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Comparison of Machine Learning methods for incipient motion in gravel bed rivers

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Soil erosion and sediment transport of natural gravel bed streams are important processes which affect both the morphology as well as the ecology of earth's surface. For gravel bed rivers at near incipient flow conditions, particle entrainment dynamics are highly intermittent. This contribution reviews the use of modern Machine Learning (ML) methods implemented for short term prediction of entrainment instances of individual grains exposed in fully developed near boundary turbulent flows. Results obtained by network architectures of variable complexity based on two different ML methods namely the Artificial Neural Network (ANN) and the Adaptive Neuro-Fuzzy Inference System (ANFIS) are compared in terms of different error and performance indices, computational efficiency and complexity as well as predictive accuracy and forecast ability. Different model architectures are trained and tested with experimental time series obtained from mobile particle flume experiments. The experimental setup consists of a Laser Doppler Velocimeter (LDV) and a laser optics system, which acquire data for the instantaneous flow and particle response respectively, synchronously. The first is used to record the flow velocity components directly upstream of the test particle, while the later tracks the particle's displacements. The lengthy experimental data sets (millions of data points) are split into the training and validation subsets used to perform the corresponding learning and testing of the models. It is demonstrated that the ANFIS hybrid model, which is based on neural learning and fuzzy inference principles, better predicts the critical flow conditions above which sediment transport is initiated. In addition, it is illustrated that empirical knowledge can be extracted, validating the theoretical assumption that particle ejections occur due to energetic turbulent flow events. Such a tool may find application in management and regulation of stream flows downstream of dams for stream restoration, implementation of sustainable practices in river and estuarine ecosystems and design of stable river bed and banks.