Shahid Chamran University of Ahvaz
Irrigation Sciences and Engineering **Vol. 41, No. 2, Summer 2018, p. 167-181**

EXTENDED ABSTRACT

Drought Forecasting Using Artificial Wavelet Neural Network Integrated Model (WA-ANN) and Time Series Model (ARIMA)

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Received: 12 May 2016 Accepted: 22 February 2017

Keywords: ARIMA, Artificial Wavelet Neural Networks, Drought, Forecasting, SPI.

Introduction

Drought prediction in water resources systems plays an important role in reducing drought damage. In recent decades, Traditional methods including: fitting and mathematical models have been widely used to predict droughts. The combination of wavelet theory and neural networks has led to the expansion of the wavelet-neural networks. The application of the wavelet as training function in the neural network has recently been identified as a substitute method in neural networks. In these models, the position and scale coefficients of the wavelets are optimized in addition to the weights (Thuillard, 2000). Considering the importance of short-term drought prediction in water resources engineering and the nonlinear characteristics of the SPI series of three months, the purpose of this study is to present an Artificial Wavelet Neural Networks integrated model for predicting short-term drought at Bidestan station in Qazvin plain.
In this research, Multi-Layer Perceptron (MLP), Radial Base Function (RBF), ARIMA time series, as well as Artificial Wavelet Neural Networks integrated model and Multi-layer Perceptron (WA-MLP) and Radial Bonding Function (WA- RBF) were used, which is done by analyzing the time series investigated by the wavelet transformation and the entry of these sub-series into an artificial neural network.
According to previous researches on drought prediction, short-term drought prediction (with the definition of a three-month standard rainfall index) using the combined model of Wavelet-Neural Network and comparing its results with artificial neural network and ARIMA time series models has not been compared. In this paper, five short-term drought prediction models have been compared and a better performance model has been introduced.

Methodology

In the current study, monthly rainfall data of the Bidestan Rainfall Station in Qazvin and Shoor watershed was used during the statistical period of 1970-1971 to 2013-2014. After ensuring the accuracy of the monthly rainfall data and performing the required statistical tests, the time series of the drought situation was calculated during the statistical period based on the SPI values in the short-term period of 3 months.
Artificial neural networks are able to provide a nonlinear mapping between inputs and outputs by selecting appropriate number of layers and neurons. In time series issues, the number of input neurons depends on the number of observations that are used to find relationships in time series

and to predict future values. Using mathematical equations, it is proved that the three-layer MLP networks are suitable for estimating each non-linear complex function with the desired accuracy.
In this research, the artificial wavelet neural network MLP and RBF have been used. For modeling, SPI time series data were divided into two parts; Part I: The SPI values set from 1970-1971 to 2005-2006 as network education data and Part II: the SPI values were used as network evaluation data from 2005-2006 to 2013-2014.
Wavelet transform is one of the most efficient mathematical transformations in signal processing. It consists of two types of continuous wavelet transform (CWT) and discrete wavelet transform (DWT). A discrete wavelet transform for processing and analysis of time series is more appropriate than it’s continuous type . After analysis of the signal (within a three months perios) by selected mother wavelet, the wavelet cofficents were defined as artificial neural network inputs.
The ARIMA model was used to model the time series of the standard rainfall index within a three-months time series.

Results and Discussion

In order to evaluate and review the performance of the tested models and determine the accuracy of the selected model, four criteria including absolute mean error (MAE), root mean square error (RMSE), coefficient of determination (R^2) and Nash-Sutcliff coefficient (NS) were used according to table (1).

Table 1- Results of testing of MLP, RBF, WA-ANN networks and time series for the SPI optimal learning environmentwithin a three-months period

Model	*Step*	*Index Evaluation*			
		R^2	*RMSE*	*MAE*	*NS*
MLP 5-4-1	*Education*	0.48	0.123	0.11	0.46
	Test	0.488	0.121	0.91	0.46
	Evaluation	0.49	0.12	0.01	0.47
RBF 4-10-1	*Education*	0.467	0.15	0.11	0.45
	Test	4.75	0.13	0.01	0.47
	Evaluation	0.47	0.14	0.01	0.46
ARIMA (1,0,1),(2,0,2)	*Education*	0.49	0.14	0.12	0.47
	Test	0.47	0.14	0.11	0.456
	Evaluation	0.46	0.15	0.12	0.45
WA-MLP 3-10-1	*Education*	0.86	0.06	0.35	0.75
	Test	0.869	0.58	0.03	0.75
	Evaluation	0.87	0.05	0.03	0.76
WA-RBF 2-5-1	*Education*	0.60	0.12	0.05	0.58
	Test	0.61	0.11	0.05	0.59
	Evaluation	0.61	0.11	0.55	0.60

The results showedthat the efficiency of the MLP network is higher than the RBF network for the SPI within a three-months (short-term) time series.
In order to use the wavelet- neural network model, we must first, select the mother wavelet.In this research, mayer wavelet is selected as the mother wavelet. Based on Table 1, the results indicatedthat the wavelet-neural network method is superior to other predictive methods used in this study. The wavelet-neural network model of the WA-MLP has higher accuracy than the WA-RBF model. The highest regration cofficent (R^2=0.87), NS cofficent (0.76), the lowest RMSE and MAE were 0.05 and 0.03, respectively, related to the WA-MLP model.
The results showed that the ARIMA model provided poor results for drought prediction than the other models used in this study.

Conclusions

The comparison of the models' efficiency studied in this research showed that wavelet neural network WA-MLP has better performance compared with the other models in predicting the standard rainfall index (three month intervals). The higher accuracy of the wavelet-neural network model is not only due to the preprocessor and the wavelet cofficents under various signals, but because of the attention to the effect of each sub-parser signal by its relative weight magnification sub signals.

References

Thuillard, M. 2000. A review of wavelet networks, wavelet, fuzzy wavelet and their application. ESIT. *In Presented in Conference, Aachen, Germany*.