Modeling of Water Quality Parameters Using Data-Driven Models

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Abstract: Water has a considerable role in all aspects of human life. Thus, evaluation of water characteristics in general and water quality in particular are necessary to enhance the health of humans and ecosystems. Data-driven models are computing methods that are capable of extracting different system states without using complex relationships. Prediction and simulation are two branches of data-driven modeling that use previous and previous-current data sets to fill gaps in time series. This paper investigates the capability of an adaptive neural fuzzy inference system (ANFIS) and genetic programming (GP) as two data-driven models to predict and simulate water quality parameters (e.g., sodium, potassium, magnesium, sulfates, chloride, pH, electrical conductivity, and total dissolved solids) at the Astane station in Sefidrood River, Iran. The writers considered six combinations of data sets, including the previously noted water quality parameters and river discharge in the previous and previous-current months, as input data. Implementation of the ANFIS and GP models in this paper illustrates the flexibility of GP in time series modeling relative to ANFIS, especially in the testing data set. Accordingly, the writers calculated the coefficient of variation of root mean squared error as the error criterion in different ANFIS and GP models (for assigning achievement probability to an appropriate solution) for each quality parameter. The average of the previously noted values for the six combinations of data sets improved (decreased) 80.51 and 80.89%, respectively, in the training and testing data sets with GP relative to ANFIS. These results indicate that the writers' proposed modeling, based on GP, is an effective tool for determining water quality parameters. **DOI: 10.1061/(ASCE)EE.1943-7870.0000706.** *© 2013 American Society of Civil Engineers.*

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Introduction

Water quality refers to physical, chemical, and biological characteristics of water. Analysts determine water quality by testing for specific chemicals over a period of time. Assessment of long-term water quality changes is a challenging problem. In recent decades, there has been an increasing demand for monitoring river water quality by regular measurements of various water quality variables (Naddafi et al. 2007). However, mathematical modeling of water quality, especially in river management, usually involves several parameters that cannot be measured or involve considerable expense. There has recently been a considerable growth in the development and application of computational intelligence and computer tools with respect to water-related problems (e.g., Haddad et al. 2008a, b, 2009, 2010; Afshar et al. 2010; Haddad and Mariño 2011; Haddad et al. 2011a, b; Ghajarnia et al. 2011; Karimi-Hosseini et al. 2011; Rasoulzadeh-Gharibdousti et al. 2011; Sabbaghpour et al. 2012; Seifollahi-Aghmiuni et al. 2011; Noory et al. 2012; and Fallah-Mehdipour et al. 2013a).

Data-driven models are computer tools that are capable of modeling water quality parameters by using algorithms such as an adaptive neural fuzzy interface system (ANFIS) and genetic programming (GP). Chang and Chang (2006) used ANFIS to build a prediction model for reservoir management. The results demonstrated that the ANFIS can provide high accuracy for reservoir water-level prediction in the short-term. Chen et al. (2006) constructed a flood forecast model using ANFIS. They compared ANFIS results with a back-propagation neural network (BPNN), and concluded that ANFIS can effectively and reliably construct an accurate flood forecast model. Kholghi and Hosseini (2009) used ANFIS and ordinary kriging for estimation of water levels in an aquifer, and reported that ANFIS is more efficient with respect to estimating groundwater levels than ordinary kriging. Tabesh and Dini (2009) forecasted water demand as a parameter that is a function of a large number of interacting variables by ANFIS and artificial neural networks (ANN). The results demonstrated the capability of the ANFIS model to predict Tehran water consumption. Mousavi et al. (2007) compared ordinary least-squares regression (OLSR), fuzzy regression (FR), and ANFIS with respect to inferring operating rules for a reservoir operations optimization problem. The results demonstrated that ANFIS is beneficial in medium-term implicit stochastic optimization, given that it is able to extract important features of the system from the generated

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