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Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland
e-mail: kacprzyk@ibspan.waw.pl

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Diego Oliva · Mohamed Abd Elaziz ·
Salvador Hinojosa

Metaheuristic Algorithms for Image Segmentation: Theory and Applications

Springer

Diego Oliva
Departamento de Electrónica, CUCEI
Universidad de Guadalajara
Guadalajara, Jalisco, Mexico

Mohamed Abd Elaziz
Faculty of Science
Zagazig University
Zagazig, Egypt

Salvador Hinojosa
Facultad de Informática
Universidad Complutense de Madrid
Madrid, Spain

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Foreword

In this book, the most important methods used for image segmentation are collected, especially for thresholding. The idea of the authors is to gather information in a document and provide the reader with the tools to implement new algorithms. They combine two important fields in computer sciences: artificial intelligence and image processing. It is well known that image segmentation is one of the most important tasks in computer vision systems. However, nowadays it is hard to find a compendium of information that presents the most relevant methods used by the scientific community. However, this book addresses the issues of image segmentation using metaheuristic algorithms that are part of the artificial intelligence field. The idea of combining the techniques is to improve the performance of the classical algorithms in image processing.

This book guides the reader along different and interesting implementations, but it also includes the theoretical support that permits to understand all the ideas presented in the chapter. Moreover, each chapter that presents applications includes comparisons and updated references that support the results obtained by the proposed approaches. At the same time, every chapter provides the reader with a practical guide to go to the reference sources. Meanwhile, the introductory chapters are easy to understand due to the images and the explanation of the equation and steps of the processes.

This book was designed for graduate and postgraduate education, where students can find support for reinforcing or as the basis for their consolidation; researchers can deepen their knowledge. Also, professors can find support for the teaching process in areas involving machine vision or as examples related to main techniques addressed. Additionally, professionals who want to learn and explore the advances on concepts and implementation of optimization and learning-based algorithms applied to image processing can find in this book an excellent guide for such purpose.

This interesting book has fifteen chapters that are organized considering an introduction to optimization, metaheuristics, and image processing. Here is also included a survey about the most recent studies related to the use of metaheuristic algorithms for image thresholding. In this sense, Chap. 1 provides a general

overview of this book. Chapter 2 presents the concept of mathematical optimization; meanwhile, in Chap. 3, the metaheuristic algorithms are explained. Chapter 4 explains the reader the necessary concepts of image processing, and Chap. 5 introduces the reader to the image segmentation. In Chap. 6, the current trends of image thresholding using metaheuristics are described. From Chaps. 7 to 11, the reader could find the most relevant methods for image segmentation using statistical metrics as the intra-class variance, proposed by Otsu or Kapur's entropy, and the fuzzy entropy is also described.

The remaining part of this book contains the last four chapters including unconventional methodologies for image segmentation. In Chap. 12, for example, a mixture of Gaussian functions to estimate the histogram is used. Moreover, the use of multi-objective optimization algorithms for image segmentation is also explained in Chap. 13. Chapter 14 explores the machine learning alternatives for image segmentation; here, the most used clustering techniques are explained. Finally, Chap. 15 shows the theory behind the energy curve that includes the contextual information of pixels.

It is important to mention that an important advantage of this structure is that each chapter could be read separately. This book is an important reference to artificial intelligence and image processing. These areas are very important and are in constant evolution. For that reason, it is hard to collect all the information in a single book. I congratulate the authors for their effort and dedication for assembling the topics addressed in this book.

Wuhan, China
December 2018

Songfeng Lu
Huazhong University of Science
and Technology

Preface

Nowadays, digital images are present in a multitude of devices. The use of cameras has increased over the last ten years, and now they are present in many aspects of our life. Images are used for leisure activities, surveillance, autonomous vehicles, medicine, communications, etc. One of the main reasons for using image processing applications is that there is no necessity to analyze all the scenes by a human expert. For example, in industrial applications the cameras acquire images to detect defects in the products. An automatic system is programmed to automatically perform the analysis of the images. Such kind of systems has different steps, and to be completely automatic they require artificial intelligence methods. Some of these methods are applied to image processing algorithms. The idea behind image processing is to employ different methods for extracting features that allow identifying the objects in the scene. The methods used include operators to analyze the pixels in diverse ways. However, most of this kind of operations is computationally expensive.

One branch of the field of artificial intelligence includes optimization algorithms capable of solving problems where the minimization or maximization of a model is required. Optimization approaches are extensively used in different areas of engineering. They are used to explore complex search spaces and obtain the most appropriate solutions to a given problem represented as an objective function. This book focuses on lightweight segmentation methods based on thresholding techniques using metaheuristic algorithm (MA) to perform the preprocessing of digital images. The aim is providing the reader with the most representative tools used for image segmentation while examining the theory and application of MA for the segmentation of images from diverse sources. In this sense, topics are selected based on their importance and complexity in this field—for example, the analysis of medical images and the segmentation of thermal images for security implementation.

This book aims to present a study of the use of new tendencies in image segmentation. When we started working on those topics almost five years ago, the related information was sparse. Now, we realize that the researchers were divided and closed in their fields. Another difference is the current integration of digital

cameras on the current lifestyle compared to a decade ago. This book explains how to use and modify different methodologies for image segmentation using metaheuristic algorithms.

Moreover, in our research, we discover non-conventional techniques for solving the problems of segment images. The reader could see that our goal is to show that a problem of image processing can be smoothly translated into an optimization task due to the existence of a natural link between both the image processing and the optimization fields. To achieve this goal, the first four chapters introduce the concepts of optimization and image processing. The structure of the rest of the sections first presents an introduction to the problem to be solved and explains the basic ideas and concepts about the implementations. This book was planned considering that the readers could be students, researcher expert in the fields, and practitioners that are not completely involved with the topics.

This book has been structured so that each chapter can be read independently from the others. Chapter 1 presents an overview of the entire book. Chapter 2 explains the theory related to mathematical optimization. In Chap. 3 are introduced the basic concepts of metaheuristic algorithms. Chapter 4 explains some important points in image processing. Readers that are familiar with those topics may wish to skip these chapters.

In Chap. 5, the reader could find an interesting study about the methods commonly used for image segmentation and metaheuristics. Meanwhile, in Chap. 6 is presented with a survey of metaheuristic algorithms for image thresholding.

Chapter 7 explains the basic concepts of the between-class variance (Otsu's method) for bi-level and multilevel thresholding. In this chapter, the tree–seed algorithm (TSA) is used to find the best thresholds using the between-class variance as an objective function.

Chapter 8 introduces Kapur's entropy and a hybrid metaheuristic algorithm based on the combination of the salp swarm algorithm (SSA) and the artificial bee colony (ABC).

In Chap. 9, the Tsallis entropy is used for bi-level and multilevel thresholding using the electromagnetism-like optimization (EMO) to find the best configuration of thresholds for image segmentation.

In Chap. 10, the concept of minimum cross entropy (MCET) is introduced. This method is also used for the segmentation of brain magnetic resonance image (MRI) in medicine using the crow search algorithm (CSA).

Chapter 11 introduces the fuzzy entropy approaches. Here are explained the basics about type I and type II fuzzy entropy for image thresholding. Moreover, it is also shown that such methodologies can easily figure out with metaheuristic algorithms.

Chapter 12 employs the histogram approximation using a mixture of Gaussian functions to find the best thresholds in image segmentation. This problem is also addressed using metaheuristic optimization algorithms.

In Chap. 13, it is used a multi-objective optimization algorithm to find the best solutions to image thresholding. This chapter explains how to formulate the problem of multilevel thresholding using multiple objective functions.

Chapter 14 explains the theory and concepts of data clustering. This chapter aims to implement the metaheuristic algorithms to optimize the most used clustering approaches for image segmentation.

Chapter 15 introduces a relatively new concept for image thresholding called energy curve. This method includes contextual information of pixels to generate a curve with the same feature of the histogram. Here is used the Ant Lion Optimizer (ALO) to search the best thresholds using the energy curve with Otsu and Kapur objective functions.

This book has been structured from a teaching viewpoint. Therefore, the material is essentially directed for undergraduate and postgraduate students of science, engineering, or computational mathematics. It can be appropriate for courses such as artificial intelligence, evolutionary computation, and computational intelligence. Likewise, the material can be useful for researches from the evolutionary computation and artificial intelligence communities.

Finally, it necessary to mention that this book is a small piece in the puzzles of image processing and optimization. We would like to encourage the reader to explore and expand the knowledge in order to create their implementations according to their necessities.

Guadalajara, Mexico — Diego Oliva
Zagazig, Egypt — Mohamed Abd Elaziz
Madrid, Spain — Salvador Hinojosa
December 2018

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