PROCEEDINGS OF SPIE

Optics, Photonics, and Digital Technologies for Multimedia Applications

Peter Schelkens
Touradj Ebrahimi
Gabriel Cristóbal
Frédéric Truchetet
Pasi Saarikko
Editors

12–15 April 2010
Brussels, Belgium

Sponsored by
SPIE

Cosponsored by
B-PHOT—Brussels Photonics Team (Belgium) • Brussels-Capital Region (Belgium) • FWO—Fonds Wetenschappelijk Onderzoek (Belgium) • ICO—International Commission for Optics • Ville de Bruxelles (Belgium)

Cooperating Organisations
CBO-BCO (Belgium) • EOS—European Optical Society (Germany) • IET— The Institution of Engineering and Technology (United Kingdom) • IOP—Institute of Physics (United Kingdom) Photonics4Life (Germany) • Photonics@be (Belgium) • Photonics 21 (Germany) • PromOptica (Belgium)

Published by
SPIE

Volume 7723

Proceedings of SPIE, 0277-786X, v. 7723

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:
Author(s), "Title of Paper," in *Optics, Photonics, and Digital Technologies for Multimedia Applications*, edited by Peter Schelkens, Touradj Ebrahimi, Gabriel Cristóbal, Frédéric Truchetet, Pasi Saarikko, Proceedings of SPIE Vol. 7723 (SPIE, Bellingham, WA, 2010) Article CID Number.

ISSN 0277-786X
ISBN 9780819481962

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIE Digital Library

SPIEDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B … 0Z, followed by 10-1Z, 20-2Z, etc.

The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID number.

Contents

Conference Committee

Symposium Chairs

Francis Berghmans, Vrije Universiteit Brussel (Belgium)
Ronan Burgess, European Commission (Belgium)
Jürgen Popp, Institut für Photonische Technologien e.V. (Germany)
Peter Hartmann, SCHOTT AG (Germany)
Hugo Thienpont, Vrije Universiteit Brussel (Belgium)

Conference Chairs

Peter Schelkens, Vrije Universiteit Brussel (Belgium)
Touradj Ebrahimi, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
Gabriel Cristóbal, Consejo Superior de Investigaciones Científicas (Spain)
Frédéric Truchetet, Université de Bourgogne (France)
Pasi Saarikko, Nokia Research Center (Finland)

Program Committee

Janne K. Aikio, VTT Elektroniikka (Finland)
Jan T. Bosiers, DALSA Corporation (Netherlands)
Jacques W. Duparré, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany)
Boris Escalante-Ramírez, Universidad Nacional Autónoma de México (Mexico)
Pascuala García-Martínez, Universitat de València (Spain)
María S. Millán García-Varela, Universitat Politècnica de Catalunya (Spain)
Tom R. L. Kimpe, Barco, Inc. (Belgium)
Martin Schrader, Nokia Research Center (Finland)
Michael Schwind, OSRAM Opto Semiconductors GmbH (Germany)
Colin J. R. Sheppard, National University of Singapore (Singapore)
Athanassios N. Skodras, Hellenic Open University (Greece)
Ari Tervonen, Helsinki University of Technology (Finland)
Andrew G. Tescher, AGT Associates (United States)
Gerald Zauner, Upper Austria University of Applied Sciences (Austria)

Session Chairs

1 Super-resolution
Gabriel Cristóbal, Consejo Superior de Investigaciones Científicas (Spain)

2 Optical and Digital Image Processing
Pascuala García-Martínez, Universitat de València (Spain)

3 Image Quality Assesment and Enhancement I
Boris Escalante-Ramírez, Universidad Nacional Autónoma de México (Mexico)

4 Steganography and Watermarking for Multimedia Content and Services I
Athanassios N. Skodras, Hellenic Open University (Greece)

5 Steganography and Watermarking for Multimedia Content and Services II
Athanassios N. Skodras, Hellenic Open University (Greece)
Vassilis E. Fotopoulos, Hellenic Open University (Greece)

6 Industrial Processing
María S. Millán García-Varela, Universitat Politècnica de Catalunya (Spain)

7 Display and Light Sources
Augustin Grillet, Barco N.V. (Belgium)

8 Image Processing and Representation
Frédéric Truchetet, Université de Bourgogne (France)

9 Camera Optics
Pasi Saarikko, Nokia Research Center (Finland)

10 Sensing and Transport
Pasi Saarikko, Nokia Research Center (Finland)

Introduction

In recent years, Moore's Law has fostered the steady growth of the field of digital image processing, though computational complexity remains a significant problem for most of the digital image processing applications. At the same time, research in the field of optical image processing has matured, potentially bypassing the limitations of digital approaches and giving rise to new applications. Additionally, from the image acquisition perspective the rapid convergence of digital multimedia devices is driving a strong industrial growth of photonics technologies. Already, photonics based enablers can be found in a myriad of multimedia applications such as displays and image sensing, illumination systems, and high-performance light engines - all of which have major volume positions in the photonics market. Along with the growing interest for emerging multimedia applications the demand for new photonics enablers is steadily increasing, and new technologies are continuously created to meet the needs.

One example is the use of compact visible laser sources for laser projection systems, which are attracting considerable interest. In miniaturizing digital cameras new challenges emerge when striving for high performance combined with mass volume production. This requires the design of sophisticated lens elements and new types of imaging optics, optimized image processing pipelines, compact high-performance sensors, etc. In addition, photonics has enabled fully digital media, with accompanied growth in image processing, in multimedia storage, retrieval and transmission techniques, and in related hardware and software. These new applications all have their specific requirements and put new challenges on the optical designs.

This volume consists of the papers presented at the SPIE Photonics Europe conference on Optics, Photonics, and Digital Technologies for Multimedia Applications that took place 12–15 April 2010 in Brussels, Belgium.

This conference is the result of the merger of two conferences organized at SPIE Photonics Europe 2008, namely, 'Optical and Digital Image Processing' and 'Photonics in Multimedia.' The aim of this conference was to create a joint forum for both research and application communities to share expertise, to solve present-day application bottlenecks and to propose new application areas.

Consequently, this conference had a broad scope, ranging from basic and applied research to dissemination of existing knowledge. The contributions were grouped in sessions covering super-resolution, optical and digital image processing, image quality assessment and enhancement, steganography and watermarking for multimedia content and services, industrial processing, display

and light sources, image processing and representation, camera optics, and finally, sensing and transport.

We thank all the participants and all those who worked hard to make this conference so successful. Special thanks to all the reviewers that helped us to improve the quality of the final proceedings.

Peter Schelkens
Touradj Ebrahimi,
Gabriel Cristóbal
Frédéric Truchetet
Pasi Saarikko