Developing reservoir operational decision rule by genetic programming

E. Fallah-Mehdipour, O. Bozorg Haddad and M. A. Mariño

ABSTRACT

The reservoir operational decision rule is an equation that can balance reservoir system parameters in each period by considering previous experiences of the system. That equation includes variables such as inflow, volume storage and released water from the reservoir that are commonly related to each other by some constant coefficients in predefined linear and nonlinear patterns. Although optimization tools have been extensively applied to develop an optimal operational decision rule, only optimal constant coefficients have been derived and the operational patterns are assumed to be fixed in that operational rule curve. Genetic programming (GP) is an evolutionary algorithm (EA), based on genetic algorithm (GA), which is capable of calculating an operational rule curve by considering optimal operational undefined patterns. In this paper, GP is used to extract optimal operational decision rules in two case studies by meeting downstream water demands and hydropower energy generation. The extracted rules are compared with common linear and nonlinear decision rules, LDR and NLDR, determined by a software package for interactive general optimization (LINGO) and GA. The GP rule improves the objective functions in the training and testing datasets by 2.48 and 8.53%, respectively, compared to the best rule by LINGO and GA in supplying downstream demand. Similarly, the hydropower energy generation improves by 48.03 and 44.21% in the training and testing datasets, respectively. Results show that the obtained objective function value is enhanced significantly for both the training and testing data using GP. They also indicate that the proposed rule, based on GP, is effective in determining optimal rule curves for reservoirs.

Key words | decision rule, genetic programming, reservoir system

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INTRODUCTION

Reservoirs are important structures that can store and release water based on decisions made by operators of the system. Those decisions directly affect the purpose of the operation, such as supplying downstream demands, generating hydropower energy and controlling floods. Prior experience helps the operator to make an appropriate decision to calculate how much (amount) and when (time) to release water from the reservoir.

In recent decades, different types of rules have been widely used to extract operational policies from long-term operational experiences. LDRs, standard operation policy (SOP), hedging rules (HRs) and NLDRs are common rules that use linear and nonlinear equations to identify operation policies. There are simulation and optimization techniques that can be used to extract operation policies. Software packages that can simulate reservoir conditions are used to extract operation policies. Although less precise than software packages, trial-and-error can be used to determine optimal/near-optimal solutions. While it is possible to calculate optimal/near-optimal solutions by trial-and-error, the probability of success is directly related to the number of times one executes trial-and-error calculations, which can be time-consuming. Thus, use of an optimization method together with a simulation model is recommended to determine optimal reservoir operation policies. Linear programming (LP) and nonlinear programming (NLP) are

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