

Advances in Computer Vision and Pattern Recognition

For further volumes:
www.springer.com/series/4205

Giovanni Maria Farinella • Sebastiano Battiato •
Roberto Cipolla

Editors

Advanced Topics in Computer Vision

 Springer

Editors

Dr. Giovanni Maria Farinella
Dipartimento di Matematica e Informatica
Università di Catania
Catania, Italy

Prof. Roberto Cipolla
Department of Engineering
University of Cambridge
Cambridge, UK

Prof. Sebastiano Battiato
Dipartimento di Matematica e Informatica
Università di Catania
Catania, Italy

Series Editors

Prof. Sameer Singh
Research School of Informatics
Loughborough University
Loughborough, UK

Dr. Sing Bing Kang
Interactive Visual Media Group
Microsoft Research
Redmond, WA, USA

ISSN 2191-6586

Advances in Computer Vision and Pattern Recognition

ISBN 978-1-4471-5519-5

DOI 10.1007/978-1-4471-5520-1

Springer London Heidelberg New York Dordrecht

ISSN 2191-6594 (electronic)

ISBN 978-1-4471-5520-1 (eBook)

Library of Congress Control Number: 2013950636

© Springer-Verlag London 2013

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. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.

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.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

Computer vision is the science and technology of making machines that see. It is concerned with the theory, design and implementation of algorithms that can automatically process visual data to recognize objects, track and recover their shape and spatial layout.

This edited volume contains a selection of articles covering both theoretical and practical aspects of the three main area in Computer Vision: Reconstruction, Registration, and Recognition. The book provides both, an in-depth overview of challenging areas, as well as novel advanced algorithms which exploit Machine Learning and Pattern Recognition techniques to infer the semantic content of images and videos. The topics covered by the chapters include visual feature extraction, feature matching, image registration, 3D reconstruction, object detection and recognition, human actions recognition, image segmentation, object tracking, metric learning, loopy belief propagation, etc. Each chapter contains key references to the existing literature.

The authors of the chapters have been selected among the best students who attended the International Computer Vision Summer School (ICVSS) in the last years, and are co-authored by world renowned researchers in Computer Vision. ICVSS was established in 2007 to provide both an objective and clear overview and an in-depth analysis of the state-of-the-art research in Computer Vision. The courses are delivered by experts in the field, from both academia and industry, and cover both theoretical and practical aspects of real Computer Vision problems. The school is organized every year by University of Cambridge (Computer Vision and Robotics Group) and University of Catania (Image Processing Lab). Different topics are covered each year. A summary of the past Computer Vision Summer Schools can be found at: <http://www.dmi.unict.it/icvss>.

It is our hope that graduate students, young and senior researchers, and academic/industrial professionals will find the book useful for understanding and reviewing current approaches in Computer Vision, thereby continuing the mission of the International Computer Vision Summer School.

Sicily, Italy
June 2013

Giovanni Maria Farinella
Sebastiano Battiato
Roberto Cipolla

Acknowledgements

We would like to take this opportunity to thank all contributors of this book, and all people involved in the organization of ICVSS.

Contents

1	Visual Features—From Early Concepts to Modern Computer Vision	1
	Martin Weinmann	
2	Where Next in Object Recognition and how much Supervision Do We Need?	35
	Sandra Ebert and Bernt Schiele	
3	Recognizing Human Actions by Using Effective Codebooks and Tracking	65
	Lamberto Ballan, Lorenzo Seidenari, Giuseppe Serra, Marco Bertini, and Alberto Del Bimbo	
4	Evaluating and Extending Trajectory Features for Activity Recognition	95
	Ross Messing, Atousa Torabi, Aaron Courville, and Chris Pal	
5	Co-recognition of Images and Videos: Unsupervised Matching of Identical Object Patterns and Its Applications	113
	Minsu Cho, Young Min Shin, and Kyoung Mu Lee	
6	Stereo Matching—State-of-the-Art and Research Challenges	143
	Michael Bleyer and Christian Breiteneder	
7	Visual Localization for Micro Aerial Vehicles in Urban Outdoor Environments	181
	Andreas Wendel and Horst Bischof	
8	Moment Constraints in Convex Optimization for Segmentation and Tracking	215
	Maria Klodt, Frank Steinbrücker, and Daniel Cremers	
9	Large Scale Metric Learning for Distance-Based Image Classification on Open Ended Data Sets	243
	Thomas Mensink, Jakob Verbeek, Florent Perronnin, and Gabriela Csurka	

10	Top–Down Bayesian Inference of Indoor Scenes	277
	Luca Del Pero and Kobus Barnard	
11	Efficient Loopy Belief Propagation Using the Four Color Theorem	313
	Radu Timofte and Luc Van Gool	
12	Boosting k-Nearest Neighbors Classification	341
	Paolo Piro, Richard Nock, Wafa Bel Haj Ali, Frank Nielsen, and Michel Barlaud	
13	Learning Object Detectors in Stationary Environments	377
	Peter M. Roth, Sabine Sternig, and Horst Bischof	
14	Video Temporal Super-resolution Based on Self-similarity	411
	Mihoko Shimano, Takahiro Okabe, Imari Sato, and Yoichi Sato	
	Index	431

Contributors

Editors' Biographies

Giovanni Maria Farinella

Giovanni Maria Farinella obtained the Master degree in Computer Science (egregia cum laude) from University of Catania in 2004. He was awarded a Ph.D. degree (Computer Vision) in 2008. He became Associate Member of the Computer Vision and Robotics Research Group at University of Cambridge in 2006. He joined the Image Processing Laboratory (IPLAB) at the Department of Mathematics and Computer Science, University of Catania in 2008 as Contract Researcher. He is Contract Professor of Computer Vision at the School of Arts of Catania (since 2004) and Adjunct Professor of Computer Science at the University of Catania (since 2008). His research interests lie in the fields of Computer Vision, Pattern Recognition and Machine Learning. He has edited three volumes and co-authored more than 50 papers in international journals, conference proceedings and book chapters. He is a co-inventor of 3 international patents. Dr. Farinella also serves as a reviewer and on the programme committee for major international journals and international conferences. He has participated to several international and national research projects. Dr. Farinella founded (in 2006) and currently directs the International Computer Vision Summer School (www.dmi.unict.it/icvss).

Sebastiano Battiato

Sebastiano Battiato received his degree in computer science (summa cum laude) in 1995 from University of Catania and his Ph.D. in computer science and applied mathematics from University of Naples in 1999. From 1999 to 2003 he was the leader of the “Imaging” team at STMicroelectronics in Catania. He joined the Department of Mathematics and Computer Science at the University of Catania as assistant professor in 2004 and became associate professor in the same department in 2011. His research interests include image enhancement and processing, image coding, camera imaging technology and multimedia forensics. He has edited 4 books

and co-authored more than 150 papers in international journals, conference proceedings and book chapters. He is a co-inventor of about 15 international patents, reviewer for several international journals, and he has been regularly a member of numerous international conference committees. Professor Battiato has participated in many international and national research projects. Chair of several international events (IWCV2012, ECCV2012, VISAPP 2012-2013-2014, ICIAP 2011, ACM Mi-For 2010-2011, SPIE EI Digital Photography 2011-2012-2013, etc.). He is an associate editor of the IEEE Transactions on Circuits and System for Video Technology and of the SPIE Journal of Electronic Imaging. Guest editor of the following special issues: “Emerging Methods for Color Image and Video Quality Enhancement” published on EURASIP Journal on Image and Video Processing (2010) and “Multimedia in Forensics, Security and Intelligence” published on IEEE Multimedia Magazine (2012). He is the recipient of the 2011 Best Associate Editor Award of the IEEE Transactions on Circuits and Systems for Video Technology. He is director (and co-founder) of the International Computer Vision Summer School (ICVSS). He is a senior member of the IEEE.

Roberto Cipolla

Roberto Cipolla obtained the B.A. degree (Engineering) from the University of Cambridge in 1984 and an M.S.E. (Electrical Engineering) from the University of Pennsylvania in 1985. From 1985 to 1988 he studied and worked in Japan at the Osaka University of Foreign Studies (Japanese Language) and Electrotechnical Laboratory. In 1991, he was awarded a D.Phil. (Computer Vision) from the University of Oxford and from 1991–1992 was a Toshiba Fellow and engineer at the Toshiba Corporation Research and Development Centre in Kawasaki, Japan. He joined the Department of Engineering, University of Cambridge in 1992 as a Lecturer and a Fellow of Jesus College. He became a Reader in Information Engineering in 1997 and a Professor in 2000. He is a Fellow at the Royal Academy of Engineering (since 2010); also a Professor of Computer Vision at the Royal Academy of Arts, London (since 2004) and Director of Toshiba’s Cambridge Research Laboratory (since 2007). His research interests are in computer vision and robotics and include the recovery of motion and 3D shape of visible surfaces from image sequences; object detection and recognition; novel man–machine interfaces using hand, face and body gestures; real-time visual tracking for localization and robot guidance; applications of computer vision in mobile phones, visual inspection and image-retrieval and video search. He has authored 3 books, edited 8 volumes and co-authored more than 300 papers. Professor Cipolla founded (in 2006) and currently directs the International Computer Vision Summer School.

List of Contributors

Lamberto Ballan Media Integration and Communication Center, University of Florence, Florence, Italy

Michel Barlaud I3S Laboratory, University of Nice-Sophia Antipolis, Sophia Antipolis, France

Kobus Barnard University of Arizona, Tucson, USA

Wafa Bel Haj Ali I3S Laboratory, University of Nice-Sophia Antipolis, Sophia Antipolis, France

Marco Bertini Media Integration and Communication Center, University of Florence, Florence, Italy

Horst Bischof Institute for Computer Graphics and Vision, Graz University of Technology, Graz, Austria

Michael Bleyer Vienna University of Technology, Vienna, Austria; Microsoft Redmond, Redmond, USA

Christian Breiteneder Vienna University of Technology, Vienna, Austria

Minsu Cho INRIA/École Normale Supérieure, Paris, France

Aaron Courville Université de Montréal, Montréal, Quebec, Canada

Daniel Cremers Department of Informatics, TU München, Garching, Germany

Gabriela Csurka Xerox Research Centre Europe, Meylan, France

Alberto Del Bimbo Media Integration and Communication Center, University of Florence, Florence, Italy

Luca Del Pero University of Arizona, Tucson, USA

Sandra Ebert Max Planck Institute for Informatics, Saarbrücken, Germany

Maria Klodt Department of Informatics, TU München, Garching, Germany

Kyoung Mu Lee Seoul National University, Seoul, Korea

Thomas Mensink LEAR Team – INRIA Grenoble, Montbonnot, France

Ross Messing University of Rochester, Rochester, NY, USA; Tandent Vision Science, Inc., Pittsburgh, PA, USA

Frank Nielsen Department of Fundamental Research, Sony Computer Science Laboratories, Inc., Tokyo, Japan; LIX Department, Ecole Polytechnique, Palaiseau, France

Richard Nock CEREGMIA, Université Antilles-Guyane, Martinique, France

Takahiro Okabe The University of Tokyo, Tokyo, Japan

Chris Pal École Polytechnique de Montréal, Montréal, Quebec, Canada

Florent Perronnin Xerox Research Centre Europe, Meylan, France

Paolo Piro Istituto Italiano di Tecnologia, Genova, Italy

Peter M. Roth Institute for Computer Graphics and Vision, Graz University of Technology, Graz, Austria

Imari Sato National Institute of Informatics, Tokyo, Japan

Yoichi Sato The University of Tokyo, Tokyo, Japan

Bernt Schiele Max Planck Institute for Informatics, Saarbrücken, Germany

Lorenzo Seidenari Media Integration and Communication Center, University of Florence, Florence, Italy

Giuseppe Serra Media Integration and Communication Center, University of Florence, Florence, Italy

Mihoko Shimano The University of Tokyo, Tokyo, Japan; PRESTO, Japan Science and Technology Agency, Tokyo, Japan

Young Min Shin Seoul National University, Seoul, Korea

Frank Steinbrücker Department of Informatics, TU München, Garching, Germany

Sabine Sternig Institute for Computer Graphics and Vision, Graz University of Technology, Graz, Austria

Radu Timofte VISICS, ESAT-PSI/iMinds, KU Leuven, Leuven, Belgium

Atousa Torabi Université de Montréal, Montréal, Quebec, Canada

Luc Van Gool VISICS, ESAT-PSI/iMinds, KU Leuven, Leuven, Belgium; Computer Vision Lab, D-ITET, ETH Zurich, Zurich, Switzerland

Jakob Verbeek LEAR Team – INRIA Grenoble, Montbonnot, France

Martin Weinmann Institute of Photogrammetry and Remote Sensing, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Andreas Wendel Institute for Computer Graphics and Vision, Graz University of Technology, Graz, Austria