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Artificial intelligence approaches for infrastructure scour prediction

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Scour process is one of the most complex and challenging water flow and erosion phenomena, the leading cause of bridge failures and one of the main climate change impacts to highway and railway infrastructure. This study proposes a novel system for the assessment of scour and sedimentation processes at foundation structures. The use of an Adaptive Neuro-Fuzzy Inference System (ANFIS) is employed to estimate the scour depth around bridge piers (see also Valyrakis et al. 2011, Valyrakis et al. 2015). 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, the approach velocity, the approach depth, the mean grain diameter and the skew to flow. Simulations are conducted with various 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 generalisation 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. A new monitoring system is then presented which consists of electromagnetic sensors that are designed to detect changes in the dielectric permittivity of the surrounding foundation. The sensing technique is evaluated to detect scour and sediment deposition in various soil types and under temperature and water salinity conditions that would commonly occur in a practical installation environment. The experimental approach was validated using ‘static’ scour simulations and real-time open channel flume experiments. The obtained results indicate that ANFIS can deliver an effective tool for pier scour depth estimation, performing well against traditional equations and covering a wider range of data. The combination of a data based predictive model, trained further with real-time information obtained from the sensing system presented in this study can offer highly versatile hybrid models, able to overcome limitations of training with limited data and adapt to the range of conditions experienced in the field.

References

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