RESEARCH ARTICLE OPEN ACCESS

PREDICTING GROUND WATER USING A HYBRID EVOLUTIONARY ALGORITHM AND ARTIFICIAL NEURAL NETWORKS

Dr D J Samatha Naidu[1], K.Venkata Ramya [2] , M. Dileep Kumar[3]

MCA Department, Annamacharya PG College of Computer Studies, Rajampet[1,2,3]

--************************----------------------------------

Abstract:

Accuracy of the groundwater level has a valuable effect in efficiency of supportive deciding system and exploitation of available water sources. In existing work, first problem, the conceptual and physical based models required for large quantity and good quality data, sophisticated methods are underlying the physical process. When data is not sufficient, we can predict the ground level water resources. Second problem, the present studies investigating the ability of a hybrid model of ANN and genetic algorithms for forecasting ground level water in a individual wells. In proposed work, The Recurrent Neural Network and Feed Forward Networks (RNN & FNN) are utilized for performing the prediction tasks. It consists of a comparative study of both hybrid models are used. RNN is a multi-layer architecture that maintains a variety of applications including control systems using back propagation technique. Final results shows that the best input combination for groundwater level forecasting is water level time series data in neighbouring water resources.

Keywords —Groundwater level prediction, machine learning, bagging and boosting, correlation analysis, time-series data.

--************************----------------------------------

I. INTRODUCTION

The estimation accuracy of the groundwater levels has a valuable effect in efficiency of a supportive deciding system and exploitation of available water resources. Kerman is one of the provinces of Iran which is located in a dry area with 150 mm precipitation on average annually. Because of the development in cities, industries, agriculture and drought in these two recent decades, groundwater level has decreased at this area (around 1 to 3 m annually). In such situation, the simulated models of groundwater level can be used as an instrument for management of withdrawing water from these limited sources.

The conceptual and physically based models require a large quantity of good quality data, sophisticated programs for calibration using rigorous optimization techniques and a detailed understanding of the underlying physical process. When data is not sufficient, empirical models are a good alternative method, and can provide useful results without a costly calibration time (Krishna et al., 2008). In recent years, artificial neural networks being capable of analysing long series and large-scale data, and it become increasingly popular in hydrology and water resources among researchers and practicing engineers.

ANNs are proven to be effective in modelling virtually any nonlinear function to an arbitrary degree of accuracy. Nasseri et al. (2008) developed a feed-forward neural network coupled with GA to simulate the rainfall field. The technique implemented to forecast rainfall for a number of times using hyetograph of recording rain gauges. Results showed that when FFN coupled with GA, the model performed better compared to similar work of using ANN alone. ANN applications in hydrology vary, from real-time to event-based modelling. They have been used for groundwater modelling, level estimation (Coulibaly et al., 2001; Nourani et al., 2008).

A comprehensive review of the applications of ANNs in hydrology can be found in the ASCE Task Committee report (ASCE, 2000a, b). A few applications of the ANN approach in groundwater related problems can be found in the literature (Coppola et al., 2005; Lallahema et al., 2005). Groundwater levels have been forecasted in an individual well by monitoring continuously over a period of time using ANN (Daliakopoulos et al., 2005). In another study a developed ANN model used to forecast groundwater levels in an urban coastal aquifer (Krishna et al., 2008). Groundwater levels have also been forecasted by taking into account the nearby wells and climatic parameters by developing a single model pertaining to each individual well by developing well at various lead periods using artificial neural networks (Nayak et al., 2006). In another study an ANN model used to forecast groundwater changes in an aquifer (Tsanis et al., 2008). In this study, a new method was proposed to improve the forecasting of monthly groundwater level by using genetic algorithm to optimize the structure of multi-layer feed-forward network (FFN) and recurrent neural networks (RNN). Genetic algorithm (GA) is used to search for optimal structure of ANNs for forecasting groundwater level. In other words, a novel, ANNs model based on genetic algorithm was developed to build relationship between time series information nearby wells, climatic parameters data and groundwater level fluctuations in individual well.

I. EXITING SYSTEM

The conceptual and physically based models require a large quantity of good quality data, sophisticated programs for calibration using rigorous optimization techniques and a detailed understanding of the underlying physical process. When data is not sufficient, empirical models are a good alternative method, and can provide useful results without a costly calibration time (Krishna et al., 2008). In recent years, artificial neural networks being capable of analysing long series and large-scale data, and it became increasingly popular in hydrology and water resources among researchers and practicing engineers.

ANNs are proven to be effective in modelling virtually any nonlinear function to an arbitrary degree of accuracy. Nasseri et al. (2008) developed a feed-forward neural network coupled with GA to simulate the rainfall field. The technique implemented to forecast rainfall for a number of times using hyetograph of recording rain gauges. Results showed that when FFN coupled with GA, the model performed better compared to similar work of using ANN alone. ANN applications in hydrology vary, from real-time to event-based modelling. They have been used for groundwater modelling, level estimation

Disadvantages

- Less Accuracy.
- Low Efficiency.

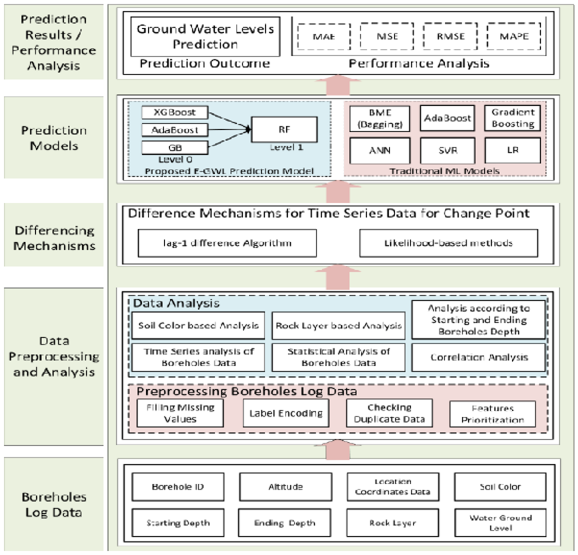
I. PROPOSED SYSTEM

A new method was proposed to improve the forecasting of monthly groundwater level by using genetic algorithm to optimize the structure of multi-layer feed-forward network (FFN) and recurrent neural networks (RNN). Genetic algorithm (GA) is used to search for optimal structure of ANNs for forecasting groundwater level. In other words, a novel, ANNs model based on genetic algorithm was developed to build relationship between time series information nearby wells, climatic parameters data and groundwater level fluctuations in individual well.

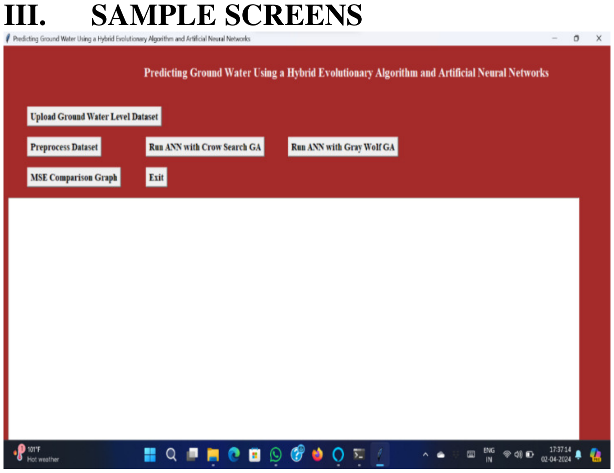
Advantages

- High Accuracy.
- High Efficiency.

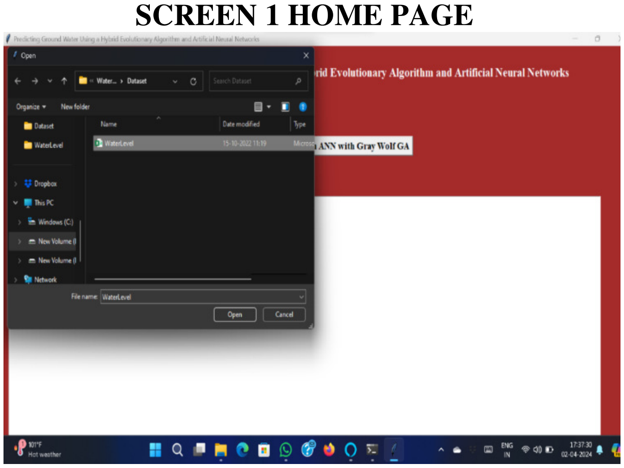
II. SYSTEM ARCHITECTURE



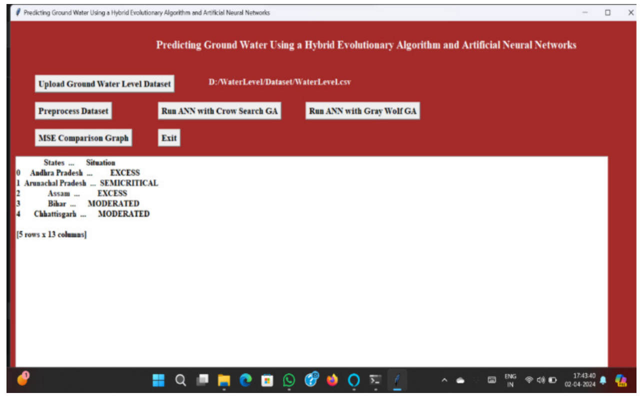
III. SAMPLE SCREENS



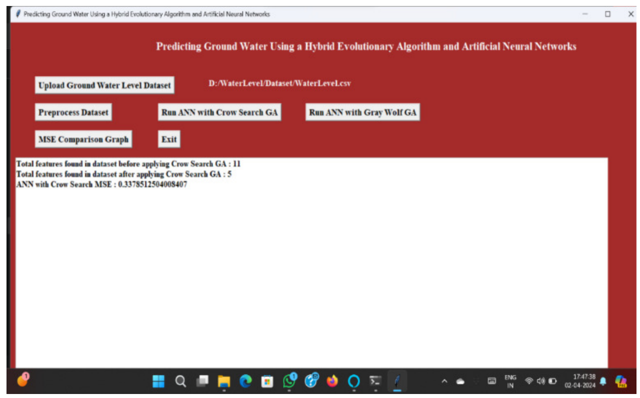
SCREEN 1 HOME PAGE



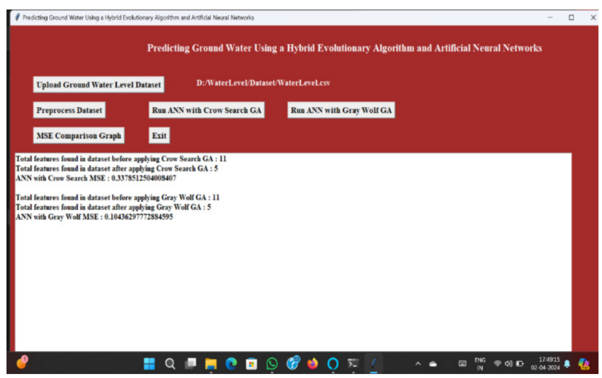
SCREEN 2 UPLOADS DATASET



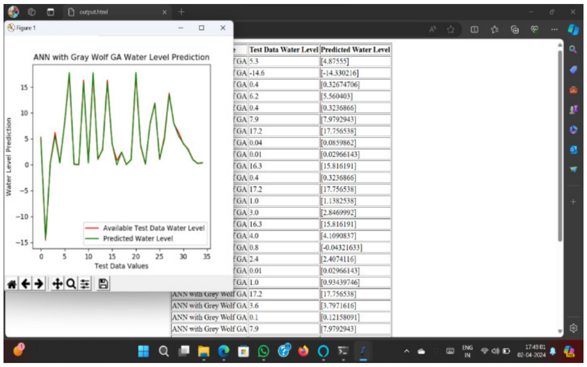
SCREEN 3 PREPROCESS DATASET



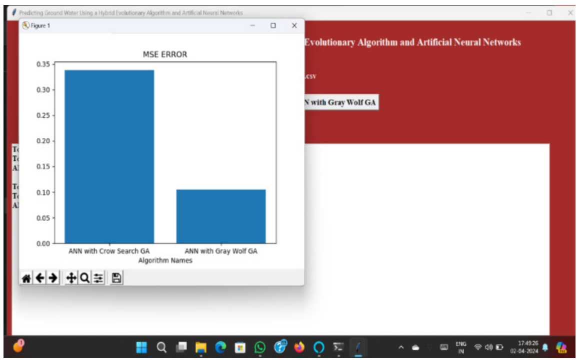
SCREEN 4 TRAIN ANN WITH CROW SEARCH GA



SCREEN 5 TRAIN ANN WITH GRAY WOLF GA



SCREEN 6 PREDICTION OUTPUT ON TESTED DATA



SCREEN 7 COMPARISON GRAPH

CONCLUSION

Finally conclude that neural networks have proven to be an extremely useful method for empirical modeling of hydrological variables. The present study utilized artificial neural networks in corporation with genetic algorithm aiming at forecasting groundwater level. Number of neurons in the hidden layer is derived using the genetic algorithm for four input combinations separately. The study showed that the best input combination for groundwater level forecasting is water level time series data in neighboring wells (input combination Number 3). Two ANN-GA hybrid models (FFN-GA and RNN-GA) were tested and results indicated an excellent agreement between the forecasted and observed data. However, the FFN-GA hybrid model was found to perform better than RNN-GA in forecasting monthly groundwater levels; although the performance of FFN-GA model is categorized as nearly perfect in predicting the middle range of water level, and it experienced little problems in water fluctuation and extreme cases.

ACKNOWLEDGMENT

This work was supported by the China National Basic Research Program (973 Program, No. 2015CB352400), NSFC under grant U1401258, NSCF under grant No. 61572488. This research was also supported in part by grants R-252-000-473-133 and R-252- 000-473-750 from the National University of Singapore. We also thank Yipeng Wu for sourcing the data in this study.

REFERENCES

1. S. Lee, K.-K. Lee, and H. Yoon, ‘‘Using artificial neural network models for groundwater level forecasting and assessment of the relative impacts of influencing factors,’’ Hydrogeology J., vol. 27, no. 2, pp. 567–579, Mar. 2019.

2. M. Sakizadeh, M. M. A. Mohamed, and H. Klammler, ‘‘Trend analysis and spatial prediction of groundwater levels using time series forecasting and a novel spatio-temporal method,’’ Water Resour. Manage., vol. 33, no. 4, pp. 1425–1437, Mar. 2019.

3. X. Wang, T. Liu, X. Zheng, H. Peng, J. Xin, and B. Zhang, ‘‘Short-term prediction of groundwater level using improved random forest regression with a combination of random features,’’ Appl. Water Sci., vol. 8, no. 5, pp. 1–12, Sep. 2018.

4. O. Kombo, S. Kumaran, Y. Sheikh, A. Bovim, and K. Jayavel, ‘‘Long-term groundwater level prediction model based on hybrid KNN-RF technique,’’ Hydrology, vol. 7, no. 3, p. 59, Aug. 2020.

5. M. Zare and M. Koch, ‘‘Groundwater level fluctuations simulation and prediction by ANFIS- and hybrid wavelet-ANFIS/Fuzzy C-means (FCM) clustering models: Application to the miandarband plain,’’ J. Hydroenvironment Res., vol. 18, pp. 63–76, Feb. 2018.

6. A. A. Nadiri, K. Naderi, R. Khatibi, and M. Gharekhani, ‘‘Modelling groundwater level variations by learning from multiple models using fuzzy logic,’’ Hydrological Sci. J., vol. 64, no. 2, pp. 210–226, Jan. 2019.

7. S. Sahoo, T. A. Russo, J. Elliott, and I. Foster, ''Machine learning algorithms for modeling groundwater level changes in agricultural regions of the U.S.'' Water Resour. Res., vol. 53, no. 5, pp. 3878–3895, May 2017.
8. E. Merem, Y. Twumasi, J. Wesley, M. Alsarari, S. Fageir, M. Crisler, C. Romorno, D. Olagbegi, A. Hines, G. S. Ochai, and E. Nwagboso, ''Assessing water resource issues in the US Pacific North West region,'' in Proc. Mississippi Political Sci. Conf. (MPCC), Jackson, MS, USA, Feb. 2018, pp. 1–19.
9. B. Hölting and W. G. Coldewey, ''Groundwater exploitation,'' in Hydrogeology. Berlin, Germany: Springer, 2019, pp. 203–230.
10. Y. Guo, S. Dong, Y. Hao, Z. Liu, T.-C.-J. Yeh, W. Wang, Y. Gao, P. Li, and M. Zhang, ''Risk assessments of water inrush from coal seam floor during deep mining using a data fusion approach based on grey system theory,'' Complexity, vol. 2020, pp. 1–12, Feb. 2020.
11. E. Zaveri, D. S. Grogan, K. Fisher-Vanden, S. Frolking, R. B. Lammers, D. H. Wrenn, A. Prusevich, and R. E. Nicholas, ''Invisible water, visible impact: Groundwater use and Indian agriculture under climate change,'' Environ. Res. Lett., vol. 11, no. 8, Aug. 2016, Art. no. 084005.