Overland flow simulation using artificial neural networks (ANNs)

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Introduction

The overland flow can be describe as a thin sheet of flow found before irregularities cause a gathering of the runoff into discrete stream channels. The overland flow is generated as a result of rainfall in excess of the saturated hydraulic conductivity of the soil or by saturation of the soil surfaces. The overland flow process plays a vital role in the hydrological cycle also is one of the most complex hydrological phenomena to comprehend, due to its tremendous temporal and spatial variability of the basin characteristics and rainfall patters (Kumar et al. 2005). A number of models i.e. artificial neural networks, physically based, black box and conceptual models have been used to simulate the complex hydrological processes such as Overland flow (Poff et al. 1996; Abrahart et al. 1999; Dawson et al. 2001, Rajurkar *et al*., 2002; Riad et al. 2004, de Voa et al. 2005; Jain & Srinivasulu, 2006; Wu et al. 2010; Chen et al., 2013, Chakravarti et al 2012, 2014 & 2015) shown to be one of the most promising tools in hydrology (ASCE Task Committee, 2000 and Kalteh et al. 2008;). However, due to its complexity and spatio-temporal variation, a few models can accurately simulate this highly non-linear process to forecast future river discharge, which are required for safe and economical aspects of hydrologic and hydraulic engineering design and water management purposes.

The main objective of the present study is to conduct laboratory experiment for the generation of overland flow data using rainfall simulator. For the validation this observed data, a model is establish for estimating observed runoff data using ANN technique. The networks were trained and tested using data that represent different characteristics of the watershed and rainfall patterns. The sensitivity of the network performance to the content and length of the calibration data was examined using various training data sets. Finally, suggestions are made concerning necessary refinements to the existing ANN prior to transfer to operational use.

Materials and Methods

1. Rainfall simulator

The experimental study was performed using rainfall simulator for overland flow i.e. rainfall runoff process. The rainfall simulator enables to demonstrate some of the major physical processes found in hydrology, including rainfall-runoff i.e. overland flow for catchment areas of varying permeability; the abstraction of ground water by wells, with surface recharge and without surface recharge from rainfall; the formation of river features.

2. Simulated Rainfall Patterns

The simulated rainfall pattern is used having two different rainfall intensity patterns (60 mm/hr to 90 mm/hr). For each value of rainfall intensity two different overland plane slopes of 2% and 4% were used. From the experimental data it is seen that for a given rainfall intensity the time to peak reduces with increase in the slope of overland plane.

3. Modeling Approach Using ANNs

The ANN model for overland flow analysis was developed using MATLAB. We collected 586 data point for overland flow at experimental model of catchment for 6 events at various slope and various rainfall intensity. These recorded data was used for model development by considering various input variables (slope, rainfall intensity and rainfall duration) and output overland flow discharge, the data base used for ANN model generation. For developing ANN model, the available data were separated as 70% for training, 15% for testing and 15% for validation.

Results and Concluding Remarks

The experiments were conducted to investigate overland flow simulation. The validation of collected dataset were analyzed and found that the artificial neural network shows better capability to estimate overland flow simulation. In the present study, the results obtained show clearly that the ANN are capable to simulate overland flow in which the rainfall and overland flow are very irregular, thus, confirming the general enhancement archived by ANN in other fields of hydrology as shown in figure 1 and 2.

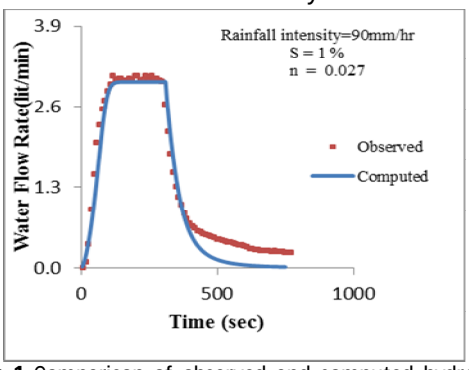

Figure 1 Comparison of observed and computed hydrograph for rainfall intensity 90mm/hr at 1% slope of the plane

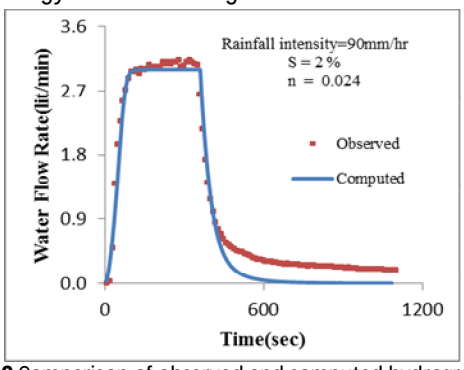

Figure 2 Comparison of observed and computed hydrograph for rainfall intensity 90mm/hr at 2% slope of the plane

The results and comparative study indicate that the ANN is best suitable technique to predict river runoff of a catchment than other classical regression model.

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