

Preface

Image processing and pattern recognition emerge as important components of decision support systems for industrial, medical, military applications, among others. Several methods have been presented in the literature to solve image processing and pattern recognition tasks. They require some method-specific parameters to be optimally tuned in order to achieve the best performance. Such requirement has naturally steered both methods toward being converted into optimization problems.

Optimization has a fundamental importance in solving many problems in image processing and pattern recognition. Such a fact is evident from a quick look at special issues, congresses, and specialized journals that focus on such areas, where a significant number of manuscripts report on the use of optimization techniques.

Classical optimization methods often face great difficulties while dealing with images or systems containing noise and distortions. Under such conditions, the use of evolutionary computation approaches has been recently extended to address challenging real-world image processing and pattern recognition problems.

Image processing and pattern recognition are both dynamic and fast moving fields of research. Each new approach that is developed by engineers, mathematicians, and computer scientists is quickly identified, understood, and assimilated in order to be applied to image processing and pattern recognition problems. In this book, we strive to bring some state-of-the-art techniques by using recent results in evolutionary computation after its application to challenging and significant problems in image processing and pattern recognition.

Evolutionary computation methods are vast and 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 optimization technique for a specific image or pattern recognition application. Therefore, any attempt to present the whole area of evolutionary computation 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

evolutionary methods in the context of image processing and pattern recognition. For this reason, the best practice is to consider only a representative set of evolutionary approaches, just as it has been done in this book.

The aim of this book was to provide an overview of the different aspects of evolutionary methods in order to enable the reader in reaching a global understanding of the field and in conducting studies on specific evolutionary techniques that are related to applications in image processing and pattern recognition that for some reason attract his interest.

Our goal is to bridge the gap between recent evolutionary optimization techniques and novel image processing methods that profit on the convenient properties of evolutionary methods. 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 either of the fields. Therefore, image processing and pattern recognition practitioners who are not evolutionary computation researchers 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 evolutionary computation community can learn the way in which image processing and pattern recognition problems can be translated into an optimization task.

This book has been structured so that each chapter can be read independently from the others. Chapter 1 describes evolutionary computation (EC). This chapter concentrates on elementary concepts of evolutionary algorithms. Readers that are familiar with EC may wish to skip this chapter.

In Chap. 2, an automatic image multi-threshold segmentation approach based on differential evolution (DE) is presented. The algorithm approximates the 1-D histogram of the image using a mixture of Gaussian functions whose parameters are calculated by using the differential evolution method. Each Gaussian function represents a pixel class and therefore a threshold point in the image.

Chapter 3 presents how the artificial bee colony (ABC) optimization can be used to reduce the number of search locations within a block matching process. In the algorithm, the computation of search locations is drastically reduced by considering a fitness calculation strategy which indicates when it is feasible to calculate or only estimate new search locations.

In Chap. 4, an effective technique for extracting multiple ellipses from an image is presented. The approach employs an evolutionary algorithm that mimics the way in which animals behave collectively, assuming the overall detection process as a multimodal optimization problem. In the algorithm, search agents emulate a group of animals that interact to each other by using simple biological rules that are modeled as evolutionary operators.

In Chap. 5, the template matching problem is solved by using an evolutionary approach based on the states of matter phenomenon. In the approach, individuals emulate molecules that experiment state transitions which represent different exploration–exploitation behaviors.

Chapter 6 presents a method for robustly estimating multiple view relations from point correspondences. The approach combines the RANSAC method and an evolutionary technique known as the clonal selection algorithm (CSA). Upon such combination, the method adopts a different sampling strategy in comparison with RANSAC in order to generate putative solutions. Under the new mechanism, new candidate solutions are iteratively built by considering the quality of models that have been generated by previous candidate solutions, rather than relying over a pure random selection as it is the case with classic RANSAC.

Chapter 7 exhibits an algorithm for the automatic detection of circular shapes from complicated and noisy images with no consideration of the conventional Hough transform principles. The detector is based on a newly developed evolutionary algorithm called the adaptive population with reduced evaluations (APRE). It reduces the number of function evaluations through the use of two mechanisms: (1) adapting dynamically the size of the population and (2) incorporating a fitness calculation strategy which decides whether the calculation or estimation of the newly generated individuals is feasible.

In Chap. 8, a segmentation algorithm based on the Harmony search (HS) algorithm is introduced. The approach combines the good search capabilities of HS with objective functions suggested by the popular segmentation methods of Otsu and Kapur.

Chapter 9 presents an algorithm for the automatic detection of white blood cells embedded into complicated and cluttered smear images that considers the complete process as a circle detection problem. The approach is based on a nature inspired technique known as the electromagnetism-like optimization (EMO) which is a heuristic method that follows electromagnetism principles for solving complex optimization problems.

Finally, Chap. 10 presents an algorithm for the automatic selection of pixel classes for image segmentation. The presented method combines a recent evolutionary method with the definition of a new objective function that appropriately evaluates the segmentation quality with respect to the number of classes. The evolutionary algorithm, called locust search (LS), is based on the behavior of swarms of locusts. Different to the most of existent evolutionary algorithms, it explicitly avoids the concentration of individuals in the best positions, avoiding critical flaws such as the premature convergence to sub-optimal solutions and the limited exploration–exploitation balance.

There are many people who are somehow involved in the writing process of this book. We thank Dr. Raul Rojas for supporting us to have it published. We express our gratitude to Prof. Lakhmi Jain, who so warmly sustained this project. Acknowledgements also go to Dr. Thomas Ditzinger, who so kindly agreed to its appearance. We also acknowledge that this work was supported by CONACYT under the grant number CB 181053.

Considering that writing this book has been a very enjoyable experience for the authors and that the overall topic of evolutionary techniques in image processing has become a fruitful subject, it has been tempting to introduce a large amount of new material and novel evolutionary methods. However, the usefulness and

potential adoption of the book seems to be founded over a compact and appropriate presentation of successful algorithms, which in turn has driven the overall organization of the book that we hope may provide the clearest picture to the reader's eyes.

Guadalajara, Mexico
September 2015

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Applications of Evolutionary Computation in Image
Processing and Pattern Recognition

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2016, XV, 274 p. 111 illus., 55 illus. in color., Hardcover

ISBN: 978-3-319-26460-8