PREDICTION OF RAINFALL USING INVERSE DISTANCE WEIGHTING METHOD AND ARTIFICIAL NEURAL NETWORKS IN PONNAIYAR RIVER BASIN

S. VEDA SAMHITHA[a1] AND P. GEETHA SRIKANTH[b]

[ab]Amrita Vishwa Vidyapeetham, Amrita University, Coimbatore, Tamil Nadu, India

ABSTRACT

Rainfall is the key parameter in cultivation and climatic elements, which decides the production of the crop and also a significant parameter for farmers. This paper discuss the estimation and the future prediction of rainfall using the Inverse Distance Weighting method (IDW) and Artificial Neural Networks(ANN) . Here, the study area is Ponnaiyar River Basin which flows through Tamilnadu, Andhra Pradesh and Karnataka states has a key role in irrigational and industrial production. Proposed method is validated on five years of data from 2012 to 2016. IDW takes care of finding a new set of rainfall data, minimum temperature and maximum temperature from the known input data. The average rainfall, minimum temperature and maximum temperature of Ponnaiyar River Basin is recorded as 1,528 mm, 21.10 c and 38.100 c respectively. ANN works to predict the new outcome with the help of input data as training data. Here the performance comparison is done based on the quality metrics such as mean square error (MSE), which is a commonly used parameter in case of predictions. The mean square error observed here is very accurate. From the analysis of results obtained from the proposed methods, it is evident that ANN is the best match for the rainfall prediction.

KEYWORDS: Artificial Neural Networks, Back Propagation Algorithm, Geographic Information system, Inverse Distance Weighting method, Rainfall.

Precipitation acts as the most significant role for the production of crops and various irrigational facilities. Rain may be considered as the major element of the hydrological cycle because farmers mainly depends on precipitation. It provides appropriate conditions for several styles of ecosystems, power plants and crop irrigation. India could be a tropical country where the utilization of water and agriculture mainly depends on monsoons. The rainfall through out the monsoon widely spreads in unequal distribution both in time and area. As our country is absolutely addicted to agriculture, rainfall prediction plays a key role.

To estimate the rainfall. Various leading interpolation methods have been used such as Spline, Kriging, Radial Basis Function and Inverse Distance Weighting method (IDW). There are so many traditional methods such as Theissan Polygons and Isohyet. But there are many disadvantages with the traditional methods. IDW Method mainly depends upon the assumption of values. It can be developed by the set of known values from the rainguage stations to observe new values.

Several methods such as Multiple Regression Model, Auto Regressive Integrated Moving Average Model, Artificial Neural Networks, Sliding Window has been used to predict rainfall.

In this paper, we discuss Artificial Neural Network Model which mainly based on the prediction of rainfall. These models are very accurate. Artificial Neural Networks simply determines the mathematical model in which the neurons are parallel to each other in a single layered or multiple layered. Artificial Neural Networks have several advantages in hydrology and other applications. Among all the Artificial Neural Network model approaches, Back propagation Algorithm is widely used for the future prediction of rainfall. This network consists of three layers.

In this paper, we discuss Back Propagation Neural Network model to determine the quality metrics. It basically works on training data and testing data. The training data can be given as one or more inputs. To train the data which is acquired from the rainguage stations we use training data. Testing data can be used to determine the network performance and it is not seen before as training data. When the error meets certain requirements or the error has certain iterations then the process stops. The Back Propagation Neural Network can be represented as

$$Y = f\left(\sum WX - \theta\right)$$

Where 'X' represents the input layer

'Y' represents the output layer

'f' represents the transfer function associated with input and output layer

'W' represents the weight.

Hence, the main objective is to estimate the

[1]Corresponding author

rainfall and predict the rainfall to provide desired accuracy.

STUDY AREA

The study area is to be selected as Ponnaiyar River Basin. It lies in Tamilnadu state. Tamilnadu state is well flourished for its urbanization and industrialization. This river basin extends between 110351 North latitudes and 770451 East longitude. It has several tributaries such as Vaniar, Pambar, Turinjalar which is drained by Ponnaiyar river. It is often known as "Little Ganga of the South". An area of 11,595 sq.km is covered by Ponnaiyar River basin. It starts from the mean sea level of 1000mts. A length of 432 km is surrounded by the Ponnaiyar River Basin. Out of which the Ponnaiyar river basin has been covered by various states. Out of 432 km, an area of 85 km is surrounded by Karnataka state, 187 km is surrounded by Salem and Dharmapuri districts , 54 km is surrounded by Tiruvannamalai and Vellore districts and Cuddalore district has 106 km in Tamilnadu. The average rainfall lies between 969-980 mm. The Ponnaiyar River Basin is fully dominated by the rocks of granite and gneisses. In Ponnaiyar River basin, the temperature is severely hot in the months of April and May. The temperature is raised to 35 c to 45 c.

The Ponnaiyar River stream is almost evaporated for remaining six months. Generally, it boosts the formation throughout the geographical region and it has been fed up by the various tanks and reservoirs.

Data Collection

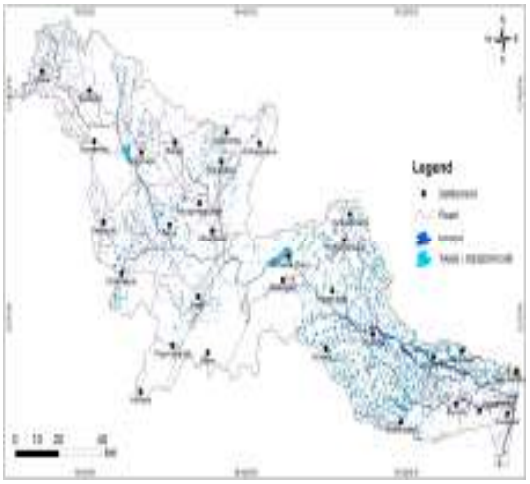

Figure 1: Ponnaiyar River Basin's

Ponnaiyar River Basin's base map was collected from the Survey of India. The periodical precipitation statistics has been observed from the various rainguage stations and the data which we have collected has been processed in ARC GIS software by using IDW algorithm. Prediction of rainfall can be developed by Artificial Neural Networks by processing the data in Matlab through several rainguage stations.

INVERSE DISTANCE WEIGHTING METHOD

IDW is commonly used for the estimation of rainfall variations. It is the most systematic approach which is commonly used for the tremendous fluctuating data. To predict the unknown value, it uses interpolation function. Interpolation is nothing but it finds the unknown points by using the known points with the help of the following equation.,

$$V_i = \frac{\sum_{j-1}^{n} \frac{1}{d_{ij}^{p}} v_j}{\sum_{j=1}^{n} \frac{1}{d_{ij}^{p}}}$$

Where Vi represents the unknown value

Vj represents the data values

n represents the number of rainguage stations

d represents the distance

p represents the power coefficient

ARTIFICIAL NEURAL NETWORKS

The term ANN is created by interconnection of artificial neurons which are formulated to assume the characteristics of neurons. Artificial Intelligence problems can be solved with the help of artificial neurons. Artificial Neural Networks can be used for several applications . In our paper, we discuss the ANN with the help of Back Propagation algorithm.

Feed Forward Back Propagation

- The Back Propagation is one of the widely used algorithm in Artificial Neural Networks. It is the most prominent and efficient method for the heterogeneous networks. The main concept deals with the several network layers through backward pass and forward pass.
- Firstly, input layer is correlated to the different network and this proliferates step by step i.e. layer to layer. Hence, the outputs are created by this network. Here, all the networks are fixed. Basically, Back Propagation network typically consists of 3 layers

i.e. input , output and hidden layers. The abundance of layers decides system capacity which creates precise yields for a specific informational collection.

METHODOLOGY

The methodology includes various steps:

Generation of Shape File

The data from the various rainguage stations has to be collected and generate a shape file in ARC GIS software.

Use of IDW Technique

The interpolation should be performed by using IDW algorithm with input as rainguage data. Then it process and the output will be obtained.

Generation of Contour and Rainfall Map

After generating the output, the generation of contours can be developed by the 'Extraction tool' in ARC GIS. Then, the average rainfall map is produced.

To predict the rainfall the back propagation algorithm typically consists of following steps;

Input Data Selection

The input data is nothing but the data which is collected from the rainguage stations in Ponnaiyar River Basin. The input parameters are temperature and rainfall data. It has 884 threshold. The input matrix will be 2*884 size. Hence, it refers that it has 2 rows and 884 column size.

Data Normalization

The data must be normalized because the input data and the output data should have correlation. Here, we consider two parameters then the mean will be as

M= Sum of all the input parameters/Number of parameters.

Training and Testing of Data

The input data must be tested such that out of 884 samples we consider 400 for training. Here, the back propagation algorithm randomly selects the training data and the remaining will be considered for the testing. After testing, training must be done and the validation has to be performed. Then we get the efficient root mean square error.

RESULTS AND DISCUSSION

The six rainguage stations which are situated in the study area measures the rainfall, maximum temperature, minimum temperature through out 2012-2016. In this study, we use IDW mathematical model to estimate the rainfall variations across the rainguage stations.

To predict the rainfall, ANN uses Nf tool to implement Back Propagation Algorithm. With the help of Nf tool we obtain minimum MSE as 4.2750. The best validation performance has been achieved at epoch 7.

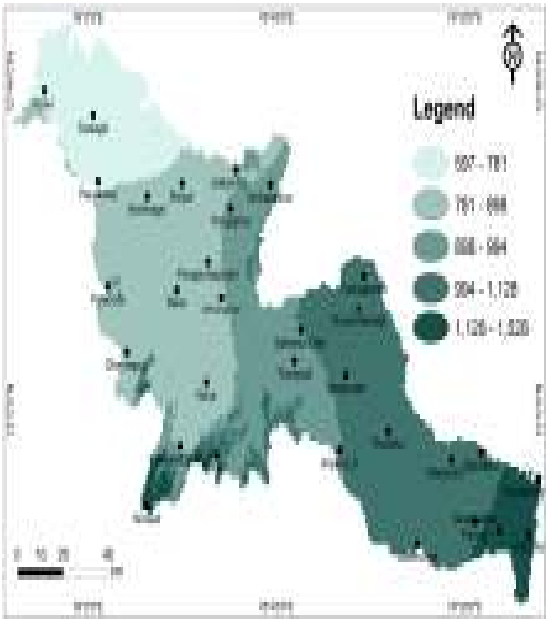

Figure 2: Rainfall Map

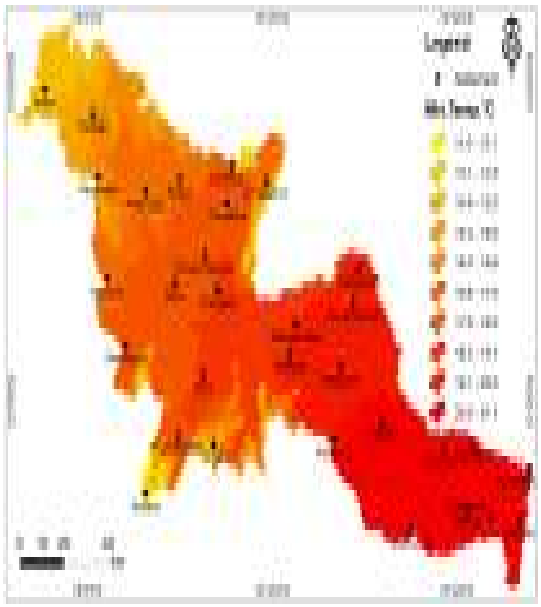

Figure 3: Minimum temperature pattern of Ponnaiyar River for the period of 2010-2016

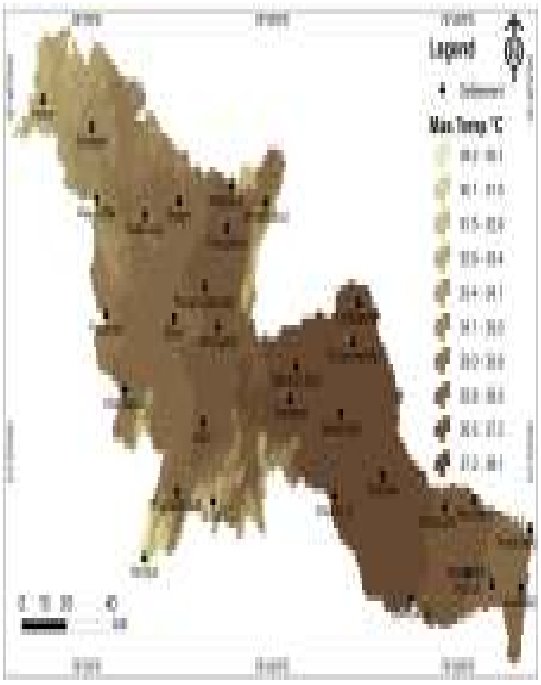

Figure 4: Maximum temperature pattern of Ponnaiyar River for the period of 2010-2016

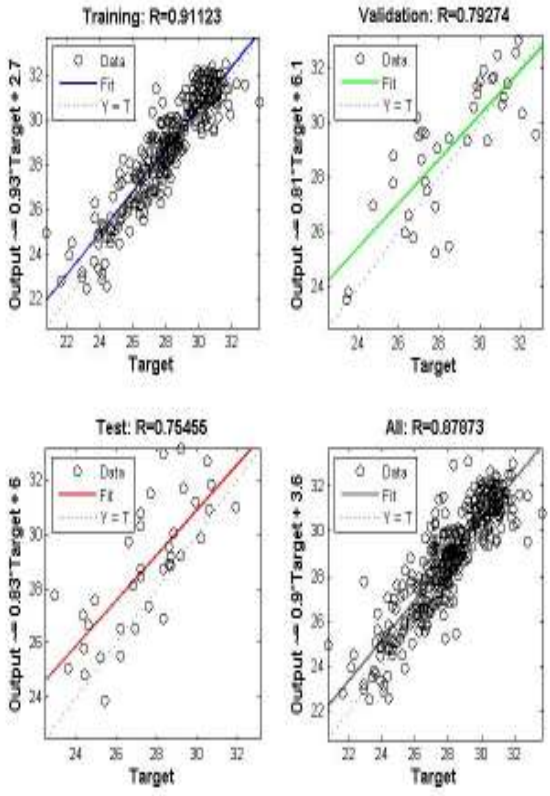

Figure 5: Regression plot

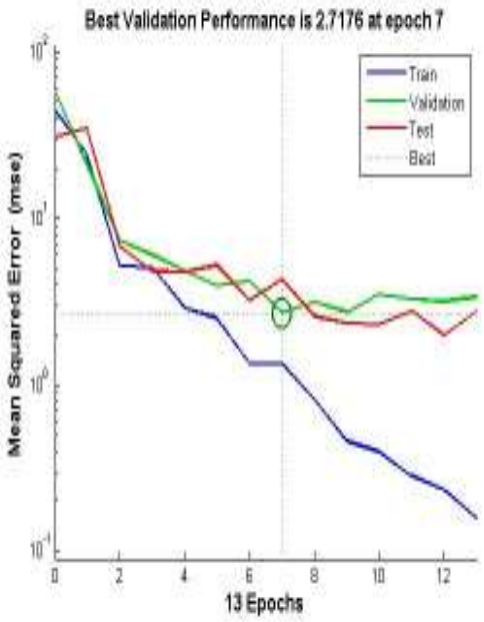

Figure 6: Performance Plot

CONCLUSION

In this paper, we studied the rainfall prediction through ANN and IDW in Ponnaiyar River basin. Ponnaiyar River basin has limited amount of rainfall. To overcome this problem, ANN and IDW has been developed. The rainfall through out the area deals with the variations across the rainguage stations. We acquire data from 2012-2016 from various rainguage stations. The obtained results has been compared with the above models. Hence, Back propagation algorithm is considered as the best for the prediction of rainfall through ANN. Higher the input data , training requires low MSE.

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