Optimal Parameter Estimation of linear Muskingum Model based on the Modified Honey Bee Mating Optimization algorithm

Majid Niazkar[1], Seied Hosein Afzali[2]
1- MSc. student of Civil Engineering,
2- Assistant Professor of Civil Engineering,
Dept. of Civil Eng., School of Engineering, Shiraz University
afzali@shirazu.ac.ir

Abstract

The linear Muskingum model is not only a simple conceptual but also effective method for flood routing. Since the Muskingum model parameters cannot be determined physically, the calibration of these parameters is the only challenge of this method. Although various techniques have been proposed to estimate the related parameters, an accurate method with faster convergence rate is still required to improve the computational precision for parameter estimation. In this study, the Modified Honey Bee Mating Optimization (MHBMO) is proposed for the estimation of the mentioned parameters. The utilized algorithm is applied for a case study from previous literature and the results are compared with the other proposed methods. The results indicate that not only the MHBMO algorithm converges so quickly but also it captures the best optimal parameters values.

Keywords: Linear Muskingum Model, Optimization, MHBMO, Flood Routing.

1. INTRODUCTION

Flow routing may be considered as an analysis to trace flow through a hydrological system [1]. It is indeed a common task for water resources engineers to route floods through the river channels. Two general approaches for flood routing are introduced called lumped routing method and the distributed routing method. The former is based on the storage concept while the latter is based on the principles of mass and momentum conservation. It is quite obvious that the amounts of time, effort and also data which are required for calibrating and solving the model increase with the degree of the complexity of that model. The Muskingum method, which is based upon the assumption that the storage volume in a stream reach is either a linear or nonlinear function of weighted inflow and outflow at an instant in time, is a commonly used hydrological routing method [2]. Linear Muskingum model utilizes the continuity and linear storage equations:

$$\frac{dS_t}{dt} = I_t - Q_t \tag{1}$$

$$S_t = K[xI_t + (1-x)Q_t] \tag{2}$$

Where S_t, I_t and Q_t are the total storage, the inflow magnitude and the outflow magnitude at time t, respectively, K is a storage-time constant which sometimes may be as an approximation of travel time through the reach and x is a weighting factor ranges between 0 for reservoir-type storage to 0.5 for a full wedge. In natural streams, the value of x is between 0 and 0.3, with a mean value near 0.2 [3]. In hydrological routing approach, the values of K and x are estimated from analysis of historical inflow and outflow records and also considered to be constant throughout the range of flow which is used for synthesizing flood hydrographs for the same stream reach. The trial and graphical procedures have been used for linear Muskingum parameter estimation for decades [4-8]. These methods are not only time-consuming but also they often do not achieve desirable accuracy. Additionally, visual judgments are inevitably involved in graphical schemes in which it can be the reason of the error in the results. On the other hand, some analytical procedures were recommended for linear Muskingum parameter estimation [6, 9].

By developing optimization algorithms starting from 1980s, different algorithms were proposed to estimate the parameters of the linear Muskingum model. Genetic Algorithm (GA), Binary-encoded Genetic Algorithm (BGA), Gray Genetic Algorithm (GGA), Gray-encoded Accelerating Genetic Algorithm (GAGA), Simulated Annealing (SA), Ant Colony Algorithm (ACA), Particle Swarm Optimization (PSO), Imperialist Competitive Algorithm (ICA) have already applied to estimate the parameters in linear Muskingum model [10-16]. Although the meta-heuristic optimization algorithms in comparison with the previous methods are