Chapter 53
Artificial Neural Network for Markov Chaining of Rainfall Over India

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ABSTRACT

Rainfall forecasting plays a significant role in water management for agriculture in a country like India where the economy depends heavily upon agriculture. In this paper, a feed forward artificial neural network (ANN) and a multiple linear regression model has been utilized for lagged time series data of monthly rainfall. The data for 23 years from 1990 to 2012 over Indian region has been used in this study. Convincing values of root mean squared error between actual monthly rainfall and that predicted by ANN has been found. It has been found that during monsoon months, rainfall of every n+3rd month can be predicted using last three months' (n, n+1, n+2) rainfall data with an excellent correlation coefficient that is more than 0.9 between actual and predicted rainfall. The probabilities of dry seasonal month, wet seasonal month for monsoon and non-monsoon months have been found.

INTRODUCTION

Water resource planning is one of the most important activities for the growth of a country like India where economy is too much dependent on agriculture. The prediction of hydrological variables *viz.* precipitation, flood stream and runoff flow play an important role for the growth and development of a nation. In India, irrigation is not common and primarily rainfall water is used for supplying water to crops by farmers. When rainfall is not sufficient, irrigation is utilized as supplement. The forecasting of probability of occurrence of rainfall is one of the most important factors for planning and management of crops and decisions related to water management, following which the liability in economy due to unpredictability of water can be reduced. Hence forecasting, modeling and monitoring of rainfall are of

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great significance in the field of agriculture as also emphasized by (Geng et al., 1986); (Hoogenboom, 2000); (Sentelhas, et al., 2001).

Weather forecasting can be defined as daily progress and advancement of the weather up to several days ahead, and seasonal forecasting is related to the average weather conditions for a few months to about a year as stated by Chang and Yeung (2003). Since seasonal forecasts provide knowledge of weather for a few months in advance, they are important for all government sectors to increase productivity and minimize losses as mentioned by Ansari (2013).

The hydrological variables vary on a scale of space and time. Spatial and time series analysis of occurrence of rainfall on monthly basis is vital for observation of the hydrological behavior. There are many contributing factors on which hydrological cycle depends and rainfall is considered as the most important of them as stated by Mimikou (1983); Hamlin and Rees (1987).

Various statistical and soft-computing techniques have been used by meteorologists in past for predicting weather variables. The purpose of this piece of research is to predict rainfall data with an accuracy which is better than previous studies and based on lesser number of training datasets. The other dimension is to find important correlations between various months' rainfall. Also, the probabilities of dry seasonal month, wet seasonal month for monsoon and non-monsoon months has been calculated.

BACKGROUND

Synoptic, numerical and statistical methods have been used for forecasting of rainfall by various authors *viz*. (Tyagi et al., 2011); (Chatterjee et al., 2009); (Iyengar & Basak,1994). Time series technique which is one of the important statistical techniques has been used by many authors as stated in (Sengupta & Basak, 1998); (Iyengaer, 1991).

Markov model, a statistical approach, has been applied to provide forecasts of weather states (dry or wet day) for some future time depending upon values of weather variables given by current and some previous states. Markov chains specify the state of each day as wet or dry and generate a relation between the state of current day and the states of preceding days. The order of Markov chain depends upon the number of preceding days under consideration. Sorup et al. (2011) observed that the first order Markov chain is quite important whereas the second order Markov Chain is even more significant. The authors also found that that there is no noticeable difference between the model parameters of first and second order. It has been observed that the wet day of previous two time periods affect positively the wet day of current time period in the rainy season as compared to the dry day of previous two time period as explained by Hossain and Anam (2012). A 3-state Markov chain model with five independent variables for rainfall forecasting in Haryana, India, has been applied by Aneja and Srivastava (1999). Dash (2012) has found that the first order Markov chain is able to provide value for the precipitation occurrence for all months in Odisha, India.

A hidden state Markov model has been developed to explain the long-term persistence in annual rainfall by Thyer and Kuzcera (1999). In another work, Selvi and Selvaraj (2011) used first order Markov Chain modeling for annual basis of rainfall measurements over Tamil Nadu. The authors have used the annual rainfall for the years 1901 to 2000 and formed the frequency distribution table. The states correspond to class interval and then a transition probability matrix is formed. The authors demonstrated that Markov Chain approach is one of the best options to model future rainfall.