Using of adaptive neuro-fuzzy inference system for rainfall-runoff modeling

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Abstract

The complexity of natural system makes traditional modeling very difficult. Intelligence modeling such as the adaptive neuro fuzzy inference system (ANFIS), FIS and ANN in modeling of rainfall-runoff process has been increased since the last decade.

In this study, applicability and capability of ANFIS model, for daily and monthly runoff forecasting is investigated. To illustrate the application capability of ANFIS, Ligvanchai River, was chosen as a case study. The performances of the ANFIS models were compared with FIS; ANN; time series and regression methods. The results show that the ANFIS model gives better modeling than the other techniques.

Keyword: rainfall-runoff modeling; ANFIS; FIS; ANN

1. INTRODUCTION

Rainfall-runoff models are essential to simulate peak flows or design for many purposes in water resources project such as spillway design and defensive structures. The performance of rainfall-runoff model requires identifying rainfall-runoff process. Rainfall-runoff process is accepted as one of the most complex and nonlinear real-world phenomena in the field of water engineering (Hsu et al. 1995). Due to the importance of rainfall-runoff modeling, different types of modeling have been suggested and used by many investigators. These can be broadly classified into (i) deterministic model, (ii) stochastic and statistical models and recently (iii) artificial neural network, fuzzy logic and ANFIS techniques (Sorooshian et al. 1993; Tayfur and Singh 2006; Alvisi et al. 2006; Matreata, 2006; Firat, 2007). The selection of an appropriate model depends on hydrological and meteorological of data and basin characteristic. (Yu et al. 2002; Firat, 2007)

For traditional modeling of physical processes are often used from regression analysis techniques (Sen and Altunkaynak, 2003; Mahabir et al. 2003). Regression equations perform best with large number of data, covering a wide range condition are represented. This characteristic make them less than ideal for runoff forecasting, where the data are often very limited and the need for reliable forecasting of low volumes is critical. In addition, regression equations are site specific and must be explicitly developed for each runoff forecast site.

Hydrologic forecasts using statistical models (regression) and stochastic models (ARMA, AR, et. al) is based upon the assumption of linearity but because of the complexities of hydrological processes, the quantity of runoff resulting from a given rainfall event depends upon a number of factors and is dominantly non-linear. (Sen and Altunkaynak, 2003; Mahabir et al. 2003; Firat, 2007)

Unlike mathematical models that require precise knowledge of all contributing variables, fuzzy logic, on the other hand offers a more flexible, less assumption dependent and self-adaptive approach to modeling hydrological processes that their natures are inherently complex, non-linear and dynamic. This method includes runoff forecasting (Mahabir et al. 2003; Firat, 2007), rainfall-runoff modeling (Ozelkan and Duckstein, 2001; Sen and Altunkaynak, 2003), sediment transport (Tayfur et al. 2003), water level forecasting (Alvisi et al. 2006), rainfall-runoff model calibration (Yu and Yang, 2000; Yang et al. 2004), rainfall forecasting (mYu et al. 2000).

With fuzzy Logic, it is possible to describe available knowledge directly in linguistic terms and according rules. Quantitative and qualitative features can be combined directly in a fuzzy model. This leads to a modeling process, which is often simpler, more easily manageable and closer to the human way of thinking, compared with conventional approaches.

In this study, the applicability of fuzzy logic to runoff forecasting is investigated for one basin in the northwest of Iran, Ligvanchai.