Optimal Monthly Reservoir Operation Rules for Hydropower Generation Derived with SVR-NSGAII

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Abstract: A novel tool is proposed that couples the nondominated sorting genetic algorithm (NSGAII) with support vector regression (SVR) and nonlinear programming (NLP) to optimize monthly operation rules for hydropower generation. The SVR-NSGAII is applied to calculate the optimized release for hydropower generation by minimizing (1) the error committed by the SVR in extracting the optimized operation rule, and (2) the number of input variables used as predictors (the parsimony feature) in a regression model. The SVR calculates the optimized reservoir release for hydropower generation based on input variables and parameters values that are found by the NSGAII. An evaluation of results obtained for the Karoon-4 reservoir of Iran indicates that the SVR-NSGAII is well suited to calculate the optimal hydropower reservoir operation rule in real time with approximately 90% accuracy. **DOI: 10.1061/(ASCE)WR.1943-5452.0000553.** *© 2015 American Society of Civil Engineers.*

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Introduction

Hydropower is a clean energy source. Its share of electricity generation is 20% worldwide. Thus the importance of optimization hydropower production by implementing efficient reservoir operation rules is of utmost interest.

Various optimization techniques have been developed and applied in the field of water resources systems such as reservoir operation (Bozorg Haddad et al. 2011a; Fallah-Mehdipour et al. 2011b, 2012a, 2013a), hydrology (Orouji et al. 2013), project management (Bozorg Haddad et al. 2010b; Fallah-Mehdipour et al. 2012b), cultivation rules (Bozorg Haddad et al. 2009; Noory et al. 2012; Fallah-Mehdipour et al. 2013b), pumping scheduling (Bozorg Haddad et al. 2011b), hydraulic structures (Bozorg Haddad et al. 2010a), water distribution networks (Bozorg Haddad et al. 2008a; Fallah-Mehdipour et al. 2011a; Seifollahi-Aghmiuni et al. 2011, 2013), operation of aquifer systems (Bozorg Haddad and Mariño 2011), site selection of infrastructures (Karimi-Hosseini et al. 2011), and algorithmic developments (Shokri et al. 2013). Only a few of these works dealt with the application of hybrid methods such as nondominated sorting genetic algorithm with support vector regression (SVR-NSGAII) for deriving optimal monthly operation rules for hydropower production.

Algorithms used to derive optimal reservoir operation rules fall into three categories, namely, mathematical programming techniques (MPTs) such as linear programming (LP), dynamic programing (DP), and nonlinear programing (NLP); artificial intelligence (AI), which includes artificial neural network (ANN) and support vector machine (SVM); and evolutionary algorithms (EAs) such as genetic algorithm (GA) and particle swarm optimization (PSO). Hybrids of AI and MPT or EA have recently surfaced and are becoming popular in water resource management.

Related to MPT, Simonovic (1992), Wurbs (1993), and Yeh (1985) presented comprehensive overviews on the MPT used for optimal operation of reservoirs. Yoo (2009) applied LP to maximize hydropower generation. Moieni et al. (2011) presented a fuzzy rule-based model derived from stochastic dynamic programming (SDP) model to calculate a steady-state policy for hydropower reservoirs operation. The proposed model was applied to the hydropower operation of the Dez Reservoir in Iran and the results were compared with those obtained with SDP. Marano et al. (2012) applied DP to optimize the management of a hybrid power plant. Results indicated that the integration of compressed energy storage (CAES) technology increased the economic benefit of renewable sources and reduced CO_2 emissions.

More comprehensive reviews and comments on the extraction of reservoir operation rules based on MPT are found in Liu et al. (2014) and Yin et al. (2014).

Related to AI, Saad et al. (1994) illustrated an application of ANN to obtain optimal operation rule in a five-reservoir system. Cancelliere et al. (2002) applied ANN to the derivation of the operating rules of the Pozzillo Reservoir on the Salso River located in Italy. Paulo and Toshiharu (2007) applied stochastic fuzzy neural network (SFNN) coupled with a GA-based model to derive the reservoir operation strategies considering water quantity and quality objectives. Mousavi et al. (2007) compared the capability of ordinary least-squares regression (OLSR), fuzzy regression (FR), and adaptive network-based fuzzy inference system (ANFIS) in deriving reservoir operation rules for the Dez reservoir in Iran. Ji et al. (2014) used SVM to derive optimal operation rule for reservoir operation. The parameters of SVM were calibrated with a grid search and cross-validation technique. More details about hydropower optimization based on based on AI methods are provided by Madani (2011).

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