

Preface

Artificial neural networks (ANNs) offer a general framework for representing non-linear mappings from several input variables to several output variables, and they can be considered as an extension of the many conventional mapping techniques. In addition to many considerations on their biological foundations and their really wide spectrum of applications, constructing appropriate ANNs can be seen as a really hard problem. A distinguished task in building ANNs is the tuning of a set of parameters known as *weights*. This will be the main focus of the present book. The trained ANNs can be later used in classification (or recognition) problems, where the ANN outputs represent categories, or in prediction (approximation) problems, where the outputs represent continuous variables.

In the process of training the ANN (*supervised learning*), the problem is to find the values of the weights that minimize the error across a set of input/output pairs (patterns) called the training set. In a first stage, the training is an unconstrained nonlinear optimization problem, where the decision variables are the weights and the objective is to reduce the training error. However, the main goal in the design and training of ANNs is to obtain a model which makes good predictions for new inputs (which is termed as *generalization*). Therefore the trained ANN must capture the systematic aspects of the training data rather than their specific details. Hence, as it has been well documented, the optimization problem involved in the training/generalization process is of an extreme hardness.

Metaheuristics provide a means for solving complex optimization problems to obtain acceptable solutions or even global optima. These methods are designed to search for such global optima in complex problems where other mechanisms fail because: the problem is ill-defined, or has a

very large dimensionality, or a high interaction between variables exists, or require unaffordable computational efforts for exact methods. Experimental testing of metaheuristics show that the search strategies embedded in such procedures are capable of finding solutions of high quality to hard problems in industry, business, and science within reasonable computational time. The tools and mechanisms that have emerged from the creation of metaheuristic methods have also proved to be remarkably efficient, resulting in what has been coined as hybrid methods.

Apart from some sparse efforts to bring together metaheuristic techniques to train ANNs (which include conference sessions on this field), there is no a single source of reference for such goal. In this book we aim at giving a unified approach to the work of training ANNs with modern heuristics, given the overwhelming literature proving their appropriateness to escape local optima and to solve problems in very different mathematical scenarios (two features that encapsulate important shortcomings of other well-known algorithms specifically designed to train ANNs).

The book's goal is to provide successful implementations of metaheuristic methods for neural network training. Moreover, the basic principles and fundamental ideas given in the book will allow the readers to create successful training methods on their own. Apart from Chapter 1, in which classical training methods are reviewed for the sake of the book's completeness, we have classified the chapters in three main categories. The first one is devoted to *local search based* methods, in which we include Simulated Annealing, Tabu Search, and Variable Neighborhood Search. The second part of the book presents the most effective *population based* methods, such as Estimation Distribution algorithms, Scatter Search, and Genetic Algorithms. Finally, the third part includes other advanced techniques, such as Ant Colony Optimization, Co-evolutionary methods, GRASP, and Memetic algorithms. All these methods have been shown to work out high quality solutions in a wide range of hard optimization problems, while in this book we restrict our attention to their application to the ANN training problem.

This book is engineered to provide the reader with a broad coverage of the concepts, methods, and tools of this important area of ANNs within the realm of continuous optimization. In fact, many applications dealing with continuous spaces could profit from the advances described in it. The chapters can be addressed separately depending on the reader's necessities. It would be of interest to researchers and practitioners not only in neural networks but also in management science, economics, and engineering in general. Besides, it can be used as a textbook in a master course, a doctoral seminar, or as a reference book for computer science in areas such as enterprise resource planning and supply chain management.

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