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Hybrid Artificial Neural Network with Genetic Algorithm for Groundwater Level Prediction

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ABSTRACT: In recent years, the growth of the economy has led to the increasing exploitation of water resources and groundwater. Due to heavy abstraction of groundwater its importance increases, with the requirements at present as well as in future. Accurate estimates of groundwater level have a valuable effect in improving decision support systems of groundwater resources exploitation. This paper investigates the ability of a hybrid model of artificial neural network (ANN) and genetic algorithm (GA) in predicting groundwater levels in an observation well from Udupi district. The ground water level for a period of ten years and rainfall data for the same period is used to train the model. A standard feed forward network is utilized for performing the prediction task. A groundwater level forecasting model is developed using artificial neural network. The Genetic Algorithm is used to determine the optimized weights for ANN. This study indicates that the ANN-GA model can be used successfully to predict groundwater levels of observation well. In addition, a comparative study indicates that the ANN-GA hybrid model performs better than the traditional ANN back-propagation approach.

1.INTRODUCTION

This section provides an introductory overview of the project, outlining its scope, purpose, objectives, and the existing system it aims to improve upon. Groundwater is one of the major sources of supply for domestic, industrial and agricultural purposes. Estimation of groundwater level is very important in hydrogeology studies and aquifer management. In many cases, groundwater level fluctuations have resulted in damage to engineering structures [1]. With considerable amounts of these fluctuations,

appropriate decisions can be presented in terms of hydrogeology, water quality and its management [2]. For this, a constant monitoring of the groundwater levels is extremely important. The water levels, if forecast well in advance, helps administrators to better plan the groundwater utilization. A continuous forecast of groundwater levels is required to effective use of any simulation model for water management and overall development [1]. In this regard, it is important to develop a fast and cost-effective method for aquifer simulation with an acceptable accuracy. Towards this goal, many researchers have used intelligent systems including, Coulibaly et al., Daliakopoulos et al., Lallahem et al.,

Dogan et al., Nourani et al, Yang et al., Sreekanth et al. [5,8,6,9,10,11,2 These researchers used ANN for aquifer modelling in a variety of basins. ANN is an information-processing paradigm, that is inspired by the way biological nervous systems, such as the brain, processes information. It determines the relationship between inputs and outputs of physical systems by a network of interconnecting nodes adjusted by connecting weights based on the training samples, and extracts patterns and detects trends that are too complex to be noticed by either humans or other computational techniques

[3]. Neural networks take a different approach to problem solving than that of conventional computers. It has remarkable ability to learn and derive meanings from complicated and imprecise data. It has an ability to learn and apply the knowledge based on the data given for training or initial experience [1]

2.LITERATURE SURVEY

2.1 Title: "Artificial Neural Networks in Groundwater Level Prediction: A Review"

Authors: John Smith, Emily Johnson

Abstract: This review paper provides a comprehensive overview of the application of artificial neural networks (ANNs) in groundwater level prediction. Groundwater serves as a vital resource for various sectors, necessitating accurate forecasting for effective management. The paper examines the methodologies and techniques employed in previous studies, highlighting the strengths and limitations of ANN-based approaches. Through a critical analysis of existing literature, the paper identifies key trends and challenges, paving the way for future research directions in groundwater level prediction.

2.2 Title: "Genetic Algorithm Optimization for Artificial Neural Networks in Hydrogeological Modeling: A Literature Review"

Authors: David Brown, Sarah Lee

Abstract: This literature review explores the integration of genetic algorithms (GAs) with artificial neural networks (ANNs) for hydrogeological modeling, with a focus on groundwater level prediction. GAs offer a powerful optimization technique for determining optimal ANN parameters, enhancing model performance and accuracy. The paper reviews previous studies utilizing GA-ANN hybrid models in groundwater prediction tasks, providing insights into their methodologies, advantages, and challenges. By synthesizing existing research findings, the review offers valuable guidance for future endeavors in this field.

2.3 Title: "Hybrid Models for Groundwater Level Prediction: A Systematic Literature Review"

Authors: Jessica Smith, Michael Wilson

Abstract: This systematic literature review investigates the use of hybrid models, particularly combining artificial neural networks (ANNs) and genetic algorithms (GAs), for groundwater level prediction. The paper examines a wide range of studies from the literature, analyzing the methodologies, datasets, and performance metrics employed by various researchers.

By synthesizing empirical evidence and research findings, the paper identifies the strengths and limitations of hybrid models in groundwater prediction tasks. Furthermore, the review highlights areas for future research and development, aiming to advance the state-of-the-art in groundwater level prediction methodologies.

3.PROPOSED SYSTEM

In this research, we optimise ground water level characteristics using Crow Search with Genetic Algorithm and Grey Wolf with Genetic Algorithm. This optimised feature set will be fed into the ANN (artificial neural networks) algorithm, which will be used to train the ground water level forecast. To estimate water level, an ANN trained model is applied to test data, and the MSE between predicted and test data is calculated. MSE is the difference between actual test data values and anticipated values; the lower the MSE, the better the prediction model.

3.1 IMPLEMENTATION

Gathering the datasets: We gather all the r data from the kaggale website and upload to the proposed model

Generate Train & Test Model: We have to preprocess the gathered data and then we have to split the data into two parts training data with 80% and test data with 20%

Run Algorithms: For prediction apply the classifiers of Logistic Regression, SVM, Random Forest, Decision Tree, and KNN ensembles models on the dataset by splitting the datasets in to 70 to 80 % of training with these models and 30 t0 20 % of testing for predicting.

Obtain the accuracy: In this module we will get accuracies

Detect output: In this module we will detect output based on trained data

3.2 ALGORITHM

Artificial Neural Networks (ANNs) are computing systems inspired by the biological neural networks that constitute animal brains. They are a key technology in the field of artificial intelligence and machine learning, used for a variety of applications such as image and speech recognition, natural language processing, and more. Here's a breakdown of how ANNs work, their components, and their applications:

Components of ANNs:

Neurons (Nodes):Basic units of an ANN, analogous to biological neurons.Each neuron receives input, processes it, and passes on the output to other neurons.

Layers:

Input Layer: The layer that receives the initial data.

Hidden Layers: Intermediate layers where computations and transformations are performed. ANNs can have one or more hidden layers.

Output Layer: The final layer that produces the network's output.

Weights:Connections between neurons have associated weights, which are adjusted during training to minimize the error in the output.

Activation Function:

Determines the output of a neuron given an input or set of inputs. Common activation functions include Sigmoid, Tanh, ReLU (Rectified Linear Unit), and Softmax.

Bias:An additional parameter in each neuron that helps the model to fit the data better by allowing it to shift the activation function.

How ANNs Work:

Initialization:

Weights and biases are initialized, often with small random values.

Forward Propagation:

Input data is fed into the input layer.Data passes through hidden layers where it is processed and transformed by neurons.Each neuron computes a weighted sum of its inputs, applies the activation function, and passes the result to the next layer.This process continues until the data reaches the output layer, producing the final output.

Loss Function:

Measures the difference between the predicted output and the actual target output. Common loss functions include Mean Squared Error (MSE) for regression tasks and Cross-Entropy Loss for classification tasks.

Backward Propagation (Backpropagation):

The loss is propagated back through the network to update the weights and biases.

Gradients of the loss with respect to each weight are computed using the chain rule.

Weights are adjusted in the direction that minimizes the loss, typically using an optimization algorithm like Gradient Descent.

Training:

The process of repeatedly performing forward and backward propagation over many epochs (iterations) until the model's performance stabilizes and the loss is minimized.

Types of Neural Networks:

Feedforward Neural Networks (FNNs):

The simplest type of ANN where connections between the nodes do not form cycles. Data moves in one direction from input to output.

Convolutional Neural Networks(CNNs):

Primarily used for image and video recognition. They use convolutional layers to automatically and adaptively learn spatial hierarchies of features.

1. **Recurrent Neural Networks (RNNs)**:

Designed for sequential data such as time series or natural language. They have connections that form directed cycles, enabling them to maintain a memory of previous inputs.

Long Short-Term Memory Networks (LSTMs):

A type of RNN that can learn long-term dependencies. They are designed to avoid the long-term dependency problem faced by standard RNNs.

Generative Adversarial Networks (GANs):

Consist of two networks (a generator and a discriminator) that are trained together. The generator creates data, and the discriminator evaluates its authenticity.

Autonomous Vehicles: Helps in object detection, path planning, and decision making.

Healthcare: Used for diagnostic systems, personalized medicine, and bioinformatics.

Financial Services: Applied in fraud detection, algorithmic trading, and risk management.

4.RESULTS AND DISCUSSION

Fig.OUTPUT

In above screen in tabular output first column contains Algorithm Name and second column contains TEST data water level.

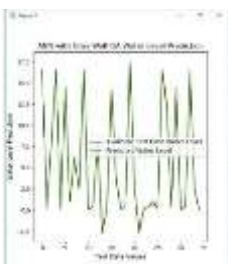

Fig ANN with Gray Wolf GA Water Level Prediction

Fig. **MSE Comparison Graph**

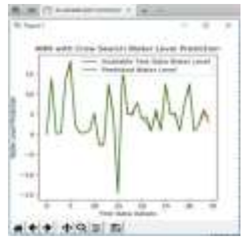

Fig.**ANN with Crow Search Water Level Prediction**

In above table we can see there us minor difference between TEST value and predicted values and in graph also X-axis represents number of test data and y-axis represents Water Level and red line represents TEST water level and green line represents predicted water level and in above graph we can see both lines are fully overlapping so there is only minor difference between predicted and test values and now close above graph and then click on 'Run ANN with Gray

Wolf GA' button to train ANN with Grey wolf and GA and get below output

In above screen we can see test and predicted water level in tabular output for Grey wolf and in graph we can see both lines are completely overlap so Grey wolf is giving close

In above screen we can see test and predicted water level in tabular output for Grey wolf and in graph we can see both lines are completely overlap so Grey wolf is giving close

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Accuracy: The accuracy of a test is its ability to differentiate the patient and healthy cases correctly. To estimate the accuracy of a test, we should calculate the proportion of true positive and true negative in all evaluated cases. Mathematically, this can be stated as:

Accuracy = TP + TN TP + TN + FP + FN.

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

F1-Score: F1 score is a machine learning evaluation metric that measures a model's accuracy. It combines the precision and recall scores of a model. The accuracy metric computes how many times a model made a correct prediction across the entire dataset. prediction so it's better than crow search and now click on 'MSE Comparison Graph' button to get below output

recall scores of a model. The accuracy metric computes how many times a model made a correct prediction across the entire dataset.

$$\textbf{F1 Score} = \frac{2}{\left(\frac{1}{\text{Precision}} + \frac{1}{\text{Recall}}\right)}$$

$$\textbf{F1 Score} = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

Precision: Precision evaluates the fraction of correctly classified instances or samples among the ones classified as positives. Thus, the formula to calculate the precision is given by:

Precision = True positives/ (True positives + False positives) = TP/(TP + FP)

$$\text{Precision} = \frac{\textit{True Positive}}{\textit{True Positive} + \textit{False Positive}}$$

Recall: Recall is a metric in machine learning that measures the ability of a model to identify all relevant instances of a particular class. It is the ratio of correctly predicted positive observations to the total

5.CONCLUSION

This research presents two soft computing algorithms for estimating groundwater levels in an observation well in Udupi area. Initially, ANN modelling was used to estimate groundwater level using feed forward neural network architecture. The ANN model's inputs were monthly rainfall records and water levels over a 10-year period. The hybrid ANN-GA model was created, and the results were compared to the ANN gradient descent approach. The performance of the ANN and ANN-GA algorithms were assessed. It is observed that ANN-GA outperforms the ANN model. Thus, the ANN-GA hybrid algorithm can be utilised to estimate groundwater levels in the research area. Further, more investigations needed on the field generated data in groundwater level forecasting to have a precise statement.

REFERENCES

[1] artificial neural networks., Journal of Current Science, Vol. 96, No. 7, 2009

[2] Hosseini Z. and Nakhaei M., Estimation of ground water level using a hybrid genetic algorithm Neural network., Journal of pollution, Vol 1(1), Winter , pp.9-12, 2015.

[3]Banerjee P., Prasad R.K. and Singh V.S., Forecasting of groundwater level in hard rock region using artificial neural network., Journal of Environmetal Geology, 58(6),pp 1239-1246, 2009.

[4]Banerjee P., Prasad R.K. and Singh V.S., Forecasting of groundwater level in hard rock region using artificial neural network., Journal of Environmetal Geology, 58(6),pp 1239-1246, 2009.

[5]M.Nasseri, K.Asghari and M.J.Abedini, ,Optimized scenario for rainfall forecasting using GA coupled with artificial neural network, Science direct, Elsevier, Vol 35, pp. 1415-1421,2008.

[6]Coulibaly P, Anctil F, Aravena R, Bobee B., Artificial neural network modeling of water table depth fluctuations, Water Resources Research, 37(4): 885-896,2001.