Chapter 8.11
Soft Computing Techniques in Civil Engineering:
Time Series Prediction

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ABSTRACT

Soft computing techniques are applied to a huge quantity of problems spread in several areas of science. In this case, Evolutionary Computation (EC) techniques are applied, in concrete Genetic Programming (GP), to a temporary problem associated to the field of Civil Engineering. The case of study of this technique has been centered in the prediction, over time, of the behavior of the structural concrete in controlled conditions. Given the temporary nature of the case of study, it has been necessary to make several changes to the classical algorithm of GP, among whom it can be emphasized the incorporation of a new operator that gives the GP the ability to be able to solve problems with temporary behavior. The obtained results shown that the proposed method has succeeded in improving the adjustment to the current regulations about creep in the structural concrete.

INTRODUCTION

The existence of numerous database in the field of Civil Engineering, and in particular in the field of structural concrete, has opened new research lines through the introduction of techniques of analysis based on the Artificial Intelligence. Two methods of working are mainly applied in this new field: the ones based on the Artificial Neural Networks (ANN) and the ones developed from the Evolutionary Computation (Arciszewski & De Jong, 2001). In the case of ANN (Wasserman, 1989) it has been mainly used the recurrent ANN to be able to obtain temporary behavior of the

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case of study. The result is a black box that, with enough training (a wide database), is capable of predicting the result of new cases.

Genetic Programming (Koza, 1990), a subgroup in the techniques of EC, lead to similar results regarding the capability of prediction, but with the difference that the process of learning leads to the establishment of mathematical expressions that join the variables taking part in the problem. The achievement of expressions starts generating at random a group of initial formulas (individuals), which will be selected, crossing and mutating among them, evolving only those that are better adjusted to the expected results (Koza, 1992).

This chapter shows the use of GP techniques to specific field of Engineering as the one of structural concrete. For this reason and due to the nature of the concrete problem to solve (modelling the creep of the concrete in controlled laboratory conditions), it has been necessary to make several changes and adjustments to the GP algorithm. Once the changes have been made, it has been applied to data coming from the Réunion Internationale des Laboratoires et Experts des Matériaux, systèmes de constructionet ouvrages - RILEM (International union of laboratories and experts in construction materials, systems and structures) (RILEM, 2009), as a whole (existing database referred to tests in Civil Engineering) with whom it has been obtained several expressions that shape the creep and they are compared to the currrent models.

DEVELOPMENT SYSTEM

Within Soft computing there are several strategies when it comes to deal with the solution of a certain problem. Soft computing is a group of techniques and methodologies that can work together to obtain in any case a flexible ability and adapted to situations of the real world (Zadeh, 1994). Its main advantage is the ability to make the most of the lack of precision, the uncertainty and the approximate reasoning to achieve strength and solutions without and excessive knowledge of the problem. The principle in which it is based is the one of designing the methods of calculus that lead to an acceptable solution through the search of an approximate solution to a given problem (Pal & Mitra, 1999).

A field where Soft Computing techniques can be applied is to the tasks of prediction, according to the type of prediction (generally classification or regression), several techniques exist to solve these tasks.

The fundamental objective that is pursued is the carrying out of prediction of the value that a certain data coming from the experimentation, that is, making symbolic regression about data. Regression uses the existing values to predict what other values are going to happen.

When it comes to deal technically with this situation, it is suggested the use of several possibilities. The techniques based on the use of the ANN have shown their solvency making tasks of regression. We can quote an example as Cladera and Mari who use ANNs to study the shear strength response of concrete beams without web reinforcement (Cladera & Marí, 2004). In this case, once the training has been made, the training ANN has been used as a virtual laboratory, predicting the values of tests that have not been made physically. The main problem of the use of ANN, within the field of Civil Engineering, is its own functioning. The ANN is able, once they have been well trained, to make good predictions, but without explaining how, that is, they work as black boxes. That is why, together with the difficulty in the decision of the ideal setup of the architecture, experts in Civil Engineering do not use them with regularity. Another technique is the use of Genetic Programming. Among other qualities, it can be emphasized the fact of being able to connect the input data (coming from experimental tests) with the result (output data) producing mathematical expressions. An example of the use of this ability of the GP is the work of Ashour et al. (Ashour,