

Digital Image Processing for Ophthalmology

Detection of the Optic Nerve Head

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Digital Image Processing for Ophthalmology: Detection of the Optic Nerve Head
Xiaolu Zhu, Rangaraj M. Rangayyan, and Anna L. Ellis

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SYNTHESIS LECTURES ON BIOMEDICAL ENGINEERING #40

ABSTRACT

Fundus images of the retina are color images of the eye taken by specially designed digital cameras. Ophthalmologists rely on fundus images to diagnose various diseases that affect the eye, such as diabetic retinopathy and retinopathy of prematurity.

A crucial preliminary step in the analysis of retinal images is the identification and localization of important anatomical structures, such as the optic nerve head (ONH), the macula, and the major vascular arcades. Identification of the ONH is an important initial step in the detection and analysis of the anatomical structures and pathological features in the retina. Different types of retinal pathology may be detected and analyzed via the application of appropriately designed techniques of digital image processing and pattern recognition. Computer-aided analysis of retinal images has the potential to facilitate quantitative and objective analysis of retinal lesions and abnormalities. Accurate identification and localization of retinal features and lesions could contribute to improved diagnosis, treatment, and management of retinopathy.

This book presents an introduction to diagnostic imaging of the retina and an overview of image processing techniques for ophthalmology. In particular, digital image processing algorithms and pattern analysis techniques for the detection of the ONH are described. In fundus images, the ONH usually appears as a bright region, white or yellow in color, and is indicated as the convergent area of the network of blood vessels. Use of the geometrical and intensity characteristics of the ONH, as well as the property that the ONH represents the location of entrance of the blood vessels and the optic nerve into the retina, is demonstrated in developing the methods.

The image processing techniques described in the book include morphological filters for preprocessing fundus images, filters for edge detection, the Hough transform for the detection of lines and circles, Gabor filters to detect the blood vessels, and phase portrait analysis for the detection of convergent or node-like patterns. Illustrations of application of the methods to fundus images from two publicly available databases are presented, in terms of locating the center and the boundary of the ONH. Methods for quantitative evaluation of the results of detection of the ONH using measures of overlap and free-response receiver operating characteristics are also described.

KEYWORDS

digital image processing, detection of blood vessels, detection of circles, edge detection, Gabor filter, Hough transform, morphological filters, node maps, optic disc, optic nerve head, pattern recognition, phase portraits, retinal fundus images

Xiaolu dedicates this book to her parents:
Qingqiao Wang *and* Guoyou Zhu

Contents

Preface	xiii
Acknowledgments	xv
1 Introduction	1
1.1 Diagnostic Imaging of the Eye	1
1.1.1 Anatomy and physiology of the eye	1
1.1.2 Diseases and conditions that affect the retina	1
1.1.3 Imaging of the retina	2
1.2 Interpretation of Images of the Retina	3
1.3 Computer-aided Diagnosis of Diseases Affecting the Eye	4
1.4 Scope and Organization of the Book	6
2 Computer-aided Analysis of Images of the Retina	9
2.1 Detection of Anatomical Features of the Retina	9
2.1.1 Detection of the optic nerve head	9
2.1.2 Detection of the macula	11
2.1.3 Detection of blood vessels	12
2.2 Detection of Abnormal Features	12
2.3 Longitudinal Analysis of Images	12
2.4 Remarks	13
3 Detection of Geometrical Patterns	15
3.1 Filters for Preprocessing Images	15
3.2 Detection of Edges	17
3.2.1 Prewitt and Sobel operators	17
3.2.2 The Canny method	19
3.3 Detection of Oriented Structures	21
3.3.1 The matched filter	21
3.3.2 The Gabor filter	22
3.4 Detection of Geometrical Patterns	24
3.4.1 The Hough transform	24

	3.4.2 Phase portraits	29
	3.5 Remarks	35
4	Datasets and Experimental Setup	37
	4.1 The DRIVE Dataset	37
	4.2 The STARE Dataset	37
	4.3 Scale Factor for Converting Between the Two Datasets	38
	4.4 Annotation of Images of the Retina	39
	4.5 Evaluation of the Results of Detection	39
	4.5.1 Measures of distance and overlap	39
	4.5.2 Free-response receiver operating characteristics	40
	4.6 Remarks	41
5	Detection of the Optic Nerve Head Using the Hough Transform	43
	5.1 Derivation of the Edge Map	43
	5.2 Analysis of the Hough Space	44
	5.2.1 Procedure for the detection of the ONH	44
	5.2.2 Selection of the circle using the reference intensity	46
	5.3 Results of Detection of the Optic Nerve Head	51
	5.4 Discussion	51
	5.5 Remarks	57
6	Detection of the Optic Nerve Head Using Phase Portraits	59
	6.1 Derivation of the Orientation Field	59
	6.2 Analysis of the Node Map	59
	6.3 Results of Detection of the Optic Nerve Head	64
	6.4 Discussion	65
	6.4.1 Comparative analysis	69
	6.5 Remarks	72
7	Concluding Remarks	75
	References	77
	Authors' Biographies	85
	Index	89

Preface

Large numbers of fundus images of the retina are being analyzed by ophthalmologists around the world. Digital imaging techniques and computing resources have been improving at rapid rates and finding more and more practical applications. Over the past 20 years, researchers have been applying digital image processing techniques to ophthalmology with the aim of improved diagnosis.

This is an introductory book on digital image processing for application in ophthalmology. In particular, methods for automated detection of landmark features in retinal fundus images, such as the optic nerve head, fovea, and blood vessels are described in detail. The digital image processing techniques described include morphological filters, edge detectors, Gabor filters, the Hough transform, and phase portrait analysis. Methods for quantitative evaluation of the results of detection, such as distance measures and free-response receiver operating characteristics are also described. The image processing and quantitative evaluation techniques are not limited to medical applications.

The methods described in this book are mathematical in nature. It is assumed that the reader is proficient in advanced mathematics and familiar with basic notions of data, signal, and image processing. The methods of image modeling and analysis are suitable for inclusion in courses for students in the final year of bachelor's programs in electrical engineering, computer engineering, mathematics, physics, computer science, biomedical engineering, and bioinformatics. The techniques should also be useful to researchers in various areas of image modeling and analysis, and could be included in graduate courses on digital image processing, medical imaging, and related topics. The book is copiously illustrated with images and examples of application to facilitate efficient comprehension of the notions and methods presented.

We wish our readers success in their studies and research.

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