

Preface

Currently, we are faced with many complex engineering systems that need to be manipulated. As they are usually not fully theoretically tractable, it is not possible to use traditional deterministic methods. Soft computing, as opposed to conventional deterministic methods, is a set of methodologies (working synergistically, not competitively) that, in one form or another, exploits the tolerance for imprecision, uncertainty and approximate reasoning to achieve tractability, robustness, low-cost solution, and close resemblance with human-like decision making. Soft computing techniques include neural networks, evolutionary computation, fuzzy logic and Learning Automata. The recent years have witnessed tremendous success of these powerful methods in virtually all areas of science and technology, as evidenced by the large numbers of research results published in a variety of journals, conferences, as well as many books.

Engineering is a rich source of problems where each new approach that is developed by mathematicians and computer scientists is quickly identified, understood and assimilated in order to be applied to specific problems. In this book we strive to bring some state of the art techniques by using recent Soft Computing techniques after its application to challenging and significant problems in engineering.

Soft Computing methods have many variants. There exist a rich amount of literature on the subject, including textbooks, tutorials, and journal papers that cover in detail practically every aspect of the field. The great amount of information available makes it difficult for no specialist to explore the literature and to find the right technique for a specific engineering application. Therefore, any attempt to present the whole area of Soft Computing in detail would be a daunting task, probably doomed to failure. This task would be even more difficult if the goal is to understand the applications of Soft Computing techniques in the context of engineering application. For this reason, the best practice is to consider only a representative set of Soft Computing approaches, just as it has been done in this book.

The aim of this book is to provide an overview of the different aspects of Soft Computing methods in order to enable the reader in reaching a global understanding of the field and, in conducting studies on specific Soft Computing

techniques that are related to applications in engineering, which attract the interest for their complexity. Our goal is to bridge the gap between Soft Computing techniques and their applications to complex engineering problems. To do this, at each chapter we endeavor to explain basic ideas of the proposed applications in ways that can be understood by readers who may not possess the necessary backgrounds on some of the fields. Therefore, engineers or practitioners who are not familiar with Soft Computing methods will appreciate that the techniques discussed are beyond simple theoretical tools since they have been adapted to solve significant problems that commonly arise on such areas. On the other hand, members of the Soft Computing community can learn the way in which engineering problems are solved and handled by using intelligent approaches.

This monograph presents new applications and implementations of Soft Computing approaches in different engineering problems. The present book collects 12 chapters. It has been structured so that each chapter can be read independently from the others. Chapter 1 describes the main methods that integrate Soft Computing. This chapter concentrates on elementary concepts of intelligent approaches and optimization. Readers that are familiar with such concepts may wish to skip this chapter.

In Chap. 2, a Block matching (BM) algorithm that combines an evolutionary algorithm (such Harmony Search) with a fitness approximation model is presented. The approach uses motion vectors belonging to the search window as potential solutions. A fitness function evaluates the matching quality of each motion vector candidate. In order to save computational time, the approach incorporates a fitness calculation strategy to decide which motion vectors can be only estimated or actually evaluated. Guided by the values of such fitness calculation strategy, the set of motion vectors is evolved through evolutionary operators until the best possible motion vector is identified. The presented method is also compared to other BM algorithms in terms of velocity and coding quality. Experimental results demonstrate that the presented algorithm exhibits the best balance between coding efficiency and computational complexity.

Chapter 3 presents an algorithm for the optimal parameter identification of induction motors. To determine the parameters, the presented method uses a recent evolutionary method called the Gravitational Search Algorithm (GSA). Different to the most of existent evolutionary algorithms, GSA presents a better performance in multimodal problems, avoiding critical flaws such as the premature convergence to sub-optimal solutions. Numerical simulations have been conducted on several models to show the effectiveness of the proposed scheme.

In Chap. 4, an image segmentator algorithm based on Learning Vector Quantization (LVQ) networks is presented and tested on a tracking application. In LVQ networks, neighboring neurons learn to recognize neighboring sections of the input space. Neighboring neurons would correspond to object regions illuminated in a different manner. The segmentator involves a LVQ network that operates directly on the image pixels and a decision function. This algorithm has been applied to color tracking, and have shown more robustness on illumination changes than other standard algorithms.

Chapter 5 presents an enhanced evolutionary approach known as Electromagnetism-Like (EMO) algorithm. The improvement considers the Opposition-Based Learning (OBL) approach to accelerate the global convergence speed. OBL is a machine intelligence strategy which considers the current candidate solution and its opposite value at the same time, achieving a faster exploration of the search space. The presented method significantly reduces the required computational effort yet avoiding any detriment to the good search capabilities of the original EMO algorithm. Experiments are conducted over a comprehensive set of benchmark functions, showing that the presented method obtains promising performance for most of the discussed test problems.

In Chap. 6, the use of the Learning Automata (LA) algorithm to compute threshold points for image segmentation is explored. Despite other techniques commonly seek through the parameter map, LA explores in the probability space providing better convergence properties and robustness. In the chapter, the segmentation task is therefore considered as an optimization problem and the LA is used to generate the image multi-threshold separation. In the approach, a 1D histogram of a given image is approximated through a Gaussian mixture model whose parameters are calculated using the LA algorithm. Each Gaussian function approximating the histogram represents a pixel class and therefore a threshold point. The method shows fast convergence avoiding the typical sensitivity to initial conditions such as the Expectation-Maximization (EM) algorithm or the complex time-consuming computations commonly found in gradient methods. Experimental results demonstrate the algorithm's ability to perform automatic multi-threshold selection and show interesting advantages as it is compared to other algorithms solving the same task.

Chapter 7 describes the use of an adaptive network-based fuzzy inference system (ANFIS) model to reduce the delay effects in gaze control and also explains how the delay problem is resolved through prediction of the target movement using a neurofuzzy approach. The approach has been successfully tested in the vision system of a humanoid robot. The predictions improve the velocity and accuracy of object tracking.

Chapter 8 presents an algorithm for the automatic detection of circular shapes from complicated and noisy images with no consideration of the conventional Hough transform principles. The presented algorithm is based on an Artificial Immune Optimization (AIO) technique, known as the Clonal Selection algorithm (CSA). The CSA is an effective method for searching and optimizing following the Clonal Selection Principle (CSP) in the human immune system which generates a response according to the relationship between antigens (Ag), i.e. patterns to be recognized and antibodies (Ab) i.e. possible solutions. The algorithm uses the encoding of three points as candidate circles over the edge image. An objective function evaluates if such candidate circles (Ab) are actually present in the edge image (Ag). Guided by the values of this objective function, the set of encoded candidate circles are evolved using the CSA so that they can fit to the actual circles on the edge map of the image. Experimental results over several synthetic as well as

natural images with varying range of complexity validate the efficiency of the presented technique with regard to accuracy, speed, and robustness.

In Chap. 9, an algorithm for detecting patterns in images is presented. The approach is based on an evolutionary algorithm known as the States of Matter. Under the proposed method can be strongly reduced the number of search locations in the detection process. In the presented approach, individuals emulate molecules that experiment state transitions which represent different exploration–exploitation levels. In the algorithm, the computation of search locations is drastically reduced by incorporating a fitness calculation strategy which indicates when it is feasible to calculate or only estimate the Normalized cross-correlation values for new search locations. Conducted simulations show that the presented method achieves the best balance over other detecting algorithms, in terms of estimation accuracy and computational cost.

Chapter 10 explores the use of the Artificial Bee Colony (ABC) algorithm to compute threshold selection for image segmentation. ABC is a heuristic algorithm motivated by the intelligent behavior of honey-bees which has been successfully employed to solve complex optimization problems. In this approach, an image 1D histogram is approximated through a Gaussian mixture model whose parameters are calculated by the ABC algorithm. For the approximation scheme, each Gaussian function represents a pixel class and therefore a threshold. Unlike the Expectation-Maximization (EM) algorithm, the ABC-based method shows fast convergence and low sensitivity to initial conditions. Remarkably, it also improves complex time-consuming computations commonly required by gradient-based methods. Experimental results demonstrate the algorithm’s ability to perform automatic multi-threshold selection yet showing interesting advantages by comparison to other well-known algorithms.

In Chap. 11, the usefulness of planning to improve the performance of feedback-based control schemes considering a probabilistic approach known as Learning Automata (LA) is considered. Standard gradient methods develop a plan evaluation scheme whose solution lies on a neighborhood distance from the previous point, forcing to explore the space extensively. On the other hand, LA algorithms are based on stochastic principles, with newer points for optimization being determined by a probability function with no constraint whatsoever on how close they are from previous optimization points. The presented LA approach may be considered as a planning system that chooses the plan with the higher probability to produce the best closed-loop results. The effectiveness of the methodology is tested over a nonlinear plant and compared with the results offered by the Levenberg-Marquardt (LM) algorithm.

Finally, Chap. 12 presents an algorithm based on fuzzy reasoning to detect corners even under imprecise information. The robustness of the presented algorithm is compared to well-known conventional corner detectors and its performance is then tested on a number of benchmark images to illustrate the efficiency of the algorithm under uncertainty conditions.

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