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Concrete compressive strength prediction using the imperialist competitive algorithm

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Abstract. In the following paper, a socio-political heuristic search approach, named the imperialist competitive algorithm (ICA) has been used to improve the efficiency of the multi-layer perceptron artificial neural network (ANN) for predicting the compressive strength of concrete. 173 concrete samples have been investigated. For this purpose the values of slump flow, the weight of aggregate and cement, the maximum size of aggregate and the water-cement ratio have been used as the inputs. The compressive strength of concrete has been used as the output in the hybrid ICA-ANN model. Results have been compared with the multiple-linear regression model (MLR), the genetic algorithm (GA) and particle swarm optimization (PSO). The results indicate the superiority and high accuracy of the hybrid ICA-ANN model in predicting the compressive strength of concrete when compared to the other methods.

Keywords: computer modeling; concrete; concrete structures; construction materials; non-destructive tests (NDT); reinforced concrete (RC)

1. Introduction

Concrete is principally formed by cement paste, aggregates and additives. The compressive strength of concrete is dependent on many factors. These factors include mainly mix proportions, methods of mixing, curing conditions and transporting. The compressive strength of concrete is one of the principal factors affecting the durability of concrete structures (Hoła *et al*. 2015).

Recently, artificial neural networks (ANNs) are one of the most powerful tools used to predict the compressive strength of concrete. The ANNs presents usually high accuracy. However, it also has some disadvantages. For example, due to the high complexity of ANN, the reasonable mathematical relationship between the input and output variables are not produced. To overcome its disadvantages, several techniques have been proposed in the past to reduce its complexity. Therefore, more frequently other techniques such the meta-heuristic algorithms or model trees may be used, e.g., M5P tree model as presented by Behnood *et al*. (2017).

In the author's opinion the imperialist competitive algorithm (ICA) can offer the following advantages: high speed with the least risk of trapping in local minima, the ability to deal with various types of constraints and also a suitable functionality compatible with the GA and PSO. In other words, the ICA is burdening the duty of finding the best weights for the recommended multi-layer perceptron ANN network. According to Kaveh (2017) nowadays ICA is successfully used to solve important civil engineering problems. The recent examples of such applications are:

- the prediction of ground vibration in quarry blasting (Hajihassani *et al*. 2015, Armaghani *et al*. 2018),
- the prediction of the corrosion current density in reinforced concrete (Sadowski and Nikoo 2014),
- the assessment of the adhesion in existing cement composites (Sadowski *et al*. 2017),
- the location of the critical slip surface in 2-dimensional soil slopes (Kashani *et al*. 2016),
- the optimum design of skeletal structures (Maheri and Talezadeh 2018),
- the prediction the surface settlement induced by tunneling (Tashayo *et al*. 2018),
- the optimization of reinforced concrete retaining walls (Sheikholeslami *et al*. 2016),
- the estimation of the bearing capacity of driven pile in cohesionless soil (Moayedi and Armaghani 2018).

In most of these applications ANNs hybridized with ICA resulted of better performance than for conventional multi-layer perceptron ANN. Considering the above, for the purpose of the compressive strength of concrete prediction, the ICA may provide satisfactory performance with enough accuracy. The ICA has been therefore employed to cover the objective of the study.

The remainder of the paper is organized as follows. Section 2 presents the description of related work. Section 3 presents a short description of the ICA. Section 4 presents the experimental setup with background and data acquisition. Section 5 presents experimental results and Section 6 presents the analysis of results, which are summarized by conclusions.

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