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Chapter V

Self-Adapting Intelligent Neural Systems Using Evolutionary Techniques

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Abstract

This chapter describes genetic algorithm-based evolutionary techniques for automatically constructing intelligent neural systems. These techniques can be used to build and train multilayer perceptrons with the simplest architecture. These neural networks are usually designed using binary-coded genetic algorithms. The authors show how the basic architectures codification method, which uses an algebra-based codification, employs a shorter string length and voids illegal architectures in the search space. The networks are trained using real number codification. The morphological crossover operator is presented and compared to other important real-coded crossover operators. The purpose is to understand that the combination of all *these techniques results in an evolutionary system, which self-adaptively constructs intelligent neural systems to solve a problem given as a set of training patterns. To do so, the evolutionary system is applied in laboratory tests and to a real-world problem: breast cancer diagnosis.*

Introduction

At present, one of the main interest areas in artificial intelligence is related to the design of self-adaptive systems, which are able to transform to solve different kinds of problems or to adapt to the changing environment (Konar, 2000). Multilayer perceptrons are feedforward neural networks with one input layer, one output layer, and several hidden layers. This model is applicable within artificial intelligence to solve a wide variety of real-world problems thanks to its properties of learning by examples, generalising to unseen data, noise filtering, and pattern classification (Principe, Euliano, & Lefebvre, 2000). Despite the advantages of these intelligent neural systems, a neural architecture that does one task accurately is useless for solving another problem. A new architecture needs to be designed from scratch: structuring the network connectivity, deciding the number of hidden units, and setting the terms in the weight adjustment algorithm. This is not a straightforward job even for the most experienced practitioners, because of the size and complexity of the search space even for the best understood network models (Manrique, 2001). Under these conditions, there is no question of building a neural network-based, self-adapting intelligent system to solve any problem presented as a set of training patterns.

However, successful results have been achieved by identifying synergies between evolutionary algorithms and artificial neural networks that can be combined to design the internal structure of the network (Barrios, Manrique, Plaza, & Ríos, 2001). The way in which the neural networks that make up the search space are encoded is a crucial step in automatic network design (Hussain & Browse, 1998). Therefore, several approaches have been developed to produce efficient codifications of artificial neural networks. The first of these is the direct binary encoding of network configuration, where each bit determines the presence or absence of a single connection (Siddiqi & Lucas, 1998). This approach can be used to encode any neural architecture. Other approaches for encoding artificial neural networks are based on the binary codification of grammars that describe the architecture of the network (Hussain, 2000). The basic architectures codification method (Barrios et al., 2001) is another approach, which is based on the definition of an Abelian semi-group with a neutral element in the set of neural architectures. It rules out illegal networks codification and needs a very short encoding length, being optimum for encoding neural networks with one output. This codification encodes any kind of generalised multilayer perceptrons with one hidden layer. Another important feature is that a one-bit variation in the string that represents a network results in a very similar neural architecture, which improves the performance of the genetic algorithm. Any of these codification methods must employ an adequate crossover operator. Besides the classical operators, like the one-point, two-point, uniform, and generalised operators, the

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