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Confidence intervals in Flow Forecasting by using artificial neural networks

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One of the major inadequacies in implementation of Artificial Neural Networks (ANNs) for flow forecasting is the development of confidence intervals, because the relevant estimation cannot be implemented directly, contrasted to the classical forecasting methods. The variation in the ANN output is a measure of uncertainty in the model predictions based on the training data set. Different methods for uncertainty analysis, such as bootstrap, Bayesian, Monte Carlo, have already proposed for hydrologic and geophysical models, while methods for confidence intervals, such as error output, re-sampling, multi-linear regression adapted to ANN have been used for power load forecasting [1-2]. The aim of this paper is to present the re-sampling method for ANN prediction models and to develop this for flow forecasting of the next day. The re-sampling method is based on the ascending sorting of the errors between real and predicted values for all input vectors. The cumulative sample distribution function of the prediction errors is calculated and the confidence intervals are estimated by keeping the intermediate value, rejecting the extreme values according to the desired confidence levels, and holding the intervals symmetrical in probability. For application of the confidence intervals issue, input vectors are used from the Mesochora catchment in western-central Greece. The ANN's training algorithm is the stochastic training back-propagation process with decreasing functions of learning rate and momentum term, for which an optimization process is conducted regarding the crucial parameters values, such as the number of neurons, the kind of activation functions, the initial values and time parameters of learning rate and momentum term etc. Input variables are historical data of previous days, such as flows, nonlinearly weather related temperatures and nonlinearly weather related rainfalls based on correlation analysis between the under prediction flow and each implicit input variable of different ANN structures [3]. The performance of each ANN structure is evaluated by the voting analysis based on eleven criteria, which are the root mean square error (RMSE), the correlation index (R), the mean absolute percentage error (MAPE), the mean percentage error (MPE), the mean percentage error (ME), the percentage volume in errors (VE), the percentage error in peak (MF), the normalized mean bias error (NMBE), the normalized root mean bias error (NRMSE), the Nash-Sutcliffe model efficiency coefficient (E) and the modified Nash-Sutcliffe model efficiency coefficient (E1). The next day flow for the test set is calculated using the best ANN structure's model. Consequently, the confidence intervals of various confidence levels for training, evaluation and test sets are compared in order to explore the generalisation dynamics of confidence intervals from training and evaluation sets.

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