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Advances and Applications of Optimised Algorithms in Image Processing

Springer

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To my family and Gosia Kijak, you are always my support

Foreword

This book brings together and explores possibilities for combining image processing and artificial intelligence, both focused on machine learning and optimization, two relevant areas and fields in computer science. Most books have been proposed about the major topics separately, but not in conjunction, giving it a special interest. The problems addressed and described in the different chapters were selected in order to demonstrate the capabilities of optimization and machine learning to solve different issues in image processing. These problems were selected considering the degree of relevance in the field providing important cues on particular applications domains. The topics include the study of different methods for image segmentation, and more specifically detection of geometrical shapes and object recognition, where their applications in medical image processing, based on the modification of optimization algorithms with machine learning techniques, provide a new point of view. In short, the book was intended with the purpose and motivation to show that optimization and machine learning main topics are attractive alternatives for image processing technique taking advantage over other existing strategies. Complex tasks can be addressed under these approaches providing new solutions or improving the existing ones thanks to the required foundation for solving problems in specific areas and applications.

Unlike other existing books in similar areas, the book proposed here introduces to the reader the new trends using optimization approaches about the use of optimization and machine learning techniques applied to image processing. Moreover, each chapter includes comparisons and updated references that support the results obtained by the proposed approaches, at the same time that provides the reader a practical guide to go to the reference sources.

The book was designed for graduate and postgraduate education, where students can find support for reinforcing or as the basis for their consolidation or deepening of knowledge, and for researchers. Also teachers can find support for the teaching process in the 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 image processing find in this book an excellent guide for such purpose.

The content of this book has been organized considering an introduction to machine learning an optimization. After each chapter addresses and solves selected problems in image processing. In this regard, Chaps. 1 and 2 provides respectively introductions to machine learning and optimization, where the basic and main concepts related to image processing are addressed. Chapter 3, describes the electromagnetism-like optimization (EMO) algorithm, where the appropriate modifications are addressed to work properly in image processing. Moreover, its advantages and shortcomings are also explored. Chapter 4 addresses the digital image segmentation as an optimization problem. It explains how the image segmentation is treated as an optimization problem using different objective functions. Template matching using a physical inspired algorithm is addressed in Chap. 5, where indeed, template matching is considered as an optimization problem, based on a modification of EMO and considering the use of a memory to reduce the number of call functions. Chapter 6 addresses the detection of circular shapes problem in digital images, and again focused as an optimization problem. A practical medical application is proposed in Chap. 7, where blood cell segmentation by circle detection is the problem to be solved. This chapter introduces a new objective function to measure the match between the proposed solutions and the blood cells contained in the images. Finally, Chap. 8 proposes an improvement EMO applying the concept of opposition-based electromagnetism-like optimization. This chapter analyzes a modification of EMO used as a machine learning technique to improve its performance. An important advantage of this structure is that each chapter could be read separately. Although all chapters are interconnected, Chap. 3 serves as the basis for some of them.

The concise comprehensive book on the topics addressed makes this work an important reference in image processing, which is an important area where a significant number of technologies are continuously emerging and sometimes untenable and scattered along the literature. Therefore, congratulations to authors for their diligence, oversight and dedication for assembling the topics addressed in the book. The computer vision community will be very grateful for this well-done work.

July 2016

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Preface

The use of cameras to obtain images or videos from the environment has been extended in the last years. Now these sensors are present in our lives, from cell phones to industrial, surveillance and medical applications. The tendency is to have automatic applications that can analyze the images obtained with the cameras. Such applications involve the use of image processing algorithms.

Image processing is a field in which the environment is analyzed using samples taken with a camera. The idea is to extract features that permit the identification of the objects contained in the image. To achieve this goal is necessary applying different operators that allow a correct analysis of a scene. Most of these operations are computationally expensive. On the other hand, optimization approaches are extensively used in different areas of engineering. They are used to explore complex search spaces and obtain the most appropriate solutions using an objective function. This book presents a study the uses of optimization algorithms in complex problems of image processing. The selected problems explore areas from the theory of image segmentation to the detection of complex objects in medical images. The concepts of machine learning and optimization are analyzed to provide an overview of the application of these tools in image processing.

The aim of this book is to present a study of the use of new tendencies to solve image processing problems. When we start working on those topics almost ten years ago, the related information was sparse. Now we realize that the researchers were divided and closed in their fields. On the other hand, the use of cameras was not popular then. This book presents in a practical way the task to adapt the traditional methods of a specific field to be solved using modern optimization algorithms. Moreover, in our study we notice that optimization algorithm could also be modified and hybridized with machine learning techniques. Such modifications are also included in some chapters. The reader could see that our goal is to show that exist a natural link between the image processing and optimization. To achieve this objective, the first three chapters introduce the concepts of machine learning, optimization and the optimization technique used to solve the problems. The structure of the rest of the sections is to first present an introduction to the problem to be solved and explain the basic ideas and concepts about the implementations.

The book was planned considering that, the readers could be students, researchers expert in the field 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 describes the machine learning (ML). This chapter concentrates on elementary concepts of machine learning. Chapter 2 explains the theory related with global optimization (GO). Readers that are familiar with those topics may wish to skip these chapters.

In Chap. 3 the electromagnetism-like optimization (EMO) algorithm is introduced as a tool to solve complex optimization problems. The theory of physics behind the EMO operators is explained. Moreover, their pros and cons are widely analyzed, including some of the most significant modifications.

Chapter 4 presents three alternative methodologies for image segmentation considering different objective functions. The EMO algorithm is used to find the best thresholds that can segment the histogram of a digital image.

In Chap. 5 the problem template matching is introduced that consists in the detection of objects in an image using a template. Here the EMO algorithm optimizes an objective function. Moreover, improvements to reduce the number of evaluations and the convergence velocity are also explained.

Continuing with the object detection, Chap. 6 shows how EMO algorithm can be applied to detect circular shapes embedded in digital images. Meanwhile, in Chap. 7 a modified objective function is used to identify white blood cells in medical images using EMO.

Chapter 8 shows how a machine learning technique could improve the performance of an optimization algorithm without affecting its main features such as accuracy or convergence.

Writing this book was a very rewarding experience where many people were involved. We acknowledge Dr. Gonzalo Pajares for always being available to help us. 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.

Finally, it is 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 create their own implementations according their own necessities.

Zapopan, Mexico
Guadalajara, Mexico
July 2016

Diego Oliva
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