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New Artificial Neural Network Based Pedotransfer Functions to Predict Soil Hydraulic Properties

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Pedotransfer functions (PTF) provide avenues for estimating soil hydraulic properties (SHP) using easily and economically available soil texture and other related data. A number of statistical approaches are available for SHP estimation based on PTF. Due to their ability of mapping non-linear input-output relationship and non-requirement of specification of apriori model structure, the use of artificial neural networks (ANNs) for PTF estimation has been growing rapidly in literature. Conventionally, ANN-PTF estimation is based on training process that minimizes sum of squared error (mean squared error, MSE), which is found effective when the database is statistically homogenous in both training and test phases. However, in situation where the statistical properties of database for training and test (application) phases are different, the ANN-PTF developed based on training data does not work well for test phase. This study addresses this problem by modifying ANN training algorithm by introducing new objective functions (OF) and its derivatives for situations where prior information in means, and variances of SHPs for test phases are available. This modification is accomplished by introducing penalty terms in the conventional MSE OF. Algorithms for three different OFs are developed hierarchically introducing penalty terms for any deviation from mean, variance and output correlation in the test dataset.

Two different categories of numerical experiments were carried out by selecting data for training and testing from two different databases. In the first category of experiments, datasets for training and test phases were selected from different quantiles of the database. In the second type of experiment, data for training and test phases were randomly picked from the original database. Since the statistical properties of training and test data were different in first category of experiment, the results of conventional ANN-PTF resulted into large bias in the results of test phase SHP. On the contrary, new ANN-PTFs could significantly reduce the bias (mean-error). The improvement in variance and output correlation (based on new proposed index) of the new ANN-PTFs were, however, modest when compared to the conventional ANN. In the second group of experiment where data for training and test were randomly picked, the differences in the statistical properties of outputs in the training and test phases were low. Hence, both conventional and newly developed ANN-PTFs resulted in low biases. The utility of new ANN-PTFs were thus found significant for reducing mean error where the training and test datasets are of different statistical properties.