Application of TreeNet in Predicting Suspended Sediment Load: A Comparative Study

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Abstract

In order to control the sedimentation destructive consequents and to evaluate the erosion in the basin, it is of great importance to estimate the river sediment transport rates precisely. When there are several mathematical and experimental models with unacceptable accuracy or when there is deficiency in records of input variables to the classical equations, machine learning techniques are perfect completes. Multiple Additive Regression Trees or TreeNet is one of machine learning techniques, which has been applied limitedly in water engineering environment so far, as reports say; therefore, its efficiency in comparison with other common models in this field is not evident. In this context, this model was compared with ANN and ANFIS models and proved competitive results in two different conditions regarding the target variable coefficient of variation, without giving negative predictions like the other two models did. Also the other advantages which distinguish the TreeNet model from the other two are its running speed and not being parametric. In present research, the two Kareh Sang and Sira stations (located on Haraz and Karaj Rivers respectively) data have been utilized. In Kareh Sang station, a parameter named "day of the year" which simulates the periodic property of sediment transport was introduced to models as a predictor variable. Applying this parameter leaded to the considerable increase in models accuracy, particularly in that of TreeNet model, which indicates that there are different relations between sediment discharge and flow discharge in different time periods of the year.

Keywords: TreeNet, Suspended sediment, Day of the year, ANN, ANFIS.

1. INTRODUCTION

In water engineering, it is very important to estimate the sediment transport rates in alluvial rivers because of the vast damages the sediments incur on water structures, agriculture and nature. Among the problems caused by sediment transport, the damages incurred on turbines, pumps, bridge piers and channel coverings can be pointed out. Furthermore, after sedimentation, the sedimentary materials can bring about other problems, like making isles on river path which leads to the reduction of floodway's capacity, sedimentation in the floodway which results in damaging farms and buildings, and also sedimentation at river bed and reduction of river depth. On the other hand, the deposited sediments and their distribution in reservoirs are the most important factors in reduction of dams and their installations life.

Due to the large number of effective factors influencing the sediment transport process, it has a special complexity in a way that studies done by river morphologists and engineers during centuries just resulted in several equations with no acceptable prediction accuracy and in some cases meaningful differences between their calculation results. In addition, mostly due to economical constraints, records of input parameters to these equations are not available that makes it impossible to use them in practical applications.

To achieve a near to fact estimation of the sediments carried by rivers, the data of flow discharge and sediment discharge in gauging stations are measured at the same time and are analyzed by the statistical methods. Then by fitting a power function to these data, a relation is formed between sediment discharge and flow discharge based on which the sediment yield is calculated. These methods cannot distinguish special features of the collected data and hence do not provide precise estimation of sediment transport rates.

By increasing the power of computer processors in recent years, machine learning techniques have been developed significantly. Machine learning is a training process of those models which are able to acquire the knowledge existing in data and can model the complex and non-linear processes like sediment transport. Among these techniques, artificial neural networks and adaptive neuro-fuzzy inference system can be mentioned that have been applied in many researches on sediment load estimation. Cigizoglu [1] investigated the performance of multi-layer perceptron (MLP) neural networks in daily suspended sediment estimation using sediment and daily mean flows belonging either to downstream or upstream stations. The results