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EXTENDED ABSTRACT

Lake Water Level Forecasting using Wavelet-ANFIS and System Dynamic Model

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1. Introduction

Nowadays challenge of water resource is a problem of many countries in the Middle East. This fact about Urmia Lake in Iran has more importance in the recent decade. Urmia Lake water level has involved many changes and fluctuations due to rainfall changes, droughts and dam constructions. The main purpose of this article is an investigation of System Dynamic (SD) methods for forecasting water level fluctuations using Wavelet Adaptive Neuro-Fuzzy Inference System (WANFIS).

2. Methodology

2.1. System Dynamic method (SD)

System dynamics (SD) is an approach to understand the nonlinear behavior of complex systems over time using stocks, flows, internal feedback loops, table functions and time delays. DC method was firstly initiated by Forrester (1961) in order to better understand the strategic issues in complex dynamic systems.

2.2. Adaptive Neuro-Fuzzy Inference Systems (ANFIS)

ANFIS architecture is an adaptive network that uses supervised learning on learning algorithm, which has a function similar to the model of Takagi–Sugeno fuzzy inference system (Suparta and Alhasa, 2013). In ANFIS model, the parameters of the fuzzy functions are well determined by Neural Network (NN).

2.3. Wavelet Transform

The wavelet transform is a mathematical tool that provides a time-frequency representation of a signal in the time domain. In addition, wavelet analysis can often compress or de-noise a signal and thus, it is introduced as an efficient approach for dealing with local discontinuities in a given time series (Mallat, 1998).

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2.4. Wavelet-ANFIS (WANFIS)

In WANFIS model firstly, the original time series are decomposed into subseries by wavelet transform. Then, these sub-time series are imposed as input of ANFIS model to forecast proposed time series.

2.5. Urmia Lake Case Study

Urmia Lake is a salt lake in Northwestern Iran and is reportedly the largest lake in the Middle East (between 45°03′00″ and 37°40′00″ east longitude and north latitude respectively). It covers an area varying from 5200 to 6000 km^2. The lake is about 140km long and 40 to 55km wide with a maximum depth of 16 m.

3. Results and discussion

A simulation model based on SD method is developed for the Urmia Lake basin. Then, for forecasting water level, effective variables upon it such as precipitation, discharge and evaporation were forecasted with the WANFIS model. For instance, the forecasted discharge time series was illustrated in Fig.1. These forecasted variables (time series) were entered into the SD model and the water level can be accounted. DC and RMSE efficiency criteria are calculated for ARIMA and SD-WANFIS to be 0.53, 0.61 and 0.31, 0.84 respectively (Table 1). As it is illustrated in Fig. 2, SD-WANFIS indirect forecasting model has more efficiency than ARIMA model due to the usage of data pre-processing wavelet transform and the application of SD method in forecasting Urmia Lake water level.

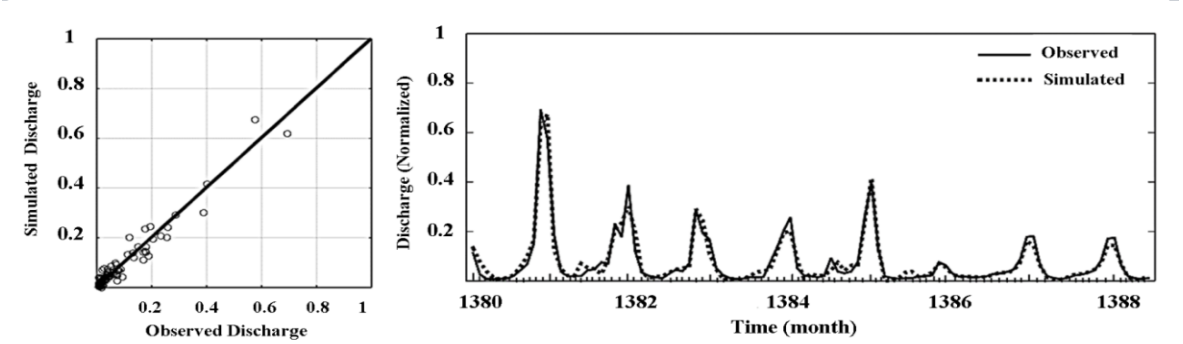

Fig.1. Computed and observed discharge time series of Urmia watershed obtained by WANFIS model

Table 1. The forecasting results measured by efficiency criteria of ARIMA and SD-ANFIS models in verification step

DC	RMSE	Model
0.53	0.61	Direct forecasting using ARIMA (4,1,5)
0.84	0.31	Indirect forecasting using SD-WANFIS

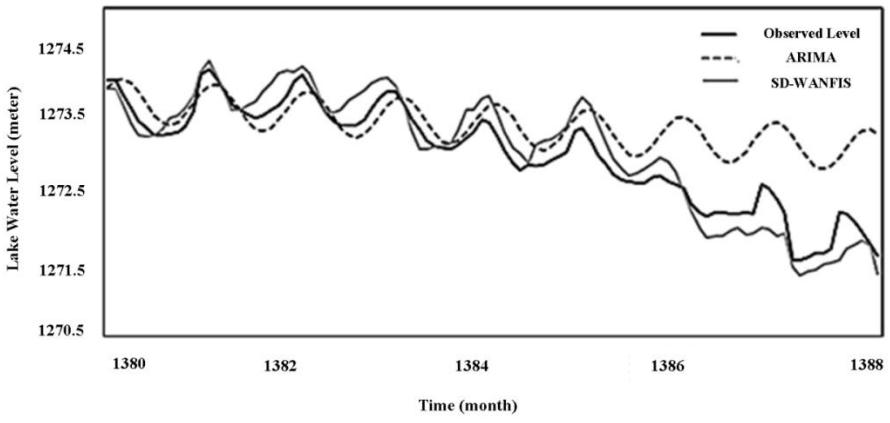

Fig. 2. Evaluation of water level forecasting ARIMA and SD-WANFIS methods

4. Conclusions

The results of this research indicate that the accuracy of new conjunction SD-WANFIS model is satisfactory. The values of statistical indexes such as RMSE and DC for SD WANFIS model were 0.31m and 0.84 in verification step respectively. Whereas, these values for black-box Auto Regressive Integrated Moving Average (ARIMA) model are calculated to be 0.61m and 0.53. As a result, results of this research reveal that coupling of two SD and WANFIS models is useful for forecasting with suitable accuracy.

5. References

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