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Edge Detection Methods Based on Generalized Type-2 Fuzzy Logic

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ISSN 2191-530X
SpringerBriefs in Applied Sciences and Technology
ISBN 978-3-319-53993-5
DOI 10.1007/978-3-319-53994-2

ISSN 2191-5318 (electronic)
ISBN 978-3-319-53994-2 (eBook)

Library of Congress Control Number: 2017932637

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Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Edge detectors have traditionally been an essential part of many computer vision systems. There are different methods that have been proposed for improving edge detection in real images. This book presents a new edge detection method based on generalized type-2 fuzzy systems (GT2 FSs) which allows better modeling of the uncertainty that exists in digital images processing.

In this book four new methods are proposed. In the first method the generalized type-2 fuzzy logic is combined with the morphological gradient technique. The second method combines the GT2 FSs and the Sobel operator; in the third approach the methodology based on Sobel operator and GT2 FSs is improved to be applied on color images. In the fourth approach, we proposed a novel edge detection method, where a digital image is converted into a generalized type-2 fuzzy image. In the contribution is also included a comparative study of type-1, interval type-2 and generalized type-2 fuzzy systems as tools to enhance edge detection in digital images when used in conjunction with the morphological gradient and the Sobel operator. The proposed generalized type-2 fuzzy edge detection methods were tested with benchmark images and synthetic images, in a grayscale and color format.

Another contribution in this book is that the generalized type-2 fuzzy edge detector method is applied in the preprocessing phase of a face recognition system, where the recognition system is based on a monolithic neural network. The aim of this part of the book is to show the advantage of using a generalized type-2 fuzzy edge detector in pattern recognition applications. Additionally, make a comparative analysis with the recognition rates obtained by the generalized type-2 against the results achieved by type-1 and interval type-2 fuzzy edge detectors.

The main goal of using generalized type-2 fuzzy logic in edge detection applications is to provide them with the ability to handle uncertainty in processing real-world images; otherwise, to demonstrate that a GT2 fuzzy systems has a better performance than the edge detection methods based on type-1 and type-2 fuzzy systems.

In Chap. 1, we offer a brief introduction about the motivation to use generalized type-2 fuzzy systems to improve the edge detection process in the digital image

processing. We describe the use of this method to process synthetic and real images in grayscale and color format; as well as, to apply this approach in pattern recognition applications. We also mention the traditional methods and soft computing approaches that there exist for edge detection.

We describe in Chap. 2 the basic theory concepts about generalized type-2 fuzzy sets. We explain the generalized type-2 fuzzy system approximation based on α -planes including the fuzzifier process, fuzzy rules, inference engine, type reducer and defuzzification process; all these definitions are used for the implementation of this investigation work.

Chapter 3 introduces the edge detection definition. This chapter describes the main edge detection methods based on gradient techniques, such as the Morphological gradient and Sobel operator. We offer the concepts, equations and pseudocode to apply these methods on grayscale and color images. We also describe in this chapter some filters used in digital image processing in which are included the low-pass filters and high-pass filters.

We explain in Chap. 4 some available metrics to measure the quality of the edge detection methods. This chapter describes the figure of merit of Pratt (FOM) and the quality measurement using the MSE, PSNR and SSIM indices. We also include the equations to calculate these metrics.

Chapter 5 describes the methodology used to develop the edge detection methods based on generalized type-2 fuzzy systems (GT2 FSs). This chapter explains the definitions, equations, the input and output membership functions, fuzzy rules and general characteristic used to develop the four edge detection approaches. The first edge detection approach is based on GT2 FSs and the morphological gradient. The second is the edge detection method based on GT2 FSs and the Sobel operator. The third is the generalized type-2 fuzzy edge detection method applied on color images and finally, the edge detection method using GT2 fuzzy images.

We explain in Chap. 6 the methodology to develop a GT2 fuzzy edge detection method based on Sobel operator, the low-pass and high-pass filters. This chapter describes the process to apply the fuzzy edge detection method on a face recognition system. We also offer the configurations used in the monolithic neural network.

Chapter 7 presents the simulation results with benchmark image databases to illustrate the advantages of the proposed generalized type-2 fuzzy edge detection methods. This chapter offers a comparison analysis with other approaches including the traditional edge detection methods and the fuzzy edge detection methods based on type-1 and interval type-2 fuzzy systems. We also present the recognition rates achieved by the face recognition system when the general type-2 fuzzy edge detection is applied.

Chapter 8, offers the conclusions regarding to research done with the focus on the general type-2 fuzzy systems and how these improve the performance for the edge detection process and the face recognition systems; as well as this methodology achieved better results than the type-1 and interval type-2 fuzzy systems.

We end this preface of the book by extending our gratitude to all the people who with their vision, knowledge and experience help us to overcome technical difficulties derived from this work. We would like to thank to our supporting agencies, CONACYT, for the opportunity to perform our research. Of course, we also need to thank the institutions, University of Baja California and Tijuana Institute of Technology, for supporting our project. Finally, we thank our families for their unconditional support during all these years to successfully conclude this book and for their motivation to go further and never give up.

Tijuana, Mexico
October 2016

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