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A review: Groundwater level forecasting using artificial neural network

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Abstract
As groundwater resources are more intensively used, there is increasing demand for monitoring of groundwater systems. Precise prediction of groundwater level is important for management of groundwater source. Out of the various methods available, ANN is a very useful tool for predicting groundwater level. In Artificial neural network also different models were used for forecasting of groundwater level but most accurate predictions was achieved with a standard feed forward neural network trained with the Leven berg-Marquardt algorithm.

Keywords: groundwater, forecasting, neural network

Introduction
Water security is one of the major challenges to India's economic and social development. The nation's annual rainfall is most ample by global standards, yet much of this rain falls during the monsoon and there is great inequality across different area. Therefore, dependence on groundwater rather than surface water in rivers and lake increasing by India's farmers, households, and industry. Due to this, a hurried and distressing decline in the nation's groundwater resources. (Wyrwoll, P. 2012) [15].

Groundwater is the major source of drinking agricultural and industrial sector. Groundwater level is indicator of groundwater availability, groundwater flow and physical characteristics of an aquifer. Due to decreased recharge and increased demand of groundwater it is necessary to check the groundwater level (Nair and Sundhu, 2016) [6].

The country's annual ground water resource is 68 % recharge by rainfall and the share of other resources (Canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures) is 32%. Due to the increasing population in the country, the national per capita annual availability of water has reduced from 1,816 cubic meters in 2001 to 1,544 cubic metre in 2011. This is a reduction of 15% (Suhag, 2016) [12]. It is estimated that 60% of groundwater sources will be in a serious state of degradation within the next twenty years. An average decline of water table 33 cm per year from 2002 to 2008 and also Local observations of annual water table decline exceeding 4 metres are common throughout India (Wyrwoll, P. 2012) [15].

The ground water development is more than 100% in the states of Delhi, Haryana, Punjab and Rajasthan. This means that annual ground water consumption is more than annual ground water recharge in these states. The use of groundwater has increased and increase overall groundwater development (Suhag, 2016) [12]. The scarcity of available water resources in the near future and it impending threats, forecasting of fluctuations in groundwater level is needed. Forecasting the ground water level fluctuations is an important requirement for planning conjunctive use in any basin. A useful and effectual technique for forecasting the ground water level fluctuations is artificial neural network.

In this direction several studies were carried out for forecasting the groundwater levels using physical models that are not only laborious a, but also have practical limitations, as many inter-related variables are involved (Daliakopoulos *et.al* 2005) [2]. In the recent past, soft computing tools like artificial neural networks (ANNs) have been used increasingly in various fields of science and technology for prediction purposes. The study of brain is an interesting area since a long time. In the field of electronics and computer science, the advance research that we can use the natural way of this thinking process of brain to design some artificial intelligence system. The firstly, artificial intelligence came into existence in 1943 when Warren McCulloch, a neurophysiologist, and a mathematician, Walter Pitts, work on it and wrote a paper on how brain neurons work (Kumar and Sharma, 2014) [3].

The artificial neural network use a mathematical or computational model for information processing and have a set of processing units called neurons (Sibanda and Pretorius, 2012) [10].
For the planning and management of groundwater resource a timely and accurately forecasting are required. Artificial neural network predict groundwater level more accurately (Lohani and Krishan) [4].

Artificial neural network
Artificial neural network is massively parallel adaptive network of simple nonlinear computing element called neurons which are intended to abstract and model some of the functionality of the human nervous system to attempt to partially capture some of its computational strength. Neurons can be three types input hidden and output. Input neurons are designated to receive external stimuli present to the network. Outputs from the network are generating as signals of output neurons. Hidden neurons compute intermediate functions and their states are not accessible to external environment. On the basis of numbers of layers in model three type of networks: Single layer network (Hopfied network and Adline network), Two layer network (Boltzman machine, Fuzzy associative memory) and Multilayer network (Multilayer Perceptron).
Three model of artificial neural network McCulloch Pitts (Fig.1), Perceptron and Adaline.

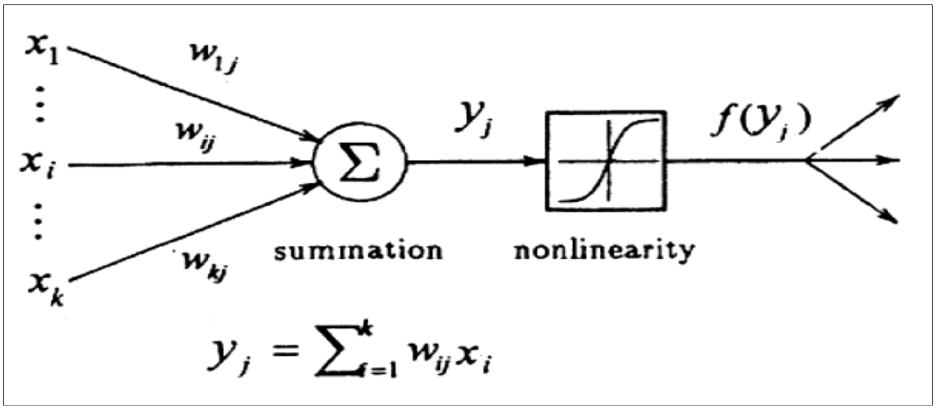

Fig 1: Show McCulloch Pitts model of artificial neuron network

Where,
A neuron is a real function of the input vector (x_0, x_2, ... x_k).
The out put is obtained as $f(y_j)$, f is a function, Three commonly used nonlinear functions are binary, ramp and sigmoid.
w = weighted sums of the functions corresponding to the neurons
The Two type of architecture most widely used in Artificial neural network are feed forward networks and recurrent networks. In a feed forward network, information flows in one direction along connecting pathways, from the input layer via the hidden layers to the final output layer and no loops formation or feedback. In this output of any layer does not affect that same or preceding layer. Recurrent networks or feedback is that network where the output of one layer routes back to a previous layer. The way that the neurons are connected to each other has a significant impacton the operation of the network. In this network a loop formation (Sibanda and Pretorius, 2012) [10].

Groundwater level forecasting using Artificial Neural Network
In this paper, a brief overview of application of Artificial Neural Network in forecasting of Groundwater level.
Rao 2000 [8] studied the artificial neural networks in hydrology. ANNs is more popular now a day in hydrology event. The practicing hydrologic community is just becoming aware of the potential of ANNs as an alternative modeling tool. In this paper, give an introduction to ANNs for hydrologists. Apart from descriptions of various aspects of ANNs and some guidelines on their usage, this paper offers a brief comparison of the nature of ANNs and other modeling philosophies in hydrology. A discussion on the strengths and limitations of ANNs brings out the similarities they have with other modeling approaches, such as the physical model.
Sreekanth *et.al* 2009 [11] researched the forecasting of groundwater level using artificial neural network. The model efficiency and accuracy were measured based on root mean squre error. The regression coefficient founded for model 4.50 and root mean squre error founded 0.93. The accurate predictions was achieved with a standard feed forward neural network trained with the Leven berg-Marquardt algorithm.
Daliakopoulos *et.al* 2005 [2] compared different neural networks in a groundwater level forecasting in order to identify an optimal ANN architecture that can simulate the decreasing trend of the groundwater level and provide acceptable predictions up to 18 months ahead in area Messara Valley in Crete (Greece). The accurate predictions can be achieved with a standard feed forward neural network trained with the Leven berg-Marquardt algorithm providing the best results for up to 18 months forecasts.
Nayak *et.al* 2006 [7] studied the groundwater level forecasting in a shallow aquifer using Artficial neural network approach in India. The forecasting of water level at two observation wells up to 6 months in advance and for this different ANN models was developed. The results show that artificial neural network is a successful tool for monthly groundwater levels forecasting. The performance evaluation parameters (RMSE, the coefficient of correlation, and the AARE) are found to be good and consistent for groundwater levels forecasted 1-month in advance. Furthermore, the prediction error is within the reasonable limit. Although good results are obtained for Munganda observation well up to 4 months ahead forecasts, the model performance is found to deteriorate after 2 month lead forecast for Cheyyeru observation well.
Mirzavand *et.al* 2014 [5] proposed the use of artificial neural networks for groundwater level forecasting in arid and semi-arid environment (Kashan plain aquifer, Iran). Rainfalls, rivers, transitional water resources from other basin and spring discharges (as aquifer recharge components),

evaporation, and aquifer discharges (borehole wells) (as aquifer discharge components) were taken as inputs, and the groundwater levels of Kashan plain aquifer in five clusters (36 Piezometric well) were the output. Simulated groundwater levels were compared with actual groundwater of all clusters in the study area. The results were shown a good fit between real and calculated data. Consequently, the study shows that training the artificial neural network with respect to effect of hydrological, meteorological and human factors on the dynamic groundwater levels gives good results.

Chitsazan *et.al* 2015 [1] studied the forecasting of groundwater level using artificial neural networks an alternative approach to groundwater modelling. In this four different algorithms: descent with momentum (GDM), Leven berg Marquardt (LM), resilient back propagation (RP), and scaled conjugate gradient (SCG) are used. The training data for ANN is obtained from observation data. Rain, evaporation, relative humidity, temperature, discharge of irrigation canal, and groundwater recharge from the plain boundary were used in input layer while future groundwater level was used as output layer. Statistical analysis in terms of Mean-Square-Error (MSE) and correlation coefficient (R) was used to investigate the prediction performance of ANN. FFN-LM algorithm has shown best result in the present study for all three hydrogeological groups. Now, to predict water level, the t time data (October 2003 to July 2009) and t+1 time data (October 2004 to July 2010) were used as input and output respectively. The best condition of this network was achieved for each group of data. Next, with defining the new input data related to August 2010 to January 2011 groundwater level was predicted for the following year. The achieved results that ANN model in contrast with results of finite difference model showed very high accuracy of artificial neural network in predicting groundwater.

Lohani and Krishan 2015 [4] studied the Application of Artificial Neural Network for Groundwater Level Simulation in Amritsar and Gurdaspur Districts of Punjab, India. For predicting the model efficiency and accuracy, different types of network architectures and training algorithms are investigated and compared. The results shown that accurate forecasting can be achieved with a standard feed forward neural network trained with the Leven berg–Marquardt algorithm providing the best results. Good estimation of groundwater level can be achieved by dividing the observation wells into different groups of data and designing distinct networks which is validated by the ANN technique and the degree of accuracy of the ANN model in groundwater level forecasting is within acceptable limits.

Nair and Sindhu 2016 [6] studied the groundwater level forecasting using Artificial neural network for monsoon and non-monsoon season with different combination of hydrological parameters. In factor analysis the correlation between input parameters Potential evapotranspiration (PET), temperature, humidity and rainfall were analysed using Statistical Package for Social Sciences (SPSS) for monsoon and non-monsoon season. Any factor having component value less than 0.5 was extracted as it is less significant for the input combination. The model gives the best performance when rainfall, humidity and PET are given as input parameters during monsoon season. During non-monsoon season, best performance is obtained when temperature is added to the input parameters, which indicates the influence of temperature on the groundwater level during non-monsoon period.

Sun *et.al* 2016 [13] demonstrated the application of neural networks in groundwater table forecasting in Singapore. The relationship between the input (reservoir level, rainfall) and the output (groundwater table) is highly nonlinear because of geological characteristics and hydrological processes were very complex. Therefore, the is not suitable to serve our study purpose and gives poorer forecasting results. The ANN forecast groundwater level more accurate than MLR model.

Shamsuddin *et.al* 2017 applied Artificial Neural Network in Forecasting of Groundwater Level by incorporating river recharge and river bank infiltration. The input to the ANN models consider of daily rainfall, river stage, water level, stream flow rate, temperature and groundwater level. Two different type of ANNs structure were used to predict the fluctuation of groundwater tables and compared the best forecasting values, The coefficient correlation (R), Mean Square Error (MSE), Root Mean Square Error (RMSE) and coefficient determination (R^2) were chosen as the selection criteria of the best model. Two pumping test was conducted and found that accurate forecasting of groundwater level by first test as the value of performance parameters high in first test.

Conclusions

Many studies have been conducted in the area of predicting groundwater level. Out of the various methods available, ANN is a very useful tool for predicting groundwater level. In Artificial neural network also different models were used for forecasting of groundwater level but most accurate predictions was achieved with a standard feed forward neural network trained with the Leven berg-Marquardt algorithm.

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