Application of the Firefly Algorithm to Optimal Operation of Reservoirs with the Purpose of Irrigation Supply and Hydropower Production

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Abstract: Population growth and socioeconomic changes in developing countries over the past few decades have created severe stresses on the available water resources across the world, particularly in arid and semiarid regions, which are predominant in Iran. Hence, the optimal management of water resources is imperative. Reservoir operation is a challenging problem that involves complexities in terms of nonlinear functions, larger numbers of decision variables, and multiple constraints. Evolutionary or metaheuristic algorithms have become an attractive alternative to the classical methods for solving complex reservoir problems. This paper applies a metaheuristic algorithm named the firefly algorithm (FA) to reservoir operation and demonstrates the superiority of this algorithm against the genetic algorithm (GA), a commonly used optimization algorithm, using (1) five mathematical test functions, (2) the operation of a reservoir system with the purpose of irrigation supply, and (3) the operation of a reservoir system with the purpose of hydropower production. The results demonstrate the superior performance of the FA in terms of the convergence rate to global optima and of the variance of the results about global optima when compared with the results of the GA. **DOI: 10.1061/(ASCE)IR.1943-4774.0001064.**

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Introduction

Among the various recent studies dealing with newly developed optimization algorithms in several fields of water resources systems analysis, such as reservoir operation (Ashofteh et al. 2013a; Ahmadi et al. 2014; Bolouri-Yazdeli et al. 2014; Ashofteh et al. 2015a), groundwater resources (Fallah-Mehdipour 2013a; Bozorg-Haddad et al. 2013), conjunctive use operation (Fallah-Mehdipour 2013a), design operation of pumped storage and hydropower systems (Bozorg-Haddad et al. 2014a), flood management (Bozorg-Haddad et al. 2015b), water project management (Orouji et al. 2014), hydrology (Ashofteh et al. 2013b), qualitative management of water resources systems (Orouji et al. 2013; Shokri et al. 2014; Bozorg-Haddad et al. 2015a), water distribution systems (Soltanjalili et al. 2013; Seifollahi-Aghmiuni et al. 2013; Beygi et al. 2014), agricultural crops (Ashofteh et al. 2014), sedimentation (Shokri et al. 2013), and algorithmic developments (Ashofteh et al. 2015b), none has focused on the application of the firefly algorithm (FA) to the optimal operation of reservoir systems with the purposes of irrigation supply and hydropower production.

Optimization methods are classified in two major groups, named classic algorithms and evolutionary or metaheuristic algorithms (EAs). Some of the classic algorithms are linear programming (LP), nonlinear programming (NLP), and dynamic programming (DP), which have been widely applied to water resources optimization problems. However, various limitations of the classic optimization methods encouraged researchers to use EAs, which do not have the typical shortcomings of classic algorithms. Some of the EAs include the genetic algorithm (GA) (Holland 1975), the simulated annealing algorithm (SA) (Kirkpatrick et al. 1983), ant colony optimization algorithm (ACO) (Dorigo 1992), the differential evolution algorithm (DE) (Storn and Price 1995), particle swarm optimization algorithm (PSO) (Kennedy and Eberhart 1995), the honeybee mating optimization algorithm (HBMO) (Bozorg-Haddad et al. 2006), the intelligent water drops algorithm (IWD) (Shah-Hosseini 2007), the imperialist competitive algorithm (ICA) (Atashpaz-Gargari and Lucas 2007), the cuckoo search algorithm (CS) (Yang and Deb 2009), and the water cycle algorithm (WCA) (Eskandar et al. 2012). The application of some of the aforementioned algorithms to reservoir operation is summarized next.

Tospornsampan et al. (2005) proposed SA for the operation of a 10-reservoir system by maximizing the total efficiency of producing hydropower energy during 12 periods of operation. Results showed the better performance of SA over GA. Jothiprakash and Shanthi (2006) used GA to develop optimal operation rules of a reservoir system in India. The objective function of this study was to minimize the sum of the annual squared differences between

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