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Application of Artificial Neural Network (ANN) in rainfall prediction

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INTRODUCTION

Advent of artificial intelligence (AI) is a revolutionary step in the world of science and technology, as it has now become possible to address numerous complex problems with the help of different AI tools such as, machine learning, deep learning, neural networks, wireless communication, Internet of Things (IoT), etc. It eases the problem solving method by simply transferring the burden of decision-making to the algorithm (Pathan et al., 2020). Since last few decades, AI based technologies have made its way into the agriculture sector too. GPS based precision agriculture, laser land levelling, app based disease detection, satellite remote sensing, drones for crop management, etc. are a few examples in the field of agriculture which uses AI or machine learning techniques. Crop yields are governed by numerous factors including soil factors, weather elements, cultivars and other management practices. Of all these factors, weather plays an important role in determining the growth and development of crops. Among all the weather parameters, rainfall particularly stands out to be the most critical component in terms of agricultural production in India, as around 68% of the total cultivated area is rainfed (Meshram et al., 2017). Any major variation in the rainfall pattern, particularly during monsoon season can increase the vulnerability of the agriculture sector to climatic changes. Hence, proper rainfall estimation is a prerequisite in the greater interest of the country's economy. However, rainfall prediction is rather complex due to the presence of hidden layers or non-linear patterns within the system (Dutta & Gouthaman, 2020). Hence, apart from the global climate models, different statistical techniques and machine learning tools have been evolved which are widely used for predicting rainfall in the regional and local levels. Artificial Neural Network (ANN) model is one such machine learning approach which has been reported to be potentially more suitable for regional rainfall forecast studies.

Brief description of ANN

ANNs, inspired by the biological neural networks of the human brain, are data-driven self-adaptive tools composed of very simple yet highly interconnected processors called neurons, which allow signals to pass through them. ANNs mainly consist of three layers, viz., input layer, which receives data from the outside world for network's learning and recognition, output layer, to react to the data set which is assigned to know about and hidden layer in between the input and output layer, to change the contribution to something that yield unit can use (El-Shahat, 2018) as shown in Fig.1. Its main function is to perform calculations in order to find out the hidden patterns and features within the system. The interconnecting neurons, more specifically termed as nodes in ANN, consist of two most important parts, viz., weight parameters and activation functions. When information is received by the nodes from different inputs, non-linearity is obtained by them through activation functions (Chen et al., 2020). ANNs make use of a training dataset and a testing dataset. If any error occurs while running the ANN model, back-propagation (BP) is done by fine-tuning the weights of the connections in ANN units. The process is repeated until the ANN can correctly recognize the required model with minimum error percentage.

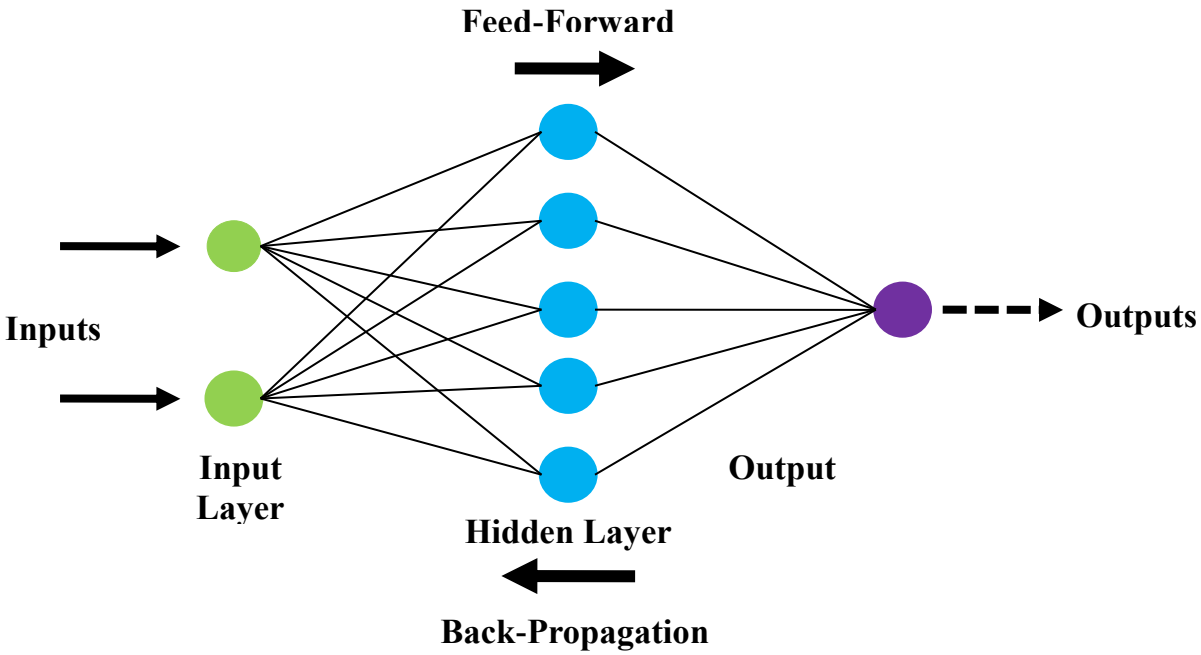

Fig. 1: Framework of a basic ANN structure

Application of ANN in rainfall prediction

With the advancement in skills and developing technologies, ANNs are now being widely used in different arenas to process large datasets. In agricultural studies, it facilitates researchers to deal with non-linear set of data series to predict crop yield, water quality, direction and velocity of winds, rainfall, runoffs, landslides, etc. Rainfall, one of the most important components of the hydrological cycle, plays an important role in human civilization. However, accurate rainfall prediction is rather challenging. In the last few years, neural networks have been extensively used in hydrological research, particularly for rainfall forecasts, both in local and regional levels. Although many advanced rainfall forecasting mechanisms have been developed by national and international institutions, sometimes it leads to over estimation or under estimation of forecasts, particularly at local level, due to highly unstable nature of local

weather situations. Under such circumstances, ANN serves to be an attractive approach in rainfall prediction, owing to its data driven learning in building forecast models. El-Shafie et al. (2011) developed a multi-layer feed forward neural network and trained it with BP algorithm to obtain a reliable and accurate rainfall forecasting in Alexandria, Egypt. They also compared the ANN results with the results of multiple linear regression (MLR) technique and found that ANN performed better using the available data. Kumar et al. (2012) analysed the possibility of predicting rainfall over the Udupi district of Karnataka with the help of ANN models utilizing 50 years data (1960-2010) where average humidity and average wind speed were incorporated as input parameters and average rainfall was obtained as the output. The important observations from their research were, Mean Square Error (MSE) decreased with the increase in input data and increase in the number of neurons and multi layer algorithm performed better than single layer algorithm. A multi layer perceptron can even predict the unexpected local heavy rainfall (Kashiwao et al., 2017).

Advantages of ANN over other machine learning approaches

Traditional rainfall prediction methods include multiple linear regression (MLR), Auto Regressive Integrated Moving Average (ARIMA), etc. When it comes to machine learning, LASSO (Least Absolute Shrinkage and Selection Operator) regression is being used and for neural network, ANN approach is being used widely. The major drawback of MLR is that it is not able to detect a non-linear relationship between the parameters. Similarly, working principle of ARIMA model is based on the presumption of a linear model. Besides, traditional prediction methods cannot capture the non-stationarity in data series. In fact, as the data scale keeps on increasing, traditional techniques become ineffective in meeting the demand of the researchers (Chen et al., 2020). Numerical weather prediction (NWP) systems that are operated in super computers, use mesoscale as well as local forecast models (Kashiwao et al., 2017), however these are not accessible to all. On the other hand, ANNs being data driven model, are free from restrictive assumptions based on time series data. They can train large size samples due to its parallel processing ability (Mohini et al., 2015). ANNs can capture functional relationship among the data even if the underlying relationship is hard to describe and can solve problems that require knowledge which is difficult to specify, provided enough data and observations are present. They can not only accommodate complex non-linear relationships between dependent and independent variables but also provide scope for testing multiple inputs.

CONCLUSION

ANNs have become the most advanced form of application of AI in rainfall prediction, owing to its high flexibility, non-linearity and ability to render accurate predictions with noisy datasets. However, ANNs are highly influenced by the size of the data. Use of short term data may lead to loss of useful information, ultimately resulting in poor prediction performance. In addition, dividing the dataset into training and testing data is an important step of ANN. It has been found that, due to ease in training, BP algorithm is one of the most commonly used algorithms in ANN. This technique has been applied in multiple fields including character recognition, face detection, weather and financial prediction. Hence, it can be inferred that there is a scope for enhancing the forecast accuracy by integrating the currently available rainfall forecasts from different agencies with forecast developed through ANN.

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