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Interpretation of concrete dam behaviour with artificial neural network and multiple linear regression models

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ABSTRACT

The safety control of large dams is based on the measurement of some important quantities that characterize their behaviour (like absolute and relative displacements, strains and stresses in the concrete, discharges through the foundation, etc.) and on visual inspections of the structures. In the more important dams, the analysis of the measured data and their comparison with results of mathematical or physical models is determinant in the structural safety assessment.

In its lifetime, a dam can be exposed to significant water level variations and seasonal environmental temperature changes. The use of statistical models, such as multiple linear regression (MLR) models, in the analysis of a structural dam's behaviour has been well known in dam engineering since the 1950s. Nowadays, artificial neural network (NN) models can also contribute in characterizing the normal structural behaviour for the actions to which the structure is subject using the past history of the structural behaviour. In this work, one important aspect of NN models is discussed: the parallel processing of the information.

This study shows a comparison between MLR and NN models for the characterization of dam behaviour under environment loads. As an example, the horizontal displacement recorded by a pendulum is studied in a large Portuguese arch dam. The results of this study show that NN models can be a powerful tool to be included in assessments of existing concrete dam behaviour.

1. Introduction

The main objective of the safety control of a concrete dam is to guarantee the functions for which it was built by maintaining its functionality and its structural integrity. The safety control is supported by monitoring activities and is based on models.

The ultimate purpose of the models is to predict the behaviour of a concrete dam and to identify whether the behaviour of the structure is still similar to past behaviour under the same loads or if there is any difference. If indeed the evolution is divergent between the model prediction and actual behaviour, then the assumptions of the models have changed and the reason for the change should be identified to assess the consequences.

Models based on mechanical principles are often difficult to construct and it is necessary to deal with the uncertainty in the parameters. In general, it is interesting to find out how changes in the input variables affect the values of the response variables. An empirical formulation for structural response is usually obtained as the sum of three terms: the temperature variation, the hydrostatic pressure variation and other unexpected unknown causes such as the result of time effects. The uncertainty of the model is represented by the residual term of the model. Some structural identification techniques have been successfully obtained by De Sortis and Paoliani [1] and Léger and Leclerc [2], although using a very complex procedure. On the other hand, with a large amount of observation data it is possible to define the characterization of a normal dam's behaviour by using statistical models without the knowledge of mechanical principles [3]. Nowadays, there is great experience in using MLR model methods for the characterization of a concrete dam's behaviour.

The NN models have been applied in different areas, including dam engineering. Some works related to this subject can be mentioned such as Perner et al. [4], Gomes and Awruch [5], Fedele et al. [6], Feng and Zhou [7], Bakhary et al. [8], Wang and He [9], Wen et al. [10], Liu et al. [11], Joghataie and Dizaji [12] and Yi et al. [13].

Both MLR and NN approaches have potential value for assessing the behaviour of the control variables that support the safety assessment of the concrete dam as is shown with a *ceteris paribus*[1] analysis in this study. In the period of normal operation of a

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[1] *Ceteris paribus* is a Latin phrase, that can be translated as "all other things being equal".

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