Evaluation of MLP-ANN Training Algorithms for Modeling Soil Pore-Water Pressure Responses to Rainfall

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Abstract: Knowledge of pore-water pressure responses to rainfall is vital in slope failure and slope hydrological studies. The performance of four artificial neural network (ANN) training algorithms was evaluated to identify the training algorithm appropriate for modeling the dynamics of soil pore-water pressure responses to rainfall patterns using multilayer perceptron (MLP) ANN. The ANN model comprised eight neurons in the input layer, four neurons in the hidden layer, and a single neuron in the output layer representing an 8-4-1 ANN architecture. The training algorithms evaluated include the gradient descent, gradient descent with momentum, scaled conjugate gradient, and Levenberg-Marquardt (LM). The performance of the training algorithms was evaluated using standard performance evaluation measures—root mean square error, coefficient of efficiency, and the time and number of epochs required to reach a predefined accuracy. It was found that all the training algorithms could be used in the prediction of pore-water pressures. However, the LM algorithm required the least time and epochs for training the network and gave the minimum error during both training and testing. The LM training algorithm is therefore proposed as an ideal and fast training algorithm for modeling the dynamics of soil pore-water pressure changes in response to rainfall patterns. **DOI: 10.1061/(ASCE)HE.1943-5584.0000599.** *© 2013 American Society of Civil Engineers.*

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Introduction

Knowledge of soil pore-water pressure responses to rainfall variation is important in the design and planning of projects related to slope failures, seepage analysis, slope stability analysis, engineered slope design, and studies related to slope hydrology (Rahardjo et al. 2007, 2008, 2009). Pore-water pressure responses to rainfall variations exhibit highly nonlinear and complex behavior (Rezaur et al. 2003). In tropical regions, highly negative pore-water pressure during dry weather provides additional shear strength for stability of unsaturated soil slopes. In the rainy season, pore-water pressures may become less negative or even positive due to heavy rainfall. Positive pore-water pressure causes a decrease in the soil shear strength and may lead to slope failure (Rahardjo et al. 2008).

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Information on pore-water pressure responses to rainfall variation is usually collected by field instrumentation programs (Rahardjo et al. 2007, 2008), which are costly, resource intensive, and time consuming. Modeling of pore-water pressure responses to climatic changes or prediction of pore-water pressures using artificial neural network (ANN) therefore seems to be an attractive alternative approach. ANN has the ability to self-adapt, can capture functional relationships, and extract patterns between input and output variables by learning from examples, even if the primary relationship is complex and difficult to describe by a physically based relationship. Thus application of ANN seems appropriate for pore-water pressure prediction problems whose solutions necessitate information that is difficult to describe and lack sufficient data or observation.

Application of ANN to different aspects of hydrologic modeling (Cigizoglu 2005; Ju et al. 2009) has enjoyed popularity in recent years. ANN has been applied with success in predicting water quality (May and Sivakumar 2009), modeling and simulation, e.g., rainfall-runoff process (Ju et al. 2009), and forecasting, e.g., combined sewer overflow (Fernando et al. 2005) and river flow (Fernando and Shamseldin 2009).

Other studies (Zhang and Govindaraju 2000; Jain and Indurthy 2003; Jain and Srinivasulu 2004) also indicate that ANNs are comparable to linear regression models. In most ANN modeling studies, regular back propagation (BP) training algorithms were used. However, it has always been a difficult task to select an appropriate ANN training algorithm for the modeling problem under consideration. Studies attempting to assess the suitability of different training algorithms for a particular ANN modeling problem are relatively few. Few studies have attempted to evaluate the performance of different training algorithms such as for rainfall-runoff prediction (Karim and Zahra 2008; Srinivasulu and Jain 2006). Chiang et al. (2004) compared the performances of conjugate gradient (CG) and standard BP training algorithms while modeling rainfall-runoff processes using ANNs. They used root mean squared

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