

# Hybrid Metaheuristics for Image Analysis

Siddhartha Bhattacharyya  
Editor

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 Springer

*Editor*

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*Siddhartha Bhattacharyya would like to  
dedicate this book to his late father Ajit  
Kumar Bhattacharyya, his late mother Hashi  
Bhattacharyya, his beloved wife Rashni  
Mukherjee, and his elder cousin sister Piyali  
Mukherjee*

# Preface

A metaheuristic is a higher-level procedure designed to select a heuristic (partial search algorithm) that may lead to a sufficiently good solution to an optimization problem, especially with incomplete or imperfect information. The basic principle of metaheuristics is to sample a set of solutions which is large enough to be completely sampled. As metaheuristics make few assumptions about the optimization problem to be solved, they may be put to use in a variety of problems. Metaheuristics do not, however, guarantee that a globally optimal solution can be found on some class of problems since most of them implement some form of stochastic optimization. Hence the solution found is often dependent on the set of random variables generated. By searching over a large set of feasible solutions, metaheuristics can often find good solutions with less computational effort than optimization algorithms, iterative methods, or simple heuristics. As such, they are useful approaches for optimization problems.

Even though the metaheuristics are robust enough to yield optimum solutions, they often suffer from time complexity and degenerate solutions. In an effort to alleviate these problems, scientists and researchers have come up with the hybridization of the different metaheuristic approaches by conjoining them with other soft computing tools and techniques to yield fail-safe solutions. In a recent advancement, quantum mechanical principles are being employed to cut down the time complexity of the metaheuristic approaches to a great extent. Thus, the hybrid metaheuristic approaches have come a long way in dealing with real life optimization problems quite successfully.

Proper and faithful analysis of digital images has been at the helm of affairs in the computer vision research community given the varied amount of uncertainty inherent in digital images. Images exhibit varied uncertainty and ambiguity of information and hence understanding an image scene is far from being a general procedure. The situation becomes even graver when the images become corrupt with noise artifacts. The applications of proper analysis of images encompass a wide range of applications which include image processing, image mining, image inpainting, video surveillance, and intelligent transportation systems to name a few. One of the notable areas of research in image analysis is the estimation of age

progression in human beings through analysis of wrinkles in face images, which can be further utilized for tracing unknown or missing persons. Hurdle detection is one of the common tasks in robotic vision that has been done through image processing, by identifying different types of objects in the image and then calculating the distance between the robot and the hurdles. Image analysis has a lot to contribute in this direction.

This volume reports on the latest results or progress in the development of hybrid metaheuristic techniques for faithful image analysis and understanding. The book comprises nine chapters.

The chapter “Current and Future Trends in Segmenting Satellite Images Using Hybrid and Dynamic Genetic Algorithms” presents the foundation of a novel variant of the genetic algorithm named the Hybrid Dynamic Genetic Algorithm. The basis of the hybridization of the proposed genetic algorithm resorts to variable length chromosomes. An application of this algorithm is demonstrated on image segmentation.

In the chapter “A Hybrid Metaheuristic Algorithm Based on Quantum Genetic Computing for Image Segmentation”, the authors present a new algorithm for edge detection based on the hybridization of quantum computing and metaheuristics. The main idea is the use of cellular automata as a complex system for image modeling, and the quantum algorithm as a search strategy. The proposed Quantum Genetic Algorithm is found to be effective in edge detection.

The chapter “Genetic Algorithm Implementation to Optimize the Hybridization of Feature Extraction and Metaheuristic Classifiers” presents two face recognition frameworks involving the hybridization of both the feature extraction and classification stages. Feature extraction is performed through the two proposed hybrid techniques, one based on the orthogonal combination of local binary patterns and a histogram of oriented gradients, and the other based on Gabor filters and Zernike moments. A hybrid metaheuristic classifier is also investigated for classification based on the integration of genetic algorithms (GA) and support vector machines (SVM), where GA is used for optimization of the SVM parameters.

The chapter “Optimization of a HMM-Based Hand Gesture Recognition System Using a Hybrid Cuckoo Search Algorithm” focuses on the optimization of a HMM-based hand gesture recognition system using a hybrid cuckoo search algorithm. The authors present a comparative analysis of other classification techniques used in hand gesture recognition with their proposed hybridized bio-inspired metaheuristic approach, namely the Cuckoo Search Algorithm for reducing the complex trajectory in the hidden Markov model (HMM).

In the chapter “Satellite Image Contrast Enhancement Using Fuzzy Termite Colony Optimization”, the authors propose the Termite Colony Optimization (TCO) algorithm based on the behavior of termites. Thereafter they use the proposed TCO algorithm and fuzzy entropy for satellite image contrast enhancement. The proposed technique has been found to offer better contrast enhancement of images by utilizing a type-2 fuzzy system and TCO.

The goal of the segmentation techniques called deformable models is to adapt a curve in order to optimize the overlapping with another image of interest with the actual contour. Some of the problems existing in optimization are the choosing of an optimization method, the selection of parameters, and the initialization of curves. The chapter “Image Segmentation Using Metaheuristic-Based Deformable Models” discusses these problems with reference to metaheuristics which are designed to solve complex optimization and machine learning problems.

The chapter “Hybridization of the Univariate Marginal Distribution Algorithm with Simulated Annealing for Parametric Parabola Detection” presents a new hybrid optimization method based on the univariate marginal distribution algorithm for a continuous domain, and the heuristic of simulated annealing for the parabola detection problem. The proposed hybrid method is applied on the DRIVE database of retinal fundus images to approximate the retinal vessels as a parabolic shape. The hybrid method is applied separately using two different objective functions. Firstly, the objective function only considers the superposition of pixels between the target pixels in the input image and the virtual parabola, and secondly, the objective function implements a weighted restriction on the pixels close to the parabola vertex. Both objective functions in the hybrid method obtain suitable results to approximate a parabolic form on the retinal vessels present in the retinal images.

Thresholding is the simplest image segmentation method, where a global or local threshold value is selected for segmenting pixels into background and foreground regions. However, the determination of a proper threshold value is typically dependent on subjective assumptions or empirical rules. In the chapter “Image Thresholding Based on Fuzzy Particle Swarm Optimization”, the authors propose and analyze an image thresholding technique based on a fuzzy particle swarm optimization for efficient image segmentation.

Electrical Impedance Tomography (EIT) is a non-invasive imaging technique free of ionizing radiation. EIT image reconstruction is considered an ill-posed problem and, therefore, its results are dependent on the dynamics and constraints of reconstruction algorithms. The use of evolutionary and bio-inspired techniques to reconstruct EIT images has been taking place in the reconstruction algorithm area with promising qualitative results. In the chapter “Hybrid Metaheuristics Applied to Image Reconstruction for an Electrical Impedance Tomography Prototype”, the authors discuss the implementation of evolutionary and bio-inspired algorithms and its hybridizations to EIT image reconstruction.

The editor has tried to bring together some notable contributions in the field of computational intelligence involving hybrid metaheuristic techniques for the purpose of image analysis. These contributions will surely open up more research avenues in this direction given the fact that faithful image analysis still remains a challenging thoroughfare in the computer vision research community. This book will serve graduate students and researchers in computer science, electronics communication engineering, electrical engineering, and information technology as a reference book and as an advanced textbook for some parts of the curriculum. Last but not least, the editor would like to take this opportunity to extend heartfelt

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