Temperature Forecasting System Using Fuzzy Mathematical Model: Case Study Mumbai City

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ABSTRACT

Temperature study and model development related to estimation is an essential and important task not only for a human life but also for animal life, agriculture, tourism, water reservation and evaporation, and many other fields. Regression is considered a dominant prediction model which is heavily used in forecasting in spite of the difficulties related to the number of available measurements, the order of the model and the nonlinearity of the data. In this article, the purpose is to use a nonlinear model structure to forecast the temperature at the airport of Mumbai city in India using the fuzzy logic technique. The datasets were collected for twelve months period starting from 1st of January 2009 to 31st of December at a weather underground in India. The datasets were divided into two parts, 288 days (80%) of the data for training and the remaining 72 days (20%) for testing. The results obtained and the error calculated using the fuzzy logic model were satisfactory.

KEYWORDS

Auto-Regression, Forecasting, Fuzzy Logic, Soft-Computing, Time Series

1. INTRODUCTION

Forecasting the future events is a very vital and important tool in numerous fields, such as rivers (Baareh et al., 2006; Baareh et al., 2007), electricity (Shahateet & Bdour, 2010), whether (Khajure & Mohod 2016), flood (Ruslan et al., 2013), temperature (Al-Matarneh et al., 2014), business (Sheta et al., 2015), military and many other fields (Baareh, 2013; Baareh, 2018). Selecting the convenient and proper model for forecasting is a very complicated, important and difficult task. These difficulties are due to the data availability, the size of the field of interest, the different sensing and measuring instruments being used. Weather forecasting is considered as one of the most important research fields due to its direct impact and effects on the environment, agriculture, water resources, economic and tourism. Weather forecasting process needs to deal with a number of non-parametric metrological parameters. The model used to be static or dynamic based on the model variables and model type.

Actually, different linear methods such as least square estimation (LSE) model were used in forecasting to estimate the model parameters. The problem with the linear models is its inability to deal with environmental changes and the results in many cases were not satisfactory due to its limitations.
Nonlinear models proved its efficiency and ability to solve a number of critical and important problems in different fields, such as forecasting, where the nonlinear model will be quantified before the parameters estimation be completed.

Recently, Soft Computing (SC) techniques such as Artificial Neural Networks (ANN), Fuzzy Logic (FL), Evolutionary Computation (EC) (i.e. genetic algorithms and genetic programming), attracted many researchers in different fields such as the weather forecasting problems (Khajure & Mohod 2016). Many modeling and identification problems were solved efficiently using SC techniques in river flow forecasting (Baareh et al., 2006), flood (Elsafi, 2014) and rainfall (Nayak et al., 2013; Namitha et al., 2015; Mislain et al., 2015) forecasting. This paper is organized as follows. Section 2 describes the related work. Section 3 describes the collected data. Section 4 present problem formulation and evaluation criteria. Section 5 describes the Fuzzy logic concept. Section 6 describes the fuzzy logic model structure. Section 7 describes the experimental results. Finally, Section 8 presents the conclusion.

2. RELATED WORK

Many researchers from different fields worked on temperature forecasting using different techniques, Al-Matarneh et.al, applied two different models for temperature forecasting, Feed Forward Neural Networks with back propagation algorithm and Fuzzy Logic model. Different evaluation criteria were used, the Variance Accounted For (VAF), and Mean Absolute Error (MAE). The results obtained were good and showed that the proposed models can act with more accuracy.

Radhika and Shashi, used the Support Vector Machines (SVMs) to predict the maximum weather temperature at a particular location based on the daily time series observations.

Hayati et.al, used the Artificial Neural Network with Multilayer perceptron (MLP) to predict the temperature for ten years dataset (1996 to 2006). The dataset was divided into two sets one for training and other for testing. The performance of the MLP network was very good with minimum errors.

Patel and Christian, developed a temperature forecasting model for Inland Cities in India. The dataset of one year of daily temperature observations was considered. Relative humidity and mean sea level pressure were measured as inputs variables. The obtained results showed a great decrease in the Root mean square error.

Also, Smith et.al, applied the ANN models to minimize the error prediction average. This is done by increasing the number of monitoring used in training, adding further input terms that describe the monitoring date, rising the prior weather data duration that included in each monitoring, and reevaluating the number of hidden nodes used in the network. The forecasting error was calculated using the mean absolute error (MAE) that showed a good result also.

Sharma et.al, studied the formulation effect of the different connectionist paradigms related to the different learning methods and then finding how well and solid the performance level provided in estimating the stock market.

Gill et.al, proposed a hybrid technique that included back propagation with genetic algorithm to train artificial neural networks. The input variables were also included to train the proposed model the mean air temperature (°C), relative humidity (%) and daily rainfall (mm)) in the Ludhiana city of Punjab (India) for January /2009. The experimental result obtained from combining the both techniques was efficient and more reliable than using any of the algorithms alone.

One more technique was proposed by Lai et.al, using rainfall and temperature weather parameters over the east coast of China. The proposed system was based on some desired data preprocessing technique and dynamically weighted time-delay neural networks (DWTDNN), which is a dynamic neural network type based on a simplified version of the focused gamma network and an extension of TDNN. The results obtained were satisfactory by using a small number of hidden layers in addition to an arbitrary bounded and non-constant activation function.
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