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Rainfall Prediction Using Data Mining techniques: A Survey

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Abstract: Data Mining is study of how to determine underlying patterns in the data. Data mining techniques like machine learning, alongside the conventional methods are deployed. Different Data mining techniques like GRNN, MLP, NNARX, CART, RBF, ARIMA and so on are used for the prediction of Rainfall. In this paper, analysis of various algorithms of data mining is used for rainfall prediction model. It is difficult to name a particular algorithm is suitable for prediction. Sometimes when certain algorithms are combined, they perform better and are more effective.

Keywords: *Generalized Regression Neural Network (GRNN), Tipping Bucket (TP), MultiLayer Perceptron (MLP), Neural Network Auto Regressive with Exogenous input (NNARX), Bayesian, CART, C4.5, Radial Basis Function (RBF), Focused time delay Neural Network (FTLNN), Adaptive Neuro Fuzzy Inference System (ANFIS),Autoregressive Integrated Moving Average (ARIMA),Particle Swarm Optimization (PSO), Ensembles of continuous Bayesian Networks (ECBN).*

I INTRODUCTION

Rainfall Prediction is one of the most challenging tasks. Though already many algorithms have being proposed but still accurate prediction of rainfall is very difficult. In an agricultural country like India, the success or failure of the crops and water scarcity in any year is always viewed with greatest concern. A small fluctuation in the seasonal rainfall can have devastating impacts on agriculture sector. Accurate rainfall prediction has a potential benefit of preventing causalities and damages caused by natural disasters. Under certain circumstances such as flood and drought, highly accurate rainfall prediction is useful for agriculture management and disaster prevention.

In this paper, various algorithms have been analyzed. Data mining techniques are efficiently used in rainfall prediction.

II RELATED WORKS

Zhi-liang wang , Hui-hua sheng [1] proposed Generalized Regression neural network model for annual rainfall in Zhengzhou. The results of GRNN have more advantage in fitting and prediction compared with BP neural network and stepwise regression analysis methods. The simulation results of GRNN for annual rainfall is better than that of BP neural network. Accuracy predicted using GRNN is better than BP. The stepwise regression method is inferior to both BP and GRNN in accuracy of simulation and prediction results .GRNN network structure is simple and stable.

Kannan, prabhakaran and ramachandran [2] computed Pearson coefficient for five years data and then compared with predicted data using regression approach. Here, the prediction of rainfall is by using multiple linear regression method. The predicted values lie below computed values. According to the results, it does not show accuracy but show an approximate value.

Andrew, Xiupeng, Anoop and Evan [3] applied five data mining algorithms to predict rainfall in watershed basin at oxford, Iowa, based on radar reflectivity and tipping bucket (TB) data. The five algorithms are employed to build rainfall prediction model such as neural network, random forest, classification and regression tree, support vector machine and k-nearest neighbor. Three Models are selected for all future time horizons. Three models are, Model I is the baseline model constructed from radar data covering oxford. Model II predicts rainfall from radar and TB data collected at south

Amana (16 km west oxford) and Iowa City (25 km east of oxford). Among 5 algorithms MLP neural network has the best performance in comparison to other algorithms. According to the computational results, they have indicated that the three models had a similar performance in predicting rainfall at current time, and model II was more than the other models in predicting rainfall at future time horizons. Different lags like t+15, t+30, t+45, t+60, t+75, t+90, t+105, t+120 were considered. The longest acceptable prediction horizon is 120 min.

Jesada, Kok and Chung [4] proposed fuzzy inference system for monthly rainfall prediction in the northeast region of Thailand. The predicted performance of the proposed model was compared to be conventional Box-Jenkins and artificial neural networks model. Accordingly, the experimental results show the modular FIS is good alternative method to predict accurately. The predicted mechanism can be interpreted through fuzzy rules. Auto-regression, Seasonal auto regressive integrated moving average and ANN modular FIS provide better results. The experimental results provide both accurate results and human-understandable prediction mechanism.

Kyaw and Othman [5] proposed Focused time delay neural network for rainfall forecasting. The network is trained by using Levenberg-Marquardt to perform one-step-ahead predictions. Here, the dataset of rainfall is converted into monthly, quarterly, biannually, yearly. Among these dataset, the yearly dataset gave most accurate results (94.25%) with testing data. The accuracy decreases for the biannual, quarterly and monthly datasets (81.11%, 76.03%, 56.02%). In FTDNN dynamics appear only a input layer of a static multilayer feed-forward network, which makes it suitable for time series prediction.

Ramesan, Shamin and Mathew [6] proposed Neural Network Auto Regressive with exogenous input (NNARX) and adaptive neuro-fuzzy inference system for rainfall runoff phenomenon effectively from antecedent rainfall and runoff information. The models which are having various input structures were constructed and the best structure was investigated with help of the proposed technique, called Gamma test. Prior to model, training data length selection and best input combination is carried out with help of Gamma test. According to the paper, the ANFIS and NNARX work efficiently in rainfall – runoff model and provide high accuracy and reliability in runoff prediction.

Thiago, Francisco, Jose, Ricardo, Mosefran and Pereira [7] proposed Neuro – fuzzy neuron technique for seasonal rainfall forecast model for first four trimesters of the year. The neo-fuzzy neuron model shows a better performance in terms of root mean square error and correlation coefficient between predicted and real output, when compared with a dynamic downscaling model using regional spectral model. The neo – fuzzy model has improvements compared to the dynamic model, using RMSE and correlation as evaluation parameters, and a low computation cost showing that can contribute with information for mounting the report on how is expected to be the rainy season on Ceara.

Wassamon, Chidchanok and Jack [8] proposed artificial neural network and wavelets decomposition as a learning tool for the prediction of daily rainfalls on the accounts of preceding events of rainfall data. Here two sets of wavelets coefficients, for which one pattern represents detail information of rainfall data and the other acts as a smoothing filter, are extracted for the ANNs is considered. Discrete wavelet transform on a given set of discrete signal provides the corresponding approximation coefficients and detail coefficients of the input data vector. These vectors are obtained by convolving signal with low-pass-filter for approximation, and with the high-pass-filter for detail information. The length of each scaling coefficients is generally decreased by two. Accordingly, the results show that the neural network based on wavelet decomposition is preferable by daily rainfall prediction in southern Thailand. Accuracy of the one-day daily rainfall prediction given satisfactory prediction with R^2=0.9948 and RMSE=0.9852mm. In addition, the network is also capable of forecasting up to 4 day in advance with reasonable accuracy. These sets of rainfall data are tested on the ANN model without the transformation of time series by using wavelet decomposition, the network learning fails to predict the rainfall in the selected areas. These signify the data preprocessing as an important step in the construction of learning network by ANN model for rainfall prediction. The wavelet transform can extract the chaotic components from the original data for the trained neural network. Therefore, this study demonstrates the importance of wavelet transform based artificial neural network as a practical tool for the prediction of daily rainfall in southern Thailand.

Valmik and Meshram [9] proposed Bayesian model for rainfall prediction. Since Bayesian prediction model can easily learn new classes. The accuracy also grows with the increase of learning data. Bayesian model issue is that if the predictor category is not present in the training data, the model assumes that a new record with that category has zero probability. According to this paper, Bayesian model for rainfall prediction provides good accuracy. The features used station level pressure, mean sea level pressure, temperature, relative humidity, vapor pressure, wind speed and rainfall. Some of features is being ignored which are less relevant features in the dataset for model computation.

Charaniya and Dudul [10] proposed Time lag neural network model with gamma memory processing neuron for one month ahead prediction of monsoon rainfall in the country based upon the Indian ocean dipole parameter. Indian Ocean dipole has an impact on the Indian monsoon,

so they develop a neural network model to predict the rainfall one month ahead. A three-layer 4-6-1 FTLNN model with gamma memory and conjugate gradient back propagation learning algorithm had been designed for prediction of rainfall series with delay taps equal to 3 and gamma memory coefficient =0.5. The prediction accuracy was found to be about 93% testing period.

Soo-yeon, Sharad, Byunggu and Dong [11] proposed CART and C4.5 to predict rainfall. To correctly perform rainfall prediction, the chance of rain is first determined. Then, hourly rainfall prediction is performed only if there is any chance of rain. 13 variables are considered, they are wind direction, wind speed, wind gust, outdoor humidity, outdoor temperature, evaporation, solar radiation, wind chill, dew point, pressure altitude, cloud base, air density, vapor pressure. The proposed model would be useful for predicting the chance of rain and estimating hourly rainfall in any geographical regions time-efficiently. CART predicted accurately 99.2% and C4.5 predicted accurately 99.3%. And the average prediction accuracy of estimating hourly rainfall with CART and C4.5 are 92.8% and 93.4% correspondingly. CART and C4.5 both have high accuracy and are efficient algorithm.

Liu, Tian, Wang [12] combined Gray theory with Markov chain to establish rainfall prediction model. The Prediction is based on rainfall grade. The Gray GM(1,1) model and modified Markov chain to improve prediction accuracy of the rainfall. The Model is poor fit for random and volatile data sequence. Because of this the prediction accuracy is low. However, the Markov chain can describe random change and dynamic system. It is mainly based on the transition probability between the different states of the subjects to infer the system's future development. The model provides a new way to predict the volatile random objects.

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Nizar and Sanjay [13] proposed a committee of artificial neural network based model with wavelet decomposition for prediction of monthly rainfall on account of the preceding events of rainfall data. Wavelet transform is being used for extraction of approximate and detail coefficient of the rainfall data series. The coefficients obtained from wavelet decomposition are used along with ANN for learning and knowledge extraction processes. After wavelet decomposition of rainfall time series, a multilayer perception with two hidden layer is found optimal for approximate coefficient prediction. Further focused time lag recurrent network with gamma memory is found optimal for prediction of detail coefficients. Thus a committee of two different ANN configurations is proposed for reliable rainfall prediction. The accuracy predicted for the rainfall model is reasonable.

James, Bavy and Tharam [14] proposed Improved Naïve Bayes Classifier (INBC) technique and explores the use of genetic algorithms (GAs) for selection of a subset of input features in classification problems. The INBC compares with genetic algorithm with average classification or general classification (GA-AC, GA-C), C4.5 with pruning, and INBC with relative frequency or initial probability density (INBC-RF, INBF-IPD) on the real meteorological data in Hong Kong. According to the performance, two schemes is built scheme I uses all basic input parameters for rainfall prediction and scheme II uses the optimal subset of input variables which are selected by a GA. According to the results predicted INBC achieved 90% accuracy rate on the rain/no-rain classification problems. INBC method also attained reasonable performance on rainfall prediction with three-level depth (Depth3) and five-level depth (Depth5) which are around 65%-70%.

Jareanpon, Pensuwon, Frank and Davey [15] proposed Adaptive radial basis function (RBF) neural network mode with a specially designed Genetical algorithm to obtain the optimal model parameters. Adaptive RBF network model is used for rainfall forecasting of one year in advance. The algorithm uses a genetic algorithm to determine an optimal value for the width (spread factor) of the hidden units. The network grows by iteratively adding one hidden node at each training epoch until the maximum performance achieves. The number of hidden neurons which are suitable is obtained automatically. The benefits of GA to optimize the adaptive RBF network represent a very good model for the prediction of rainfall.

Dingsheng, Yaming, Nan and Yufeng [16] proposed the annual average extreme rainfall prediction model based on BP network combined with stepwise discriminant method and use Bayesian statistical method to further improve the network's generalization ability and model prediction accuracy, but the overall performance can be further improved, such as to further improve the correct ratio on discriminant analysis. The experimental results validate the method and the prediction accuracy is satisfactory.

Nan and Dingsheng [17] proposed BP network combined with stepwise regression as selection method of input vectors is used to analyze the annual average extreme rainfall prediction model. The Bayesian regularization method is further used to improve the network's generalization ability. This proposed method is effectively used to implement to forecast which is about the trend of annual average extreme rainfall. The proposed model is indeed valid and reliable by experimenting on many years' daily precipitation data of two sites in Yangtze River. Stepwise regression model is used to select independent variables.

Jethangir and Onaiza [18] proposed BP and learning vector Quantization (LVQ) is used for monsoon rainfall prediction. 45 years monsoon rainfall data is used to train Neural Network and evaluate the performance of these models over a test period of 5 years from 2005-2009. The results were compared with multiple linear regressions and statistical

downscaling models, but the results reveals neural network has better performance in terms of accuracy, and also in terms of greater lead time and fever required resources. LVQ is used for classification. LVQ overcomes the problem that we might face in BP of having output 1 for more than one output neurons. This may raise potential problems. LVQ takes less training time than BP. However, in our case of monsoon rainfall prediction almost a year in advance, training time difference that was in seconds is insignificant.

Dong li, Xu Shu, Meng and Yang [19] proposed a time series analysis method which is decomposed into trend items, cycle items, respectively extracted by establishment of various forecasting model and statistics method is used to predict the month precipitation in crop growth period in the area of Chahayang from 1956 to 2008, in order to seek the rule of month precipitation change in crop growth period in this area. It provides data to evaluate the efficiency water resource utilization, and provide reliable basis for local department to manage and plan.

Kesheng and Lingzhi [20] presented a novel modular type support vector machine to simulate rainfall prediction. V-SVM regression model, which introduced a new parameter 'V' which can control the number of support vectors and training errors without defining ϵ a prior. To be more precise, the author posed that 'V' is an upper bound on the fraction of margin errors and lower bound of the fraction of support vectors. First of all, a bagging sampling technique is used to generate different training sets. Secondly, different kernel function of SVM with different parameters, i.e, base models, is then trained to formulate different regression based on the different training sets. Thirdly, the partial least square (PLS) technology is used to select choose the appropriate number of SVR combination member. Finally, a V-SVM can be produced by learning from all base models. V-SVM produced greater forecasting accuracy and improving prediction quality V-SVM is to solve nonlinear regression problems.

Harshani, Uditha and Asanga [21] proposed four ANN to predict the monthly rainfall of Colombo for the southwest monsoon season (may, june, july and august) using ENSO, EQUINOU and OLTC as predictor variables. Optimizing the ANN architecture and adjusting the inputs and weights for optimal performance is proposed. The month may gave best rainfall prediction of all months. The rainfall 2007 was different than actual rainfall value.

Jiaxing and Shaohui [22] built Immune evolutionary algorithm based on Back propagation network is used for rainfall prediction. The rainfall data are considered from June to August in 1971-2000 in Tengchong. The trained network model is used to predict the rainfall from June to August in 2001-2010 in Tengchong. At the same time, the author compares the predicted result with that of BP network algorithm model. The results show that the algorithm has not only higher accuracy but better stability. This method provides a novel effective method with solving complicated problems of optimization such as rainfall prediction. IEA-BP increase optimal process of network greatly. It can improve the fault tolerance of BP network algorithm. IEA-BP gives predictive accuracy and also convergence rate improve greatly and has stable predictive performance. The comparison shows that each predicting result is close to measured value IEA-BP network algorithm model and forecast accuracy increase more than substantial BP network algorithm model.

Long, Ying and Hua [23] proposed a nonlinear statistical ensemble prediction modeling method for predicting monthly mean rainfall using particle swarm optimization (PSO) algorithm and neural networks technique. Using PSO algorithm, the connection weight and network structure of Neural Network are optimized, and a number of different Neural Networks are constructed. PSO-NN ensemble prediction (PNNEP) model is superior to the traditional linear statistical forecast method is prediction capability. Computation and analysis of PNNEP also demonstrate that the prediction of the ensemble model integrates predictions of dozens of ensemble members and the network structure of each member is objectively determined by means of PSO algorithm, so that the generalization capacity of the ensemble prediction model is also enhanced, suggesting that PNNEP model opens up a vast range of possibilities for operational weather prediction. BPNN depends on initial weights, poor convergence that may contain local minima. Besides, structure of BPNN (number of hidden nodes) is usually subjectively determined by increase or decrease of trial and error method. So output of training samples is inconsistent with that of prediction samples precision of training samples rises, yet the accuracy of prediction samples drops down, impeding its wide application. PSO algorithm tries to optimize the connection weights and structure of BPNN algorithm that has global searching performance. PSO algorithm can objectively determine the network structure (number of hidden nodes) and is beneficial for jumping out of local optima due to improper determination of connection weight. Number of individual BPNN models are first created and then integrated to build an ensemble prediction model.

Scott, Amy and Ming [24] introduced Ensembles of continuous Bayesian Networks for rainfall prediction. An ensemble approach is a learning salient dependence relationships and to predicts values for continuous data. By training individual Bayesian Networks on both a subset of data (bagging) and a subset of the attributes in the data (randomization), ECBN produces models for continuous domains that can be used to identify important variables in a dataset and to identify relationships between those variables. They use linear Gaussian distributions within those ensembles, providing efficient network level inference. By ensembling these networks, they are able to represent

nonlinear relationships. Storm scale ensemble forecast (SSEF) data that ECBN performs better than the raw SSEF prediction for rainfall predictions.

Subartono , Dwi , Bambang, Sutikno and Heri [25] proposed a ensemble method based on ANFIS and Autoregressive integrated moving average (ARIMA) for forecasting monthly rainfall data at certain area of Indonesia, namely pujon and Wagis area is proposed. Two empirical rainfall datasets were used to compare the forecasting accuracy between individual ARIMA, ANFIS and ensemble method. The results showed that individual method is more accurate than ensemble methods. For wagis accuracy is predicted using ARIMA and for pujon better accuracy predicted using ANFIS. Two rainfall data from Jan 1975 – Dec 2010, for testing Jan – Dec 2010 are used. In general, these results in line with M3 competition results that more complicated model not always yield better forecast than simpler one.

Narasimha, Prudhvi and Naidu [26] proposed decision tree method using SLIQ to implement the precipitation model. It is observed that decision tree method achieves closer agreement between actual and estimated rainfall. SLIQ method gives high accuracy rate when compared to other prediction model like fuzzy logic, NN etc. The use of Gini index for rainfall analysis is quite apt because of the irregularities present in the statistical data of precipitation. It gives accuracy of 72.3% and completely based on historical data. The decision tree constructed and the classification rule are generated.

Mark, Bobby, Yung and Beth [27] proposed time series analysis is used as prediction algorithm. Two components rainfall/evaporation and crop management. Decision support system for Agriculture management using prediction algorithm aimed to develop a system that will determine the trend of rainfall and evaporation using time series analysis as its prediction algorithm, to develop web-based application that displays graphs and tables according to the result of the prediction algorithm, and to utilize a classification of crops that aids farmers as basis for recommendation according to the predicted amount of rainfall per quarter. The system is found useful in terms of efficiency, reliability. It shows interface the quarter of the year labeled Q1, Q2,Q3, Q4, prediction of average amount of rainfall and evaporation, the trends, and the seasonal effects in its provided field in the table.

III CONCLUSION

In this paper, analysis of various data mining algorithms is presented for rainfall prediction. Data Mining deploys techniques based on machine learning, alongside the conventional methods. More importantly, these techniques can generate decision or prediction models, based on historical data. Based on this analysis BP is combined with various other algorithms. Recent algorithms analyzed in this paper are ANFIS, ARIMA, SLIQ Decision Tree which used for prediction of Rainfall.

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