Square Error (RMSE). These results indicate a desirable error rate for the Improved Hwang, Chen and Lee Method, which is lower than that of fuzzy time series and stochastic model.

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