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Application of artificial neural network to estimate bedload transport rates and bedload granulometry using outputs of stationary ADCP measurements

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Measuring and assessing the bedload data is a crucial for successful and efficient river management. Hence, the information about the bedload transport and characteristics helps to describe the dynamics of the river morphology and to evaluate the impacts on boat navigation, hydropower production, ecological systems and aquatic habitat.

Although the acoustic Doppler current profilers are designed to measure water velocities and discharges, they have been successfully used to measure some bedload characteristics, such as the apparent bedload velocity. The correlation between the apparent bedload velocity and the bedload transport rates measured by physical bedload samplers (e.g. pressure difference) has been examined and relatively high correlations have been reported. Moreover, laboratory experiments have proven that there is a strong correlation between the bedload concentration and particle size distribution and corrected backscattering strength obtained from the ADCPs.

The bedload transport rates yielded from the ADCPs outputs are usually derived as regression model-fitting of the measured apparent velocity and the physically collected bedload samples at the same time and position. Alternatively, a semi-empirical kinematical approach is used, where the apparent bedload velocity is the main component and the bedload concentration is empirically estimated. However, the heterogeneous and sporadic motion of the bedload particles is often followed by high uncertainty and weak performance of these approaches.

Machine learning offers a relatively simple and robust method that has the potential to describe the nonlinearity of the complex bedload motion and so far, it has not been previously exploited for predicting transport rates. This study implements artificial neural network techniques to develop a model for predicting bedload transport rates by using only ADCP data outputs as training data. Data processing techniques are used to extract relevant features from the corrected backscattering strength and apparent velocity obtained from the ADCPs. More than 60 features were derived in the ADCPs dataset, and the most relevant features are selected through neighborhood component analysis. These features are used as inputs in conventional supervised

neural network architecture which consists of two hidden layers and 35 neurons. This model is used to capture the distribution of the ADCP features for each output (e.g., physically measured transport rates and grain size from bedload samples) in the training sample. The back-propagation algorithm (BPA) is still one of the most widely used learning algorithms in the training process and thus herein applied. The learning rate, number of neurons and hidden layers were optimized by using Bayesian optimization techniques. The network was trained with more than 60 bedload samples and corresponding 5 - 10 min time series of ADCP preprocessed data. The rest of the samples were used for validation of the model. The validation resulted in correlation coefficients higher than 0.9 and the, which is significantly higher value than the corresponding values for the methodologies developed before. Aiming to develop a more robust and stable ANN model, further testing of different training algorithms must be performed, different ANN architecture should be tested, and more data shall be included.