Preface

Segmentation of medical images in 2-D, 3-D, and 4-D has taken new dimension. This is mainly because for real-time image guidance in diagnosis and therapeutics. The application of image/volume registration is prominently seen in reconstruction, multimodality fusion, and now propagating in atlas-based analysis. The focus of this book is to share the application of combined segmentation and registration in medical imaging.

Some of the cutting edge topics in segmentation covered in the book are graph cut, energy minimization methods, cine loop processing in cardiac applications, parametric and geometric deformable models in combination with principal component analysis, breast mass classification, classification of thyroid lesions into benign and malignant using vasculature properties, classification of autistic versus nonautistic brain data sets, and geometric modeling for prosthesis design. Some of the advanced topics in image/volume registration are optimizers for image registration, such as Amoeba, conjugate gradient, and gradient-based methods and techniques for alignment of images of a textured object with a given prototype, multimodality approaches to image registration. The book also presents united variation frameworks where prior segmentation information can be seamlessly integrated into nonrigid registration procedures for brain structure registration. The detail layout of the book is as follows.

Chapter 1 gives a brief overview of the most popular medical image segmentation techniques and discusses their capabilities and basic advantages and limitations. Moreover, the state-of-the-art techniques of the last decade are outlined.

Chapter 2 presented a graph cut-based segmentation approach to segment cerebral white matter (CWM) from magnetic resonance images (MRIs). This approach is based on using a probabilistic variation of the traditional graph cut algorithm with an improved parameter selection mechanism for the energy function, to be optimized in a graph cut problem.

Chapter 3 introduced a new framework to analyze noncontrast agent cine cardiac magnetic resonance (CMR). The framework includes two automated algorithms (1) to segment the inner and outer borders (or walls) from the surrounding tissues in cine CMR images based on using a new stochastic speed function to control the evolution of geometric deformable model, and (2) to estimate the local wall thickness, and thickening function indexes based on solving Laplace's equation in the segmented wall to find point-to-point correspondences between the inner and outer border of the segmented wall.

Chapter 4 presented a novel shape-based segmentation approach using learned prior and current appearance model. The target shapes are approximated directly with linear combinations of distance vectors describing positions of the mutually aligned training shapes with respect to their common centroid. Such a vector space is now closed with respect to the linear operations and it is of much smaller dimensionality than the 2-D distance maps. Prior knowledge of visual appearance of the object is represented by Gibbs energies of its gray levels. To accurately separate the object from its background, each current empirical marginal probability distribution of gray values within a deformable boundary is also approximated with an adaptive linear combination of discrete Gaussians. Both the shape/appearance priors and the current probabilistic appearance description control the boundary evolution.

An improved level set-based mass segmentation is presented in Chap. 5 to classify the segmented mass to malignant or benign based on the estimated texture and morphological features. The new mass segmentation algorithm is based on a new energy functional, which combines energy terms from several traditional algorithms. In Chap. 6, an image-based framework is presented to diagnose single thyroid nodule. This image-based approach is based on three main steps: (1) image preprocessing; (2) morphological aperture for contrast agent bubbles detection; (3) thresholding and 3-D lesion reconstruction. Chapter 7 covers a novel framework to analyze the cortex of the patient with autism using spherical harmonics analysis. Chapter 8 covers state-of-the-art approaches related to surface reconstruction and geometric methods that have been used for digital prosthesis design. Chapter 9 covers the necessary background information required to understand medical image registration, the basic tools required to implement registration algorithms, and to demonstrate a complete application for various types of registration between different modalities using freely available and maintained software.

Chapter 10 presented a novel approach to align an image of a textured object with a given prototype using a new similarity measure. Visual appearance of the images, after equalizing their signals, is modeled with a Markov–Gibbs random field (MGRF) with pairwise interaction. Similarity to the prototype is measured by a Gibbs energy of signal co-occurrences in a characteristic subset of pixel pairs derived automatically from the prototype. Chapter 11 covers three registration methods that address some of the technical choices that are part of specific engineering solutions. These, while driven by concrete clinical needs, may generalize well to similar problems in other domains requiring image registration. Chapter 12 presented registration-based framework to estimate ocular surface temperature. Chapter 13 presented simultaneous segmentation and registration approach to track brain morphological changes in MRIs.

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