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Hydro Meteorological Drought Forecasting, using Artificial Neural Network (ANN) and Predict Values of Hydro Meteorological Drought Condition Derived using Rainfall Data

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Abstract— This paper focuses on Hydro Metrological Drought Forecasting, using Artificial Neural Network (ANN) and predicts the values of Hydro Meteorological Drought condition derived using Rainfall data of Bhopal (M.P). We have used the Rainfall data as input data of ANN model for Hydro Meteorological Drought forecasting, and determine Standardized Precipitation Index (SPI). Artificial Neural networks operate on the principle of learning from a training set. There is a large variety of neural network models and learning procedures. Two classes of neural networks that are usually used for prediction applications are feed-forward networks and recurrent networks. They often train both of these networks using back-propagation algorithm.

Keywords— Data Source, Artificial Neural Network

I. INTRODUCTION

Artificial intelligence (AI) is a growing trend in computer automation systems. Several types of artificial intelligence technology are available. These include robotics, voice-recognition systems, and many smart computer systems. Artificial intelligence refers to any computer system that uses a logical process to learn and improve, based on the surrounding environment and prior mistakes. This technology is undergoing a great evolution, but is still far short of the capacity of the human brain. It may take several decades before computers will can actually use logic to determine the best approach for problem solving. The current AI systems can learn, but in a limited spectrum. This is because the human brain processes thousands of variables to solve a specific problem.

II. ARTIFICIAL NEURAL NETWORK

Neural networks provide a method for extracting patterns from noisy data. We have applied them to a wide variety of problems, including cloud classification (Bankert,[2], 1994) and tornado warnings (Marzban and Stumpf,[3], 1996) in a meteorological context. We discuss the advantages and disadvantages of neural networks in comparison to other statistical techniques for pattern extraction in (Marzban and Stumpf,[3] (1996)). We can find more detail about the construction of neural networks in (Marzban and Stumpf,[3] (1996)) and (Mu̎ller and Reinhardt,[4] (1991)) and references therein. The standard procedure for use of a neural network involves ''training'' the network with a large sample of representative data. The network has some number of input and output ''nodes'' representing the predictor and predict and variables, respectively. In between, there are a number of hidden nodes arranged in layers. The number of hidden nodes and layers is usually determined empirically to optimize performance for the particular situation. Each connection between nodes on a particular layer and the layer above it can be represented by a weight, viz. that indicates the importance of that connection between the i^{th} and j^{th} nodes. The training phase of the neural network is designed to optimize the weights so that the mean-squared error of the output is minimized. For each node at a particular layer, the input node values from the previous layer are multiplied by the weight of the connections between the nodes and then all of the different connections are summed to produce the value at that node. This process is repeated for all nodes and then for each layer. The network then can be used to make predictions based on new input values.

III. USE OF ARTIFICIAL NEURAL NETWORKS (ANNs) FOR FORECASTING HYDRO METEOROLOGICAL DROUGHT CONDITION

In recent decades artificial neural networks (ANNs) have shown exceptional ability in modelling and forecasting non-linear and non-stationary time series and in most of the cases especially in prediction of phenomena have showed excellent performance.

This discussion presents the application of artificial neural networks to predict hydro meteorological drought in meteorological station Bhopal (M.P). In this paper, different architectures of artificial neural networks in

Rainfall Data have been used as inputs of the models. According to the results taken from this research, dynamic structures of artificial neural networks, including Recurrent Network (RN) and Time Lag Recurrent Network (TLRN) showed better performance for this application (because of higher accuracy of its outputs). Finally, TLRN network with only one hidden layer and hyperbolic tangent transfer function was the most appropriate model structure to predict drought for the next year. In fact, by a prediction of the Hydro Meteorological Drought before its occurrence, it is possible to evaluate Hydro Meteorological Drought characteristics in advance. It was found that ANN is an efficient tool to model and predict Hydro Meteorological Drought events.

Artificial Neural networks operate on the principle of learning from a training set. Two classes of neural networks that are usually used for prediction applications are feed-forward networks and recurrent networks. We often train both of these networks using the backpropagation algorithm. An advantage of backpropagation is that it is simple. Prediction networks usually take the historical measured data, and after some processing stages, future condition is simulated. In this research, after evaluation and testing of different ANN Structures, TLRN and RN we selected networks because of their higher performance, and then between these two, TLRN network showed slightly higher abilities. Therefore, TLRN was the final selected ANN type for Hydro Meteorological Drought prediction in this study.

IV. STUDY AREA AND DATA SOURCE

Bhopal

The geographical location of the Bhopal City lies within North Latitude 23°16' and East Longitude 77°36'. The location of Bhopal falls in the northwestern portion of Madhya Pradesh. If seen in the Map of India, Bhopal occupies the central most region of the country. The city of Bhopal shares its border with two large and picturesque lakes. Like few other big cities of the country, Bhopal is also divided into two parts - the old city and the new one. The Old Bhopal is situated in the northern part of the city, while the southern part is called as the New Bhopal. The two lakes of the Bhopal City are referred as the Upper and the Lower Lakes.

Bhopal has a humid subtropical climate, with mild, dry winters, a hot summer and a humid monsoon season. Summers start in late March and go on till mid-June, the average temperature being around 30 °C (86 °F), with the peak of summer in May, when the highs regularly exceed 40 °C (104 °F). The monsoon starts in late June and ends in late September. These months see about 40 inches (1020 mm) of precipitation, frequent thunderstorms and flooding. The average temperature is around 25 °C (77 °F) and the humidity is quite high. Temperatures rise again up to late October when winter starts, which lasts up to early March. Winters in Bhopal are mild, sunny and dry, with average temperatures around 18 °C (64 °F) and little or no rain. Total annual rainfall is about 1146 mm (46 inches).

V. STANDARDIZED PRECIPITATION INDEX (SPI)

The SPI is an index developed by McKee,[5] et al. (1993) based on the probability of rainfall for the time scale of interest and is relatively less complex to compute. The time scale reflects the impact of Hydro Meteorological Drought on the availability of the different water resources. Soil moisture conditions respond to rainfall anomalies on a relatively short scale. Groundwater, stream flow, and reservoir storage reflect the longer-term rainfall anomalies. For the calculation of SPI for any location long time series of rainfall for the desired period (monsoon season for this study) is used. This long time series of rainfall is fitted to a probability distribution, which is then transformed into a standardized normal distribution so that the mean SPI for the location and desired period is zero. Positive SPI values indicate greater than median rainfall and negative values indicate less than median rainfall. The classification of the Hydro Meteorological Drought intensities based on the SPI value is as follows;

Table.1. SPI V/s Drought

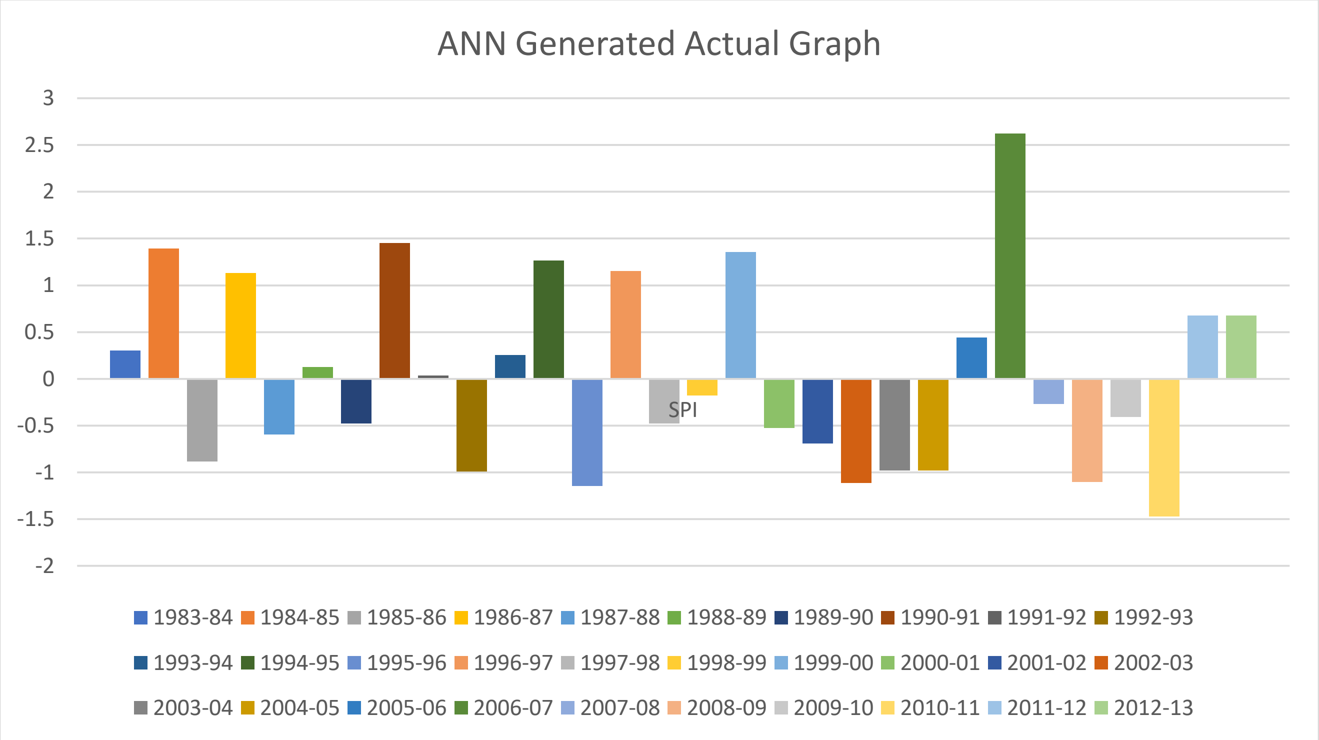
Table for SPI	
2.0 +	Extremely Wet
1.5 to 1.99	Very Wet
1.0 to 1.49	Moderately Wet
-.99 to .99	Near Normal
-1.0 to -1.49	Moderately Drought
-1.5 to -1.99	Severely Drought
-2 and less	Extremely Drought

The SPI is an index developed by McKee,[5], et al. (1993) based on the probability of rainfall for the time scale of interest and is relatively less complex to compute. The time scale reflects the impact of drought on the availability of the different water resources. The SPI is calculated using the following equation, written as

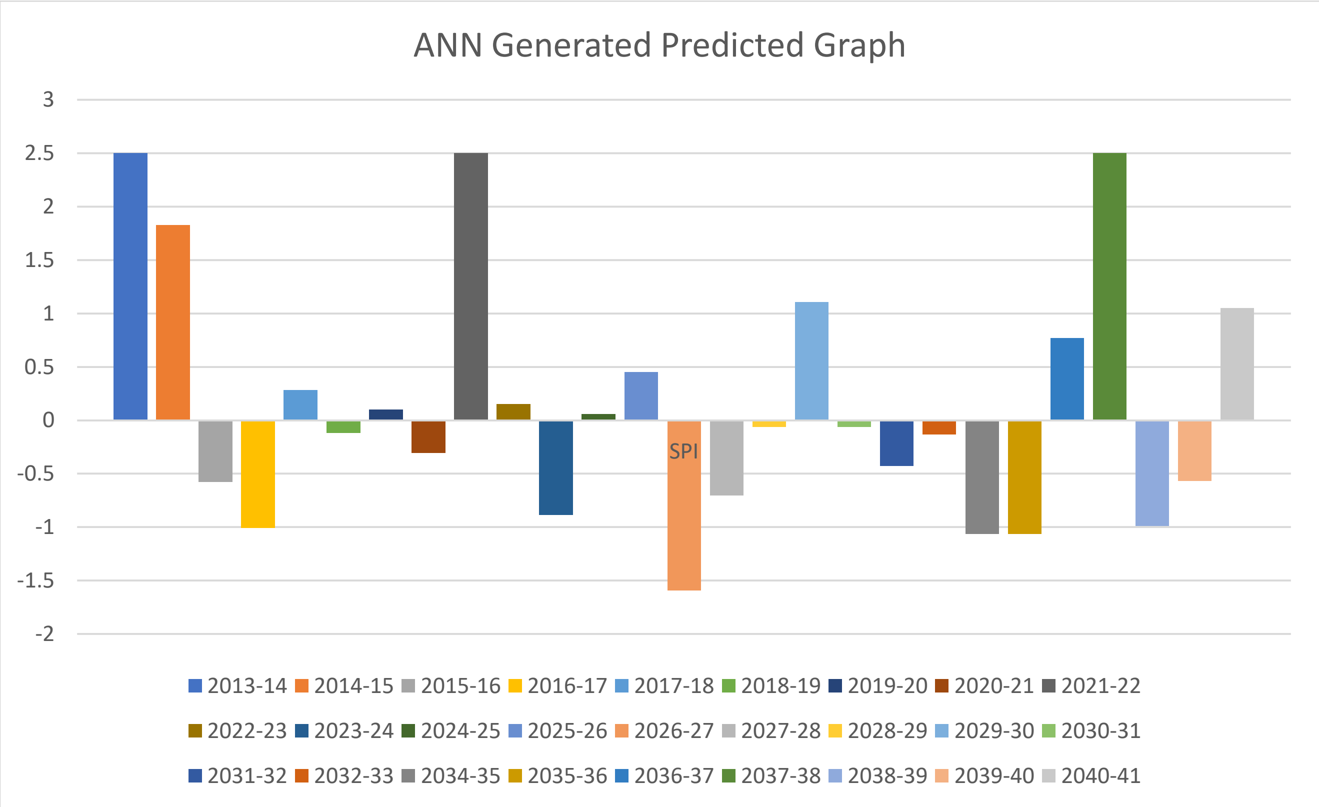
$$\mathbf{SPI}=\frac{Xij - Xim}{\sigma}$$

Where, Xij is the seasonal precipitation at the ith rain-gauge station and jth observation, Xim is its long-term seasonal mean and σ is its standard deviation. Although McKee,[6], *et al.*, (1995) in the original classification scheme proposed ‘mild drought’ for SPI values less than 0.00, in the modified SPI classification scheme of Agnew,[1],(1999), there is a straight jump from ‘no drought’ to ‘moderate drought’. In the present study, SPI maps have been classified using the modified scheme of Agnew,[1],(1999) to represent various hydro-meteorological drought intensities, however, ‘mild drought’ has been recognized corresponding to the SPI values less than -0.50, which has a probability of occurrence 0.309 (Agnew,[1],1999). Seasonal normal's of 30 years (1982-2012) have been used for calculation of SPI. Instead of averaging anomalies for the entire terrain, SPI has been computed separately for each of the rain-gauge stations falling within and around the study area.

VI. ANN GENERATED (SPI) GRAPH



Graph.1. ANN Generated Actual (SPI) Graph



Graph.2. ANN Generated Prediction (SPI) Graph

VII. CONCLUSION

Initially, the ANN model has been conducted on the whole dataset. We have performed graphical visualization in order to make it easier to understand the data itself graph 1and 2 shows it.

The SPI graph generates by ANN model indicate that hydro meteorological drought appears in the Bhopal region in a random fashion. From graph 1 the negative bars in years 1995-96, 2002-03, 2010-11 depict moderately hydro meteorological drought condition and remaining years show mild hydro meteorological drought occurrence.

The positive bars in years 1983-84, 2005-06, 2011-12, 2012-13 show that good rainfall condition. Higher positive values indicate to good rainfall.

Similarly, from prediction graph 2 the negative bars in years 2026-27 show severely hydro meteorological drought condition, while 2016-17, 2034-35, 2035-36 show moderately hydro meteorological drought condition occurrence in these years. The positive bars in years 2025-26, 2036-37 show that good rainfall condition. It is observed that the actual result is very close to the predicted result in concerned area.

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