

Studies in Computational Intelligence

Volume 821

Series editor

Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland

e-mail: kacprzyk@ibspan.waw.pl

The series “Studies in Computational Intelligence” (SCI) publishes new developments and advances in the various areas of computational intelligence—quickly and with a high quality. The intent is to cover the theory, applications, and design methods of computational intelligence, as embedded in the fields of engineering, computer science, physics and life sciences, as well as the methodologies behind them. The series contains monographs, lecture notes and edited volumes in computational intelligence spanning the areas of neural networks, connectionist systems, genetic algorithms, evolutionary computation, artificial intelligence, cellular automata, self-organizing systems, soft computing, fuzzy systems, and hybrid intelligent systems. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution, which enable both wide and rapid dissemination of research output.

The books of this series are submitted to indexing to Web of Science, EI-Compendex, DBLP, SCOPUS, Google Scholar and Springerlink.

More information about this series at <http://www.springer.com/series/7092>

Rafał Scherer

Computer Vision Methods for Fast Image Classification and Retrieval

Rafał Scherer
Institute of Computational Intelligence
Częstochowa University of Technology
Częstochowa, Poland

ISSN 1860-949X ISSN 1860-9503 (electronic)
Studies in Computational Intelligence
ISBN 978-3-030-12194-5 (hardcover) ISBN 978-3-030-12195-2 (eBook)
ISBN 978-3-030-12197-6 (softcover)
<https://doi.org/10.1007/978-3-030-12195-2>

Library of Congress Control Number: 2018968376

© Springer Nature Switzerland AG 2020

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

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

Preface

Computer vision and image retrieval and classification are a vital set of methods used in various engineering, scientific and business applications. In order to describe an image, visual features must be detected and described. Usually, the description is in the form of vectors. The book presents methods for accelerating image retrieval and classification in large datasets. Some of the methods (Chap. 5) are designed to work directly in relational database management systems.

The book is the result of collaboration with colleagues from the Institute of Computational Intelligence at the Czestochowa University of Technology. I would like to thank my former Ph.D. students Dr. Rafał Grycuk and Dr. Patryk Najgebauer for their cooperation.

I would like to express my sincere thanks to my friend Prof. Marcin Korytkowski for his invaluable help in research and to Prof. Leszek Rutkowski, who introduced me to scientific work and supported me in a friendly manner. I am also grateful to the Institute of Computational Intelligence at the Czestochowa University of Technology for providing a scholarly environment for both teaching and research.

Finally, I am truly grateful to my wife Magda, my children Karolina and Katarzyna for their love and patience and to my mother for raising me in the way that she did.

Czestochowa, Poland
November 2018

Rafał Scherer

Contents

1	Introduction	1
	References	3
2	Feature Detection	7
2.1	Local Features	7
2.1.1	Scale-Invariant Feature Transform (SIFT)	7
2.1.2	Speed-Up Robust Features (SURF)	9
2.2	Edge Detection	12
2.2.1	Canny Edge Detection	16
2.3	Blob Detection and Blob Extraction	18
2.4	Clustering Algorithms	19
2.4.1	K-means Clustering Algorithm	20
2.4.2	Mean Shift Clustering Algorithm	20
2.5	Segmentation	22
2.6	Global Features	26
2.6.1	Colour and Edge Directivity CEDD Descriptor	27
2.7	Summary and Discussion	29
	References	29
3	Image Indexing Techniques	33
3.1	Image Classification by Fuzzy Rules	34
3.1.1	Boosting-Generated Simple Fuzzy Classifiers	36
3.1.2	Classification of a Query Image	40
3.1.3	Experiments	41
3.1.4	Conclusions	42
3.2	Salient Object Detector and Descriptor by Edge Crawler	44
3.2.1	System for Content-Based Image Retrieval	47
3.2.2	Experimental Results	49
3.2.3	Conclusions	55

3.3	Fast Two-Level Image Indexing	55
3.3.1	Hash Generation	56
3.3.2	Structure of the Proposed Descriptor Index	58
3.3.3	Index Search Process	58
3.3.4	Experimental Results	60
3.3.5	Conclusions	63
3.4	Image Colour Descriptor	64
3.4.1	Method Description	65
3.4.2	Color Descriptor	66
3.4.3	Colour Relationship Sub-descriptor	67
3.4.4	Descriptor Comparison	67
3.4.5	Experimental Results	68
3.4.6	Conclusions	71
3.5	Fast Dictionary Matching	71
3.5.1	Description of the Problem	72
3.5.2	Method Description	73
3.5.3	Comparison Between Descriptors and Dictionary	73
3.5.4	Matching Sets of Keypoints	74
3.5.5	Experimental Results	76
3.5.6	Conclusions	78
3.6	Summary and Discussion	79
	References	80
4	Novel Methods for Image Description	83
4.1	Algorithm for Discontinuous Edge Description	83
4.1.1	Proposed Approach	86
4.1.2	Experimental Results	90
4.1.3	Conclusions	93
4.2	Interest Point Localization Based on the Gestalt Laws	95
4.2.1	Problem Description	96
4.2.2	Method Description	97
4.2.3	Experiments	102
4.2.4	Conclusions	103
4.3	Summary and Discussion	103
	References	104
5	Image Retrieval and Classification in Relational Databases	107
5.1	Bag of Features Image Classification in Relational Databases	108
5.1.1	System Architecture and Relational Database Structure	109
5.1.2	Numerical Simulations	112
5.1.3	Conclusions	113

5.2	Bag of Features Image Retrieval in Relational Databases	114
5.2.1	Description of the Proposed System	114
5.2.2	Numerical Experiments	117
5.2.3	Conclusions	118
5.3	Database Indexing System Based on Boosting and Fuzzy Sets	118
5.3.1	Building Visual Index	119
5.3.2	Proposed Database Framework	120
5.3.3	Numerical Simulations	124
5.3.4	Conclusions	126
5.4	Database Retrieval System Based on the CEDD Descriptor	126
5.4.1	Simulation Environment	130
5.4.2	Conclusions	133
5.5	Summary and Discussion	133
	References	134
6	Concluding Remarks and Perspectives in Computer Vision	137