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Flood Forecasting Using Neural Network

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ABSTRACT

This paper presents a forecasting model designed using ANN(Artificial Neural Network) to predict flood in rivers using simple and fast calculations to provide real-time results and save the lives of people who may be affected by the flood. Our prediction model uses multiple variable robust linear regression which is easy to understand and simple and cost effective in implementation, is speed efficient, but has low resource utilization and yet provides predictions with reliable accuracy, thus having features which are desirable in any real world algorithm. As the multilayer perceptrons are considered as the universal approximator, we use a multilayer perceptron for the flood detection system. We train our flood detection system with the previous rain fall events. We also evaluate the performance of our trained system and find that our system gives a very good performance.

Keywords— supervised learning, neural network, flood forecasting

I. INTRODUCTION

Floods can occur anywhere after heavy rain. All flood plains are vulnerable and heavy storms can cause flash flooding in any part of the world.

In this paper, we discuss the design of a flood forecasting system that is based on artificial neural networks.The neural network based flood forecasting system provides prediction by learning neural network weights for combining the different individual rankings of the entities on the basis of the training data. The system works in two phases namely training phase and running phase. In the training phase, flood forecasting system is provided with multiple districts rainfall data and a desired overall data. Then, this system learns weights for the neural network to predict an aggregated list that matches the desired overall rainfall data of those districts. In the running phase, the trained neural network is used to predict the overall rainfall data for the new set of ranked lists.

This paper is organized as follows. In section 2, we briefly look at the background and related work. In section 3, we briefly review the theoretical details of neural network and related terminologies. We show our experimental results in section 4. Finally, we conclude in section 5.

II. BACKGROUND AND RELATED WORK

Lets us begin with some useful definitions and notations used in flood forecasting. Then, we discuss the previous work done in the area of flood forecasting.

There are a good number of studies performed on flood warning or forecasting in the past. Artificial neural network modelling of flood prediction and early warning this paper research explores the use of artificial neural network models to predict the onset of floods. Rainfall is considered as the primary factor influencing the likelihood of flood, and a number of artificial neural network architectures were evaluated as flood prediction models[14]. River level forecasting J.V. Aguilar, P. Langarita, L. Linares, M. Gómez, and J. Rodellar, Senior Member, IEEE provides an adaptive predictive approach for river leve forecasting. This paper presents an alternative approach in which the river network is modeled as a cascade of interconnected input-output systems[15]. Neural Net Water Level Trend Prediction and Dynamic Water Level Sampling Frequency.Steven P Sweeney1, Sehwan Yoo2,Albert Chi, Frank Lin, Taikyeong Jeong, Sengphil Hong, Sam Fernald works related to NNWLTP. This paper deals primarily with the NNWLTP(Neural

Network Water Level Trend Prediction), which would allow sampling frequency change commands to be transmitted to the sensors when a transition or turning point was detected[3]. Multi-step-ahead neural networks for flood forecasting, Fi-John Chang, Yen-Ming Chiang & Li-Chiu Chang reseaches on a systematic investigation of three common types of artificial neural networks (ANNs) for multi-stepahead (MSA) flood forecasting is presented[7].

III. NEURAL NETWORK BASED FLOOD FORECASTING SYSTEM

In this section, we first discuss the basics of artificial neural networks then we discuss the details of the flood forecasting system based on the neural network.

A. Artificial Neural Network

An artificial neural network (ANN), often just called a neural network is a mathematical model or computational model based on biological neural networks. It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. ANNS are usually used to model complex relationships between inputs and outputs or to find patterns in the given data. Multilayer feed forward neural network popularly called as multilayer perceptrons consists of multiple layers of computational units, usually interconnected in a feed-forward way. Back propagation is a popular method of training multilayer feedforward ANNs. The back propagation algorithm uses supervised learning, which means that we provide the algorithm with examples of the inputs and outputs we want the network to compute, and then the error (difference between actual and expected results) is calculated.

The artificial neurons, which are organized in different layers, send their signals “forward”, and then the errors are propagated backwards [9].

B. Flood Forecasting using Neural Network

Design of ANN consist of one Input layer , two Hidden layer and one Output layer.Input layer consist of five neurons , first Hidden layer consist of five neurons , second Hidden layer consist of ten neurons and output layer has only one neurons.

A neural network has to be configured such that the application of a set of inputs produces (either 'direct' or via a relaxation process) the desired set of outputs. Various methods to set the strengths of the connections exist. One way is to set the weights explicitly, using a priori knowledge. Another way is to 'train' the neural network by feeding it teaching patterns and letting it change its weights according to some learning rule.

After providing values to the input nodes we use feedforward neural network topology and Backpropagation method for the calculation of the weights of the neural network and these weights will further used to categorized test examples. We use Multi-layer perceptron as feed forward neural network to train our system. To provide values to the input nodes of neural network we use first 7 column from a set of normalized rank tables (such as N1, N2 & N3) and last 8^{th} column of the tables as a predicted output to the output nodes of neural network. The Predicted output is subtracted from the actual output and an error value for the networks is calculated.

$$V' = [(V-minA)/(maxA-minA)]$$

Where,

minA = is the minimum value along particular column,

maxA = is the maximum value along particular column,

V = original value,

V’ = normailsed value.

TABLE I. SAMPLE UNORMALISED TABLE

Month\Year	2004	2005
JAN	37.7	1.2
FEB	0	5.9

TABLE II. SAMPLE NORMALISED TABLE

Month\Year	2004	2005
JAN	0.040162	0.001278
FEB	0.000000	0.006285

And then we store it in the Text document for the input purpose.

The neural network then uses supervised learning, which in most cases is back propagation, to train the network. Back propagation is a learning algorithm for adjusting the weights. It starts with the weights between the output layer PE's and the last hidden layer PE's and works backwards through the network.Once back propagation has finished, the forward process starts again, and this cycle is continued until the error between predicted and actual outputs is minimized.

After the Training of Neural network we obtain a pool of weights of the neural network and these weights will further used to categorized test examples. We store all obtained weights into a file and if want to simulate any new example we will use these weights. For any new query first build up Normalize rank table of that query and than use previously calculated weights to get actual output for this query using Neural Network. We perform 5 fold cross validation of these results. We validated the forecasting model by comparing the predicted user feedback based rainfall output with the actual user feedback based rainfall output.After performing cross validation our Neural Network is now fully trained to categorize any new example. So, for any new data we can use obtained weights (out1a , out2a , out3a , out4a , out5a) of Neural Network to get aggregated output list which is close to the response of it's predefined data list.

IV. EXPERIMENTS AND RESULTS

Design of ANN consist of one Input layer , two Hidden layer and one Output layer.Input layer consist of five neurons , first Hidden layer consist of five neurons , second Hidden layer consist of ten neurons and output layer has only one neurons.

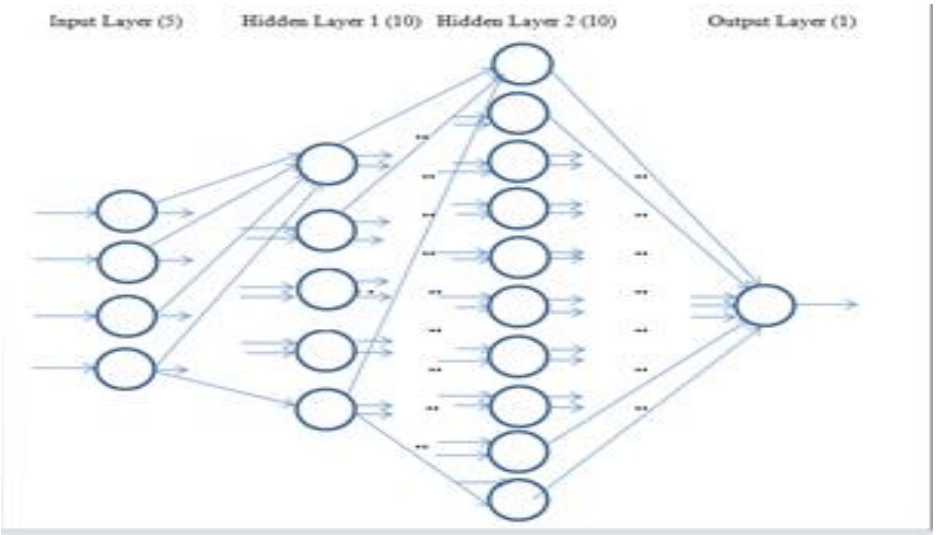

Fig.1 Design of MLP

The Back propagation neural network was used in this work which established accuracy 99.79%, in the training stage we got accuracy of 94.28%. The corresponding Mean Square Error for each data type is as shown in the Table.

TABLE III. PERFORMANCE TABLE

Data Type	Accuracy
Training	99.79
Testing	94.28

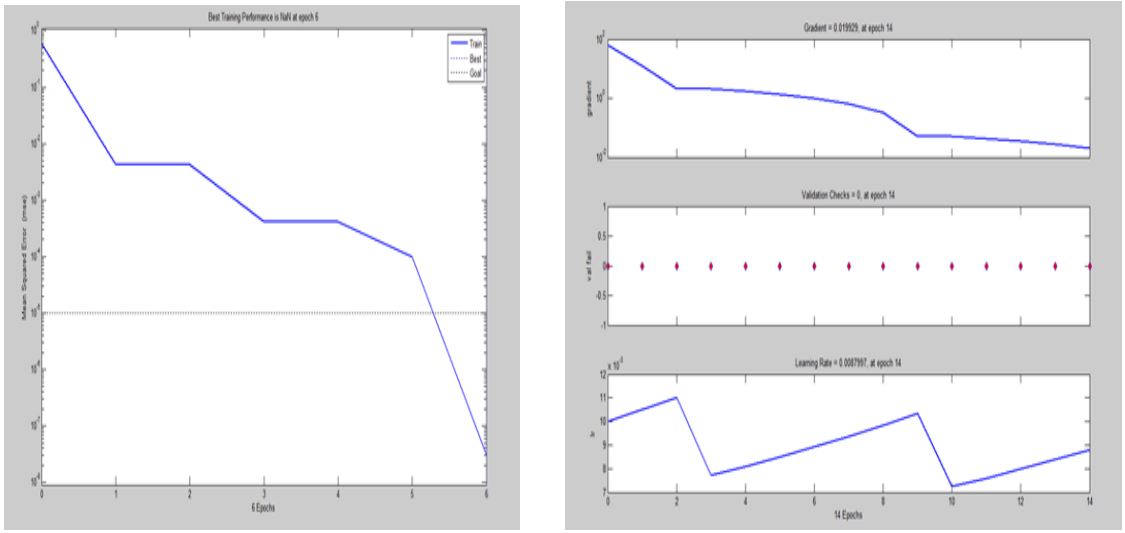

Fig. 2 Performance Plots

TABLE IV. SPEARMAN CORRELATION COEFFICIENT TABLE

Table No	Spearman correlation coefficient value
N1	0.999906
N2	0.999675
N3	0.999780
N4	0.999569
N5	0.999443
N6	0.999497
N7	0.999776
N8	0.999187
N9	0.999657
N10	0.999394
N11	0.999837
N12	0.999565
N13	0.999772
N14	0.999888
N15	0.999875
N16	0.999562
N17	0.999356
N18	0.999423
N19	0.999856
N20	0.999388
AVG	**.9996203**

Targer output division according to Threshold Value,If the rain fall data range lies between 0.0 and 0.25 than there is no probability of flood, if data lies between 0.25 and .5 then low probability of flood , if data lies between 0.5 and .75 then medium probability of flood, if data lies between 0.75 and .9 then high probability of flood.

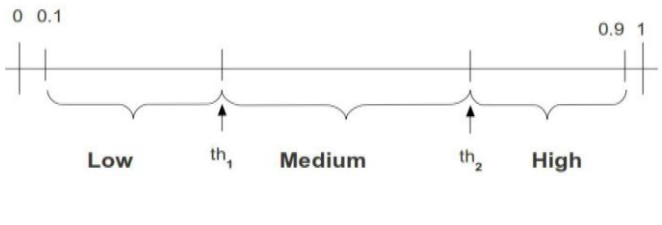

Fig.3 Threshold Value

CONCLUSION

In this paper we proposed a neural network based flood forecasting system for efficient flood warning. As the multilayer perceptrons are considered as universal approximators, we used a multilayer perceptron for flood forecasting. In this work, MATLAB tools are used to predict monthly average state flood prediction. Previous rain fall data between 2004 and 2008 are used for training and learning the neural network, while data between 2009 and 2010 are used for validation and testing. We used spearman rank correlation coefficient to measure the correlation between the previous data and cross validated data.

Overall, the results show that the results of the preliminary tests also indicated that the linear (Purelin) activation function was appropriate for the network architectures considered in this research. Our approach is a reasonable technique to apply for flood prediction, if a limited number of variables are available.

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