Preface

Image and video segmentation is one of the most critical tasks of analysis which has the objective of extracting information (represented by data) from an image or a sequence of images (video). In the last 40 years, this field has experienced significant growth and progress, resulting in a virtual explosion of published information.

The field of image and video segmentation is still a very hot topic, with much advancement in recent years. As a consequence, there is considerable need for books like this one, which attempts to bring together a selection of the latest results from researchers involved in state-of-the-art work on image and video segmentation.

This book is intended for scientists and engineers who are engaged in research and development in image and video segmentation and who wish to keep pace with advances in this field. Comprehensive coverage of various branches of image and video segmentation is provided by more than 50 experts around the world. The book includes 20 chapters and they are organized into six sections.

Section I is for the purpose of providing background information, which consists of one introductory survey chapter (Chapter I). Section II is focused on image segmentation, which consists of four chapters (Chapters II through V) showing the advances of image segmentation by using optimization, variational model, meta-heuristic and dynamical systems. Section III is focused on video segmentation, which consists of four chapters (Chapters VI through IX) showing the advances of video segmentation in mean shift-based filtering, video object segmentation, active shape model, and shot boundary detection. Section IV consists of four chapters (Chapters X through VIII) presenting several new algorithms for segmenting particular types of images, such as color, texture, 3-D medical and multi-channel images. Section V contains four chapters (Chapters XIV through XVII) depicting various applications of segmentation techniques in fresh areas, such as human lip segmentation, machine-printed character segmentation, food image segmentation and blind navigation. Section VI presents higher level topics of segmentation evaluation,which consists of three chapters (Chapters XVIII through XX). Unsupervised and supervised evaluations, objective video evaluation as well as a summary of recent evaluation progress are presented.

Chapter I is entitled, "An Overview of Image and Video Segmentation in the Last 40 Years." A general rendering of research and development of image segmentation in the last 40 years is provided. The history of segmentation of digital images using computers can be traced back 40 years, and since then, this field has evolved very quickly and undergone great change. In this chapter, the position of image segmentation in the general scope of image techniques is first introduced; the formal definition and extension of image segmentation, as well as three layers of research on image

segmentation, are then explained. Based on the introduction and explanations, statistics for the number of developed algorithms is provided, a scheme for classifying different segmentation algorithms is discussed and a summary of existing survey papers for image segmentation is presented.

Chapter II is entitled, "Optimal Image Segmentation Methods Based on Energy Minimization." Three "case studies" are taken as representatives of recent work on solving segmentation problems (region segmentation, deformable templates matching and grouping) from the energy minimization perspective. Each of the three problems is solved via an optimization approach: respectively jump-diffusion, belief propagation and Bayesian inference. The purpose of the chapter is to show the connection between the formulation of the corresponding cost function and the optimization algorithm. This selection of only three problems and solutions allows the presentation of the fundamental elements of optimization in each particular case and brings the reader to the arena of optimization-based segmentation.

Chapter III is entitled, "Variational Problems in Image Segmentation and Γ–Convergence Methods." Variational models for image segmentation aim to recover a piecewise, smooth approximation of a given input image together with a discontinuity set which represents the boundaries of the segmentation. In the variational method introduced by Mumford and Shah, the length of the discontinuity boundaries in the energy is included; such a geometric term makes the minimization of the corresponding functional a difficult numerical problem. A mathematical framework for the Mumford-Shah functional is considered. The use of the Γ-convergence theory to approximate the functional by elliptic is suggested. The design of an iterative numerical scheme for image segmentation based on the Γ-convergent approximation is discussed. The relation between the Mumford-Shah model and the Perona-Malik equation has also been discussed.

Chapter IV is entitled, "A Graph-Based Image Segmentation Algorithm Using Hierarchical Social Metaheuristic." This chapter proposes a new evolutionary graph-based image segmentation method to improve quality results. Such an approach is quite general. It starts from an image described by a simplified, undirected weighted graph where nodes represent either pixels or regions and weighted edges measure the dissimilarity between pairs of pixels or regions. The resulting graph is successively partitioned into two sub-graphs in a hierarchical fashion, corresponding to the two most significant components of the actual image, until a termination condition is met. This graph-partitioning task is solved as a variant of the min-cut problem (normalized cut) using a Hierarchical Social (HS) meta-heuristic. As a consequence of this iterative graph bipartition stage, pixels or regions are initially merged into the two most coherent components, which are successively bi-partitioned according to this graph-splitting scheme.

Chapter V is entitled "Modeling Complex Dynamical Systems for Image Segmentation." As motivated by biological experimental findings, two network models of coupled chaotic elements for image segmentation are introduced in this chapter. In both models, time evolutions of chaotic elements that correspond to the same object in a given image are synchronized with one another, while this synchronized evolution is desynchronized with respect to time evolution of chaotic elements corresponding to other objects in the image. The first model is a continuous flow, and the segmentation process incorporates geometrical information of input images, while the second model is a network of discrete maps for pixel clustering, accompanying an adaptive moving mechanism to eliminate pixel ambiguity.

Chapter VI is entitled, "Joint Space-Time-Range Mean Shift-Based Image and Video Segmentation." In this chapter, image and video segmentation is addressed by using mean shift-based filtering. A variety of mean shift filtering approaches are described for image/video segmentation and nonlinear edge-preserving image smoothing. A joint space-time-range domain mean shift-based video segmentation approach is presented. Segmentation of moving/static objects/background is obtained through inter-frame mode-matching in consecutive frames and motion vector mode estimation. Newly appearing objects/regions in the current frame, due to new foreground objects or uncovered background regions, are segmented by intra-frame mode estimation.

Chapter VII is entitled, "Fast Automatic Video Object Segmentation for Content-Based Applications." An algorithm has been devised for fast, fully automatic and reliable object segmentation from live video for scenarios with static camera. Methods for: (1) adaptive determination of the threshold for change detection; (2) robust stationary background reference frame generation, which, when used in change detection, can reduce segmentation fault rate and solve the problems of occluded objects appearing as part of segmented moving objects; (3) adaptive reference frame selection to improve segmentation results; and (4) spatial refinement of modified change detection mask by incorporating information from edges, gradients and motion to improve the accuracy of segmentation contours are proposed.

Chapter VIII is entitled, "A Fully Automated Active Shape Model for Segmentation and Tracking of Unknown Objects in a Cluttered Environment." A fully automated active shape model (ASM) for the tracking of non-rigid unknown objects in a cluttered and changing environment is described. The segmentation of shapes is automated, using a new objective function to deform and move a contour toward the actual shape. New profile modeling and optimization criteria to automatically find corresponding points are also applied for segmentation and tracking of people in cluttered backgrounds. This algorithm presents a major extension to the state-of-the-art and the original ASM, which was designed for known objects in smooth nonchanging backgrounds, and where the landmark points need to be manually picked offline. This is a fully automated, real time ASM that deals with changing backgrounds and does not require prior knowledge of the object to be segmented and tracked.

Chapter IX is entitled, "Video Shot Boundary Detection and Scene Segmentation." This chapter presents a new and efficient method for shot boundary detection (SBD) and scene segmentation. The new SBD method is based on sequential change detection to achieve improved detection accuracy. The method is then extended to segment videos into scenes. Compared with existing scene segmentation methods, the proposed method can also obtain more accurate results over a large set of test videos.

Chapter X is entitled, "Color Image Segmentation in Both Feature and Image Spaces." Watershed algorithm is traditionally applied on image domain. It fails to capture the global color distribution information. In this chapter, the watershed algorithm is first applied in feature space to extract clusters with irregular shapes. After getting the initial segmentation result by feature space analysis, attention is turned to image space, and the final result is obtained by minimizing a global energy function based on Markov Random Field theory. Two efficient energy minimization algorithms, Graph Cuts and Highest Confidence First (HCF), are explored under this framework.

Chapter XI is entitled, "Optimising Texture Primitives Description, Analysis, Segmentation, and Classification Using Variography." Most approaches dealing with various aspects of texture analysis and segmentation require the application of a template

to a given image, pixel by pixel, to yield a new image. The selection of an appropriate window size is critical and affects directly the results obtained. In this chapter, a new approach based on the concept of variography is proposed to automatically select the optimal window. Some direct applications, including textural primitive's description, mathematical morphology, textural segmentation and textural classification are reported.

Chapter XII is entitled, "Methods and Applications for Segmenting 3D Medical Image Data." An overview of the popular and relevant methods that may be applicable for the general problem of 3D medical image segmentation is provided, with a discussion about their advantages and limits. Specifically, the issue of incorporating prior knowledge into the segmentation of anatomic structures is discussed and the concept and issues of Knowledge Based Segmentation are described in detail. Typical sample applications will accompany the discussions throughout this chapter. This will help an application developer to gain insights in the understanding and application of various computer vision approaches to solve real-world problems of medical image segmentation.

Chapter XIII is entitled, "Parallel Segmentation of Multichannel Images Using Multidimensional Mathematical Morphology." It is recognized that mathematical morphology-based segmentation of multi-channel imagery has not been fully achieved yet, mainly due to the lack of vector-based strategies to extend classic morphological operations to multidimensional imagery. In this chapter, a vector-preserving framework to extend morphological operations to multi-channel images is described, and a fully automatic, multi-channel watershed segmentation algorithm that naturally combines spatial and spectral/temporal information is proposed. Due to the large data volumes often associated with multi-channel imaging, a parallel implementation strategy to speed up performance is also developed.

Chapter XIV is entitled, "Fuzzy Clustering-Based Approaches for Automatic Lip Segmentation from Color Images." Lip image segmentation plays an important role in lip image analysis, which has recently received much attention because the visual information extracted has been shown to provide significant improvement for speech recognition and speaker authentication, especially in noisy environments. This chapter describes different lip image segmentation techniques, with emphasis on segmenting color lip images. The state-of-the-art classification-based techniques for color lip segmentation—the "spatial fuzzy c-mean clustering (SFCM)" and the "fuzzy c-means with shape function (FCMS)" are described in detail. These methods integrate color information along with different kinds of spatial information into a fuzzy clustering structure.

Chapter XV is entitled, "Mathematical Morphology Based Automatic Restoration and Segmentation for Degraded Machine-Printed Character Images." This chapter presents a morphological approach for automatic segmentation of seriously degraded machine-printed character images. This approach consists of four modules: (1) detecting and segmenting natural pitch characters based on the vertical projection of their binary images; (2) detecting fragments in broken characters and merging these fragments before the eventual segmentation; (3) employing a morphological thickening algorithm on the binary image for locating the separating boundaries of overlapping characters; and (4) executing a morphological thinning algorithm and calculating segmentation cost for determining the most appropriate coordinate at the image for dividing touching characters.

Chapter XVI is entitled, "Segmentation in Food Images." A robust algorithm to segment food image from a background is presented using colour images in this chapter. The proposed method has three steps: (1) computation of a high contrast grey value image from an optimal linear combination of the RGB colour components; (2) estimation of a global threshold using a statistical approach; and (3) morphological operation in order to fill the possible holes presented in the segmented binary image. The segmentation performance was assessed by computing the area A_z under the Receiver Operation Characteristic (ROC) curve.

Chapter XVII is entitled, "Segmentation via Thresholding Methodologies by Using Measure of Fuzziness Towards Blind Navigation." Blind navigation is specialized research directed toward the development of navigation aids for blind people to minimize assistance from sighted individuals during navigation. In this paper, two methodologies of segmentation are detailed and certain aspects of the methodologies are compared. Measure of fuzziness is applied in both the segmentation methodologies to find the threshold values. The first methodology was developed for a single camera, whereas the second was developed for stereo camera systems.

Chapter XVIII is entitled, "Unsupervised and Supervised Segmentation Evaluation." Though many segmentation methods have been proposed in the literature, it is difficult to compare their efficiency. In order to solve this problem, some evaluation criteria have been proposed for the last decade to quantify the quality of a segmentation result. Supervised evaluation criteria use some *a priori* knowledge, such as a ground truth, while unsupervised evaluation computes some statistics in the segmentation result according to the original image. The main objective of this chapter is to review both types of evaluation criteria from the literature first, then to make a comparative study in order to identify their efficiency for different types of images.

Chapter XIX is entitled, "Objective Evaluation of Video Segmentation Quality." The current practice for the evaluation of video segmentation quality is based on subjective testing, which is an expensive and time-consuming process. Objective segmentation quality evaluation techniques can alternatively be used, once appropriate algorithms become available. The evaluation methodologies and objective segmentation quality metrics, both for individual objects and complete segmentation partitions, are introduced. Standalone and relative evaluation metrics are proposed for use when reference segmentation is missing, or available for comparison, respectively.

Chapter XX is entitled, "A Summary of Recent Progress for Segmentation Evaluation." This chapter provides a summary of the recent (especially in the 21st century) progress in evaluating image and video segmentation. It is seen that much more attention has been given to this subject recently than several years ago. A number of works are based on previous proposed principles, several works made modifications and improvements on previous proposed techniques and some works presented new ideas. The generality and complexity of the evaluation methods and performance criteria used in these works have been thoroughly compared. As the research in this field is still on the rise, some existing problems and several future research directions are also pointed out.

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