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Comparative Analysis of ANFIS, ARIMA and Polynomial Curve Fitting for Weather Forecasting

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Abstract

Background/Objectives: Weather forecasting is to facilitate the appliance of knowledge and tools to predict the state of the atmosphere for a future time at a given location. **Methods/Statistical Analysis:** This paper focused to forecast the weather conditions on Indian weather conditions using three approaches such as ANFIS, ARIMA and polynomial curve fitting. It's disbursed by collection quantitative information regarding state of the atmosphere and past and/or present experiences. **Findings:** In this analysis, this work reveals the superior performance of polynomial curve fitting through the SSE, RMSE, MAE and R^2.

Keywords: ANFIS, ARIMA, Curve Fitting, MAE, RMSE, R^2, SSE, Weather Forecasting

1. Introduction

Weather prediction systems are having most difficult systems equation that can solve only by computer. Weather predicts[1] gives significant reports about its upcoming weather. Here are different systems concerned in weather predicting, from rather easy examination of sky to very compound mechanical mathematical techniques. The meteorological information of weather[2] is fuzzy (uncertain) in nature and unclearly defined the forecasting may be inaccurate. The amount of incorrectness originates from the network of sensors, calligraphy and so on. Alternatively, research can gives information about the upcoming weather from the past reports. Here, there is a necessary of weather pre-processing of data to improve the worth for exact data weather evaluation. As of India Meteorological department data can also be composed which is over all India climate stations head place of work. In information set having five parameters these are: humidity, maximum temperature, air pressure and minimal temperature, and this occur simplest on climate challenge in Hyderabad. In this paper, ANFIS, ARIMA and Curve fitting techniques were used for the analysis and forecasting of weather data mentioned above. The curve fitting techniques along with fuzzy logic[3] proposed in this paper still improves the performance of forecasting of data. A comparative analysis was carried out between ANFIS, ARIMA and the proposed Fuzzy based Curve fitting through SSE, R^2, RMSE and MAE.

The forecasting challenge of weather is equal to first significant problem depends on non-linear equations leading numerical means and mathematical physics (fluid flow). In type-2 fuzzy logic[4] and fuzzy c-mean using based on these two methods authors introduced a new approach. They presented a proportional study of dissimilar weather prediction approaches. For example, they are used different methods those are Markov-Fourier Gray Model, Neuro-Fuzzy Logic System[5], Numerical Weather Prediction (NWP), Clustering Analysis, Artificial Neural Networks (ANNs) and Fuzzy logic. Those approaches used for comparison of their results and discuss their weakness and strengths. In[6], ANFIS and ARIMA these two

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methods used by authors for Wi-max traffic prediction. Result shown that compare to the ARIMA ANFIS has better accuracy, and compare to the ANFIS ARIMA takes less time to execute. ANFIS model shown in[6] it is better for predicting the weather. This method authors utilized for rainfall forecasting based on other weather data. Here authors applied multi parameters ANFIS for regular rainfall in Indonesia, PT Tamika and data series utilizing of pressure, relative moisture, heat and rainfall. In conclusion, in forecasting daily rainfall values, in every day rainfall forecasting[7] values them presenting a multivariate ANFIS application. It is mainly concentrated on data training length and one more thing also establish that ANFIS[8] was delicate to dissimilar amplitudes and ANFIS was scale size and ANFIS was not right tool for rainfall[8]. In shown about radiation prediction fog this is depends on fuzzy logic rule. Whenever situation is disordered and irregular at that time weather prediction is important. Such conditions, NWP (Numerical Weather Prediction) system not gives exact results. To maintain with abnormal (vague or/and chaotic) reports of meteorological, a prediction weather system utilizing fuzzy logic on predicted analysis is calculated[9]. It has been focused on comparison fuzzy logic and numerical approach. Introduced authors dissimilar if-then fuzzy rules used for statement of forecasting. In summary, problem of fuzzy rule model of presented data has been recognized in research and specifies a solution used for forecasting the probability of design of fog with originating issue in the a fuzzy framework[10]. In ANFIS model has another work. Authors introduce for daylight inside luminance of the time series forecasting system attained using Adaptive Neuro Fuzzy Inference System (ANFIS). The ANFIS[11] has automatic recognized algorithm and compare to neural networks it has easy designing w. r. to less no. of parameters and fast adaption. In conclusion, the main advantage of this approach is capacity to forecast normal systems performance at future; it can be used for control of lighting. It shows that compare to the Artificial Neural Network ANFIS approach have best performance. They predict rainfall used for Malaysia Klang River on monthly basis. For performances comparison, five things are used such as Nash Sutcliffe coefficient (NE), Root Mean Square Error (RMSE), Spearman Correlation Coefficient (SCC) and Correlation Coefficient (R2). In summary shown that ANFIS approach is better for the ANN approach in prediction rainfall monthly[12].

The next of this paper is set as follows: Section 2 illustrates the complete details about the ANFIS based forecasting. Section 3 illustrates the complete details about the ARIMA[13] based forecasting. Section 4 illustrates the proposed fuzzy based curve fitting based forecasting and the obtained results. Finally, section 5 concludes the paper.

2. Adaptive Neuro Fuzzy Inference System (ANFIS)

Fuzzy implication model and ANFIS both working conditions are similar, ANFIS is an adaptive network and considered to in a literature as "adaptive neuro fuzzy implication model" or "adaptive network based fuzzy implication system". Possibly the integrated hybrid neuro-fuzzy system and structural design is equal that obtainable in Figure 1. In ANFIS system, brittle series input are changed to inputs fuzzy through increasing association functions used for every series input. Association function model utilize for series input of shape Gaussian. The inputs to the fuzzy logic are given from the output of Neural Network (NN) and also their membership functions. At the nodes of the network to transfer the functions of the different layers of the fuzzy inputs in the model by a network ANFIS approach allows only one output, which can be combined to get a single crisp output fuzzy linear membership functions to obtain the process outputs. Data from January-2000 to June-2008, the membership of the functions and parameters of the forecast error is minimized to keep changing the application of a hybrid technique is used to train the network. The resulting model is then applied to the test data in the period from December-2008 to July-2008.

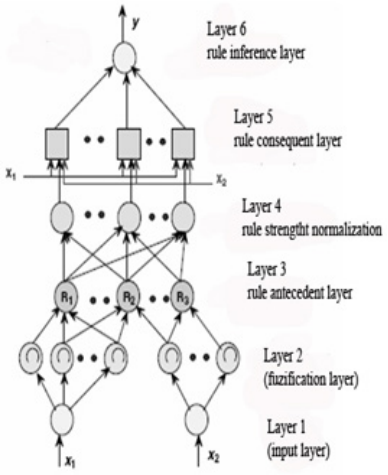

Figure 1. Takagi Sugeno neuro-fuzzy model.

Table 1. Realized ANFIS parameters and their values

Realized ANFIS parameters	Values
Number of nodes	55
Number of linear parameters	80
Number of nonlinear parameters	24
Total number of parameters	104
Number of training data pairs	500
Number of checking data pairs	164
Number of fuzzy rules	16

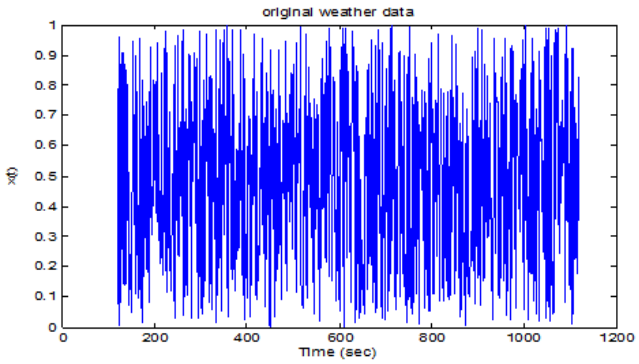

Figure 2. Original weather data.

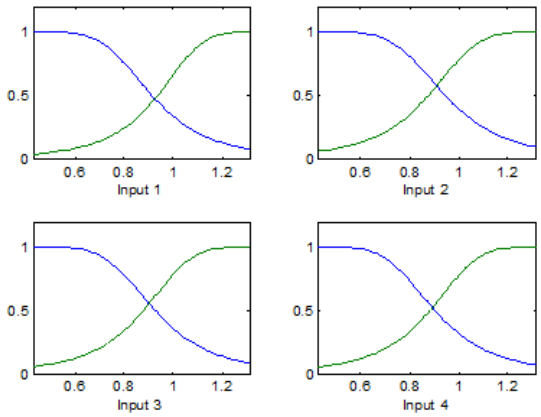

Figure 3. Membership functions of ANFIS model.

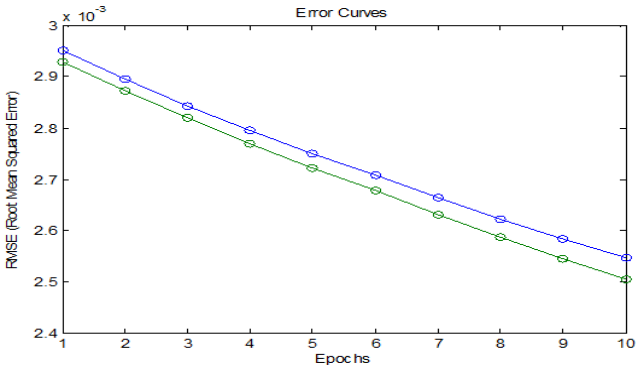

Figure 4. Step Size error of 10 epochs.

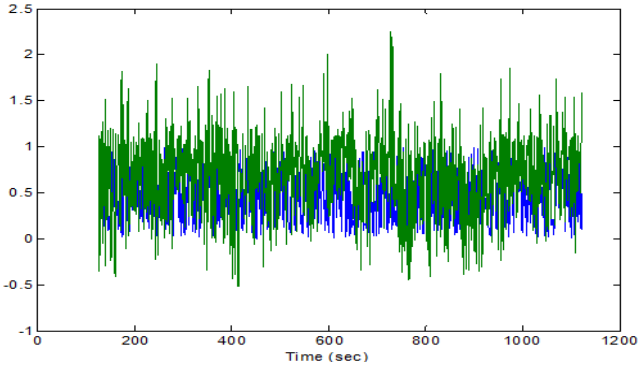

Figure 5. Real and ANFIS system output.

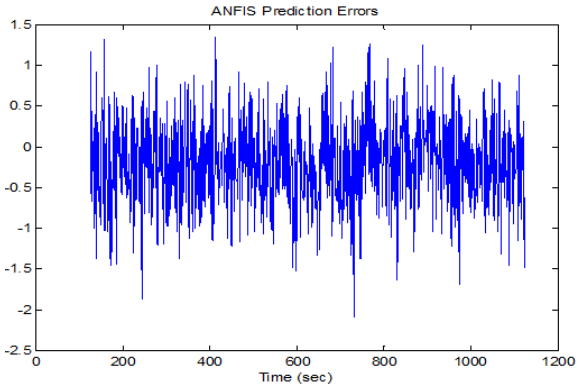

Figure 6. Error output of the model.

Presentation study of the ANFIS system is recognized utilizing MATLAB's GUI editor[13] and Fuzzy Logic Toolbox[14].

3. Auto Regressive Moving Average (ARIMA)

Various procedures in real would application can be characterized utilizing the time sequences as:

$$X(t\text{-}p), \ldots \ldots, x(t\text{-}2), x(t\text{-}1), x(t)$$

Used for manufacture a forecast utilizes time series, a huge diversity of methods are obtainable. Forecast of time sequences for scalar values $\{x^A(n)\}$ gives to the assignment of decision approximation $x^A(n+1)$ of upcoming potential model x(n+1) centred on the information of the narration of time successions, i.e. sequences x(n+1), x(n+2) (Rank 2003).

Linear forecast, wherever the approximate is constructed on a linear collection of N previous sequences, can be characterized as shown below:

$$x^{A}(n+1) = \sum_{i=0}^{N-1} a_i, x(n-i) \quad (1)$$

By forecast coefficients α_i, i = 0, 1, …N-1.

Introducing common nonlinear purpose f(.) f(.):$R^n \rightarrow$ R applied to vector [x(n), x(n-M), ..., x(x-N-1)M x(n) = T] of the past samples, nonlinear forecast method $x^A(n+1)$ = f(x(n)) (Rank 2003) is reached.

Usually, a time series predicting issue is begins by linear method such as Auto Regressive Integrated Moving Average (ARIMA) and Auto Regressive Moving Average (ARMA) and systems famous through Jenkins and Box (1976).

Normal variety of ARIMA(p,q)[15] system can be shown as below:

$$X_t - \sum_{r=1}^{p} f.X_{t-r} = \sum_{s=0}^{q} q_s.e_{t-s} \quad (2)$$

Where $\{\varepsilon_t\}$ is white Gaussian noise. The entire procedure is motionless for proper ϕ, θ (Jenkins and Box 1976).

The common model of ARIMA can be represented by:

$$Y_t = a_0 + \Sigma a_i . y_{t-1} + \Sigma b_j . e_{t-j} \quad (3)$$

İ = 1,2, ..., p∧j = 0,1,...,q

Where Y_t a stationary[16] is a non-zero average stochastic process, a_0 - constant, e_i - a disturbance term of white noise, a_i denotes autoregressive coefficients and b_j represents moving average coefficients.

For computing ARIMA model, this approach used MATLAB software[17].

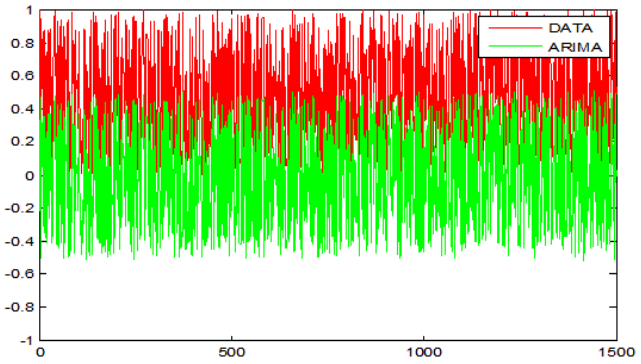

Figure 7. Data plot with predicted values.

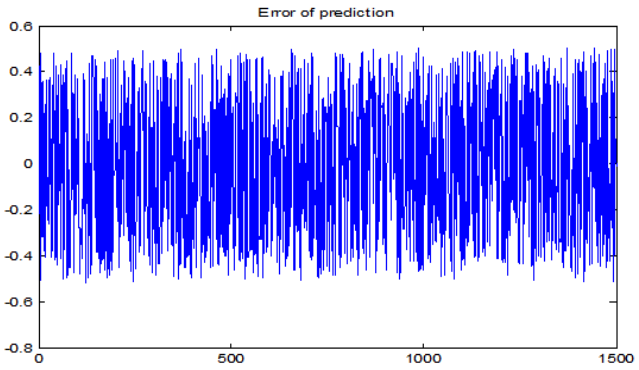

Figure 8. Error of the prediction.

4. Curve Fitting

Function estimation or Curve fitting is the method of series fitting of curves data points. Improved package use curve fitting method to get a prediction polynomial curve depends on principle of min. quadratic error for loads peaks. In tool box of curve fitting gives an app i.e., fitting the curves functions are used and for data surfaces are used. For mathematical function or a curve constriction curve fitting procedure is used, it is the one of the better to a sequence of points data, probably issue of limitations. Fitting the curve can also include interruption, where accurate fit information is needed, or smooth out, where build a function of smooth that around hysterics the data. A correlated issue is degeneration study, which involves extra on queries of arithmetical deduction such as in curve, uncertainty current how much i.e., is fit to data seen by random errors. For visualizing the data fitted curve can be used, where data is unavailable to assume values of function, to conclude the connection between variables two or more.

A multiplicative replica of the following type was designed

$f(t) = a_0 + a_1 * \cos(w*x) + b_1 * \sin(w*x) + a_2 * \cos(2*w*x) + b_2 * \sin(2*w*x)...$

Where a_1, a_2, b_1, b_2 = pastloads

x = step 1100

w = start point ($w_1 = 0.394$, $w_2 = 0.245$, $w_3 = 0.989$, $w_4 = 0.8125$, $w_5 = 0.124$, $w_7 = 0.185$ $w_8 = 0.508$,)

In tool of curve fitting, choose two Fourier since of the replica category. Designed for Fourier series replica, toolbox measures optimized initial points, depends on present dataset.

$Y = a_0 + a_1 * \cos(x*w) + b_1 * \sin(x*w) + a_2 * \cos(2*x*w) + b_2 * \sin(2*x*w)...$

$a_0 = 97.2$, $a_1 = 92.3$, $a_2 = 90.1$, $b_1 = 87.3$, $b_2 = 88.1$

f(t) = (97.2 + 92.3*cos(0.394*1)87.3*sin(0.394*1+90.1*cos(2*0.394*1)+88.1*sin(2*0.394)...

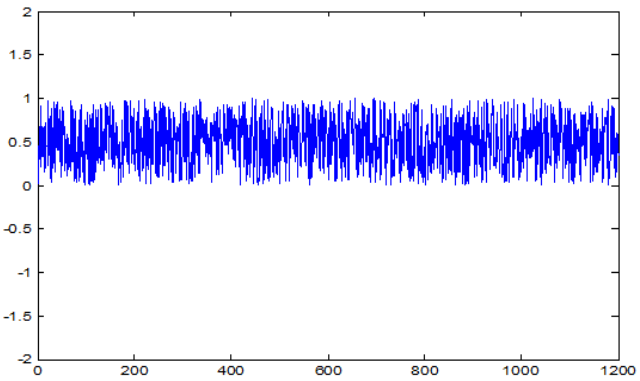

Figure 9. Original data.

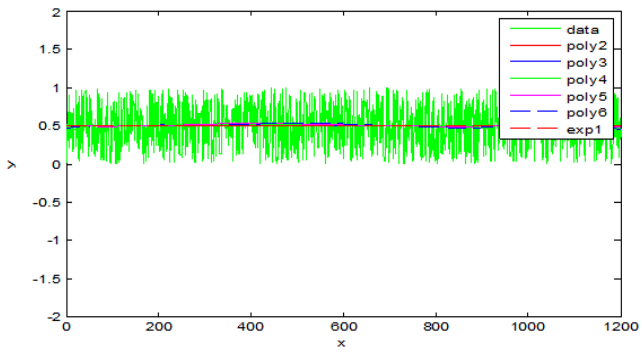

Figure 10. Fitted curve with predicted values.

In this paper, the data used for evaluation and comparison is taken from India Meteorological Department (IMD). The duration of the data collected is 2004 to 2014. After collecting data, the complete data is processed for cleaning of inconsistent and missing data. The ANFIS model here used is for four inputs and one output. 95% of data is processed for training the model and the remaining 5% is used for testing. The ARIMA model used in this evaluation is ARIMA (2, 0, 1). The same data is also applied for proposed polynomial curve fitting. The performance of all the three approaches is done by evaluating SSE, MAE, RMSE and R2 and the obtained results are represented in Table 2.

Table 2. Comparative analysis of ANFIS, ARIMA and curve fitting based on metric parameters

Metric	ANFIS	ARIMA	Curve Fitting
SSE	2.1487	0.4782	0.3248
R2	-1.5682	0.7749	0.8862
RMSE	5.2684	1.8549	1.2478
MAE	4.2846	1.2824	1.0040

5. Conclusion

This paper focused on weather forecasting of Indian weather data taken from Indian meteorological department. For the purpose of weather forecasting with present data, this work tried to estimate the missing data using three methods: ANFIS, ARIMA and Polynomial Curve Fitting. The performance of all the three approaches was verified through four performance metrics such as SSE, R^2, RMSE and MAE. From the above mentioned results, it is clear that the curve fitting based on fuzzy logic performs better compared with ANFIS and ARIMA.

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