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A novel bridge scour monitoring and prediction system

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Earth's surface is continuously shaped due to the action of geophysical flows. Erosion due to the flow of water in river systems has been identified as a key problem in preserving ecological health but also a threat to our built environment and critical infrastructure, worldwide. As an example, it has been estimated that a major reason for bridge failure is due to scour. Even though the flow past bridge piers has been investigated both experimentally and numerically, and the mechanisms of scouring are relatively understood, there still lacks a tool that can offer fast and reliable predictions. Most of the existing formulas for prediction of bridge pier scour depth are empirical in nature, based on a limited range of data or for piers of specific shape.

In this work, the use of a novel methodology is proposed for the prediction of bridge scour. Specifically, the use of an Adaptive Neuro-Fuzzy Inference System (ANFIS) is proposed to estimate the scour depth around bridge piers. In particular, various complexity architectures are sequentially built, in order to identify the optimal for scour depth predictions, using appropriate training and validation subsets obtained from the USGS database (and pre-processed to remove incomplete records). The model has five variables, namely the effective pier width (b), the approach velocity (v), the approach depth (y), the mean grain diameter (D50) and the skew to flow. Simulations are conducted with data groups (bed material type, pier type and shape) and different number of input variables, to produce reduced complexity and easily interpretable models. Analysis and comparison of the results indicate that the developed ANFIS model has high accuracy and outstanding generalization ability for prediction of scour parameters. The effective pier width (as opposed to skew to flow) is amongst the most relevant input parameters for the estimation.

Training of the system to new bridge geometries and flow conditions can be achieved by obtaining real time data, via novel electromagnetic sensors monitoring scour depth. Once the model is trained with data representative of the new system, bridge scour prediction can be performed for high/design flows or floods.