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Flood routing in branched river by genetic programming

1 Hossein Orouji MSc
Student, Department of Irrigation & Reclamation Engineering, Faculty of Agricultural Engineering & Technology, College of Agriculture & Natural Resources, University of Tehran, Karaj, Tehran, Iran

2 Omid Bozorg Haddad PhD
Assistant Professor, Department of Irrigation & Reclamation Engineering, Faculty of Agricultural Engineering & Technology, College of Agriculture & Natural Resources, University of Tehran, Karaj, Tehran, Iran

3 Elahe Fallah-Mehdipour PhD
Candidate and Research Assistant, Department of Irrigation & Reclamation Engineering, Faculty of Agricultural Engineering & Technology, College of Agriculture & Natural Resources, University of Tehran, Karaj, Tehran, Iran

4 Miguel A. Mariño PhD
Distinguished Professor Emeritus, Department of Land, Air & Water Resources, Department of Civil & Environmental Engineering, and Department of Biological & Agricultural Engineering, University of California, Davis, CA, USA


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Flood routing in branched rivers is an important issue in river engineering. Hydraulic approaches to address the issue involve complex equations that are applied in flood routing with high accuracy but using a lot of data, especially river specifications. In contrast, hydrologic flood routing approaches are simple and employ limited parameters coupled with linear and nonlinear equations based on the continuity equation to route the flood. In the present study, to achieve a routed flood hydrograph considering both accuracy and simplification in the routing process, two hydrologic methods, based on (1) an extended version of the Muskingum method and (2) genetic programming (GP), were applied in a branched river in Iran for 10 and 100 year flood return periods and the results compared with those of the St. Venant equations as a numerical hydraulic method. The results show that GP decreased (improved) the sum of the squared deviation (*SSQ*) between hydraulic and hydrologic routed outflows by 90·71 and 49·24% compared to the extended Muskingum method for 10 and 100 year flood return periods, respectively, although GP used less input data than the St. Venant equations. There was no considerable difference between GP and St. Venant routed hydrographs. In addition, the GP approach is simple but its application is not restricted to single-reach problems. The present results indicate that the proposed hydrologic method, based on GP, is effective in routing flood hydrographs in branched rivers.

1. Introduction

Flood as a natural phenomenon is an overflow of excess water that submerges land. This phenomenon can also occur in rivers, when flow exceeds the capacity of the river. A river typically contains a single stream of water, but some rivers contain several interconnecting streams of water from different rivers, forming branched rivers. Branched rivers are found in most basins worldwide, such as in southwestern Iran. To prevent considerable flood damage in urban, industrial, and agricultural areas which are near branched rivers, it is necessary to identify flood characteristics such as a hydrograph.

Generally, two hydraulic and hydrologic approaches are used for flood routing through river channels. The hydraulic approach is based on both continuity and momentum equations and uses numerical techniques such as finite differences and finite elements for flood routing. This approach has adequate accuracy but requires a lot of data related to the river geometry and specifications which makes the calculations very expensive (Samani and Shamsipour, 2004). In contrast, hydrologic approaches consist of simple processes such as the continuity equation to calculate an appropriate solution. The Muskingum model is a known hydrologic flood routing approach that has been used by several investigators (Chu and Chang, 2009; Geem, 2006, 2011; Kim *et al.*, 2001; Mohan, 1997; Orouji *et al.*, 2011) in a single input–single output (SI–SO) system. In other words, only one river channel with a single input in the upstream and a single output in the downstream of the river has been considered in all the aforementioned studies. However, a branched river with a multi input–single output (MI–SO) is an important system, because its outflow flood may cause more damage in different regions. Khan (1993) developed a new version of the Muskingum model for a