

PROCEEDINGS OF SPIE

***Mathematics of Data/Image
Coding, Compression, and
Encryption with Applications XII***

**Mark S. Schmalz
Gerhard X. Ritter
Junior Barrera
Jaakko T. Astola**
Editors

**2-4 August 2010
San Diego, California, United States**

Sponsored and Published by
SPIE

Volume 7799

Proceedings of SPIE, 0277-786X, v. 7799

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

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 *Mathematics of Data/Image Coding, Compression, and Encryption with Applications XII*, edited by Mark S. Schmalz, Gerhard X. Ritter, Junior Barrera, Jaakko T. Astola, Proceedings of SPIE Vol. 7799 (SPIE, Bellingham, WA, 2010) Article CID Number.

ISSN 0277-786X
ISBN 9780819482952

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

Copyright © 2010, Society of Photo-Optical Instrumentation Engineers

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/10/\$18.00.

Printed in the United States of America.

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

The logo for SPIE Digital Library features the word "SPIE" in a bold, sans-serif font above the words "Digital Library" in a smaller, similar font. To the right of the text is a stylized graphic consisting of three vertical bars of increasing height, resembling a bar chart or a signal waveform.

SPIDigitalLibrary.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

vii	<i>Conference Committee</i>
ix	<i>Introduction</i>

SESSION 1 IMAGING THEORY I, WITH APPLICATIONS

- 7799 02 **Object/image relations in full and weak perspective and 3D reconstruction** [7799-01]
P. F. Stiller, Texas A&M Univ. (United States)
- 7799 03 **The design of wavelets for limited-angle tomographic hyperspectral imaging systems**
[7799-02]
J. F. Scholl, College of Optical Sciences, The Univ. of Arizona (United States), MKS Imaging
Technology, LLC (United States), and HNU Photonics (United States); E. K. Hege, MKS
Imaging Technology, LLC (United States) and The Univ. of Arizona (United States);
E. L. Dereniak, College of Optical Sciences, The Univ. of Arizona (United States)
- 7799 04 **An overview of view-based 2D/3D indexing methods** [7799-03]
R.-D. Petre, T. Zaharia, Institut Télécom, Télécom SudParis, CNRS (France); F. Prêteux, Mines
ParisTech (France)

SESSION 2 IMAGING THEORY II, WITH APPLICATIONS

- 7799 06 **Image Algebra Matlab language version 2.3 for image processing and compression
research** [7799-05]
M. S. Schmalz, G. X. Ritter, E. Hayden, Univ. of Florida (United States)
- 7799 07 **A comparison study between Wiener and adaptive state estimation (STAP-ASE) algorithms
for space time adaptive radar processing** [7799-06]
O. Malek, A. Venetsanopoulos, A. Anpalagan, Ryerson Univ. (Canada)
- 7799 08 **Information theoretic analysis of edge detection in visual communication** [7799-07]
B. Jiang, Old Dominion Univ. (United States); Z. Rahman, NASA Langley Research Ctr. (United
States)

SESSION 3 PATTERN RECOGNITION THEORY I, WITH APPLICATIONS

- 7799 09 **Combination of the sensitivity in EM field and the optimum nonlinear interpolation
approximation as a favorable means of CAD of composite meta-materials** [7799-08]
Y. Kida, Ohu Univ. (Japan); T. Kida, Tokyo Institute of Technology (Japan)
- 7799 0A **3D object recognition with photon-counting integral imaging using independent
component analysis** [7799-09]
C. M. Do, Univ. of Connecticut (United States)

- 7799 0B **Decision tree classifier for character recognition combining support vector machines and artificial neural networks** [7799-10]
M. Grafmüller, Karlsruhe Institute of Technology (Germany); J. Beyerer, K. Kroschel, Fraunhofer-Institut für Informations- und Datenverarbeitung (Germany)

SESSION 4 PATTERN RECOGNITION THEORY II, WITH APPLICATIONS

- 7799 0C **OVIDIUS: an on-line video indexing universal system** [7799-11]
A. Bursuc, T. Zaharia, Institut Télécom, Télécom SudParis, CNRS (France); F. Prêteux, Mines ParisTech (France)

SESSION 5 COMPRESSION I

- 7799 0E **Data compression for complex ambiguity function for emitter location** [7799-13]
M. Pourhomayoun, M. L. Fowler, Binghamton Univ. (United States)
- 7799 0F **A fast partial Fourier transform (FPFT) for data compression and filtering** [7799-14]
M. W. Smith, Sandia National Labs. (United States)
- 7799 0G **Recent achievements in lossless compression of hyperspectral data** [7799-15]
B. Aiazzi, Istituto di Fisica Applicata Nello Carrara, CNR (Italy); L. Alparone, Univ. degli Studi di Firenze (Italy); S. Baronti, Istituto di Fisica Applicata Nello Carrara, CNR (Italy); A. Garzelli, Univ. degli Studi di Siena (Italy)

SESSION 6 ERROR MODELING AND ANALYSIS I

- 7799 0H **Theory of the optimum running approximation of extended filter banks with slightly non-linear analysis filters** [7799-17]
Y. Kida, Ohu Univ. (Japan); T. Kida, Tokyo Institute of Technology (Japan)
- 7799 0I **Error analysis of filtering operations in pixel-duplicated images of diabetic retinopathy** [7799-18]
M. Mehrubeoglu, Texas A&M Univ.-Corpus Christi (United States); L. McLauchlan, Texas A&M Univ.-Kingsville (United States)
- 7799 0J **Image registration error analysis using pattern recognition algorithms** [7799-19]
P. Duraisamy, Y. Shen, X. Yuan, Univ. of North Texas (United States)

SESSION 7 COMPRESSION II

- 7799 0K **An overview of semantic compression** [7799-20]
M. S. Schmalz, Univ. of Florida (United States)
- 7799 0L **DWT and DCT embedded watermarking using chaos theory** [7799-21]
L. McLauchlan, Texas A&M Univ.-Kingsville (United States); M. Mehrubeoglu, Texas A&M Univ.-Corpus Christi (United States)

SESSION 8 ERROR MODELING AND ANALYSIS II

- 7799 ON **Error reduction in three-dimensional metrology combining optical and touch probe data** [7799-24]
J. R. Gerde, U.S. Customs and Border Protection (United States); W. A. Christens-Barry, Equipoise Imaging, LLC (United States)
- 7799 OO **Error analysis and performance estimation of two different mathematical methods for image registration** [7799-25]
P. Duraisamy, Y. Shen, K. Namuduri, S. Jackson, Univ. of North Texas (United States)

POSTER SESSION

- 7799 OP **Wavelet Transform (WT) and neural network model applied to canopy hyperspectral data for corn Chl-a estimation in Songnen Plain, China** [7799-26]
D. Lu, Jilin Institute of Architecture and Civil Engineering (China); K. Song, Northeast Institute of Geography and Agricultural Ecology (China) and Indiana Univ.-Purdue Univ. Indianapolis (United States); L. Li, Indiana Univ.-Purdue Univ. Indianapolis (United States); Z. Wang, J. Du, L. Zeng, X. Lei, Northeast Institute of Geography and Agricultural Ecology (China)
- 7799 OQ **Compression scheme of sub-image transformed elemental images based on residual images in 3D computational integral imaging systems** [7799-27]
C.-H. Yoo, H.-H. Kang, E. S. Kim, Kwangwoon Univ. (Korea, Republic of)
- 7799 OR **Laser reflectometry near the critical angle for the analysis of chemical reactions** [7799-28]
T. O. Chang-Martínez, M. C. Peña-Gomar, G. Viramontes-Gamboa, Univ. Michoacana de San Nicolás de Hidalgo (Mexico)
- 7799 OS **Error analysis of two methods for range-images registration** [7799-29]
X. Liu, Shenzhen Univ. (China); Y. Yin, Tianjin Univ. (China); A. Li, D. He, X. Peng, Shenzhen Univ. (China)
- 7799 OT **Evaluation of video quality by CWSSIM method** [7799-30]
Y.-T. Chen, National Central Univ. (Taiwan); S.-W. Hsu, B.-J. Pong, Industrial Technology Research Institute (Taiwan); O.-Y. Mang, National Chiao Tung Univ. (Taiwan)
- 7799 OX **A robust improved image stitching algorithm based on keypoints registration** [7799-34]
H. Lei, F. Gu, H. Feng, Z. Xu, Q. Li, Zhejiang Univ. (China)

Author Index

Conference Committee

Program Track Chair

Khan M. Iffekharuddin, The University of Memphis (United States)

Conference Chairs

Mark S. Schmalz, University of Florida (United States)

Gerhard X. Ritter, University of Florida (United States)

Junior Barrera, Universidade de São Paulo (Brazil)

Jaakko T. Astola, Tampere University of Technology (Finland)

Program Committee

Stefano Baronti, Istituto di Fisica Applicata Nello Carrara, CNR (Italy)

Mark L. Fowler, Binghamton University (United States)

Victoria T. Franques, U.S. Department of Energy (United States)

Andrea Garzelli, Università degli Studi di Siena (Italy)

Abdelsalam Sumi Helal, University of Florida (United States)

Lifford McLauchlan, Texas A&M University-Kingsville (United States)

Mehrübe Mehrübeoglu, Texas A&M University-Corpus Christi
(United States)

Daniel S. Myers, Sandia National Laboratories (United States)

Françoise J. Preteux, TELECOM & Management SudParis (France)

James F. Scholl, HNU Photonics (United States)

Session Chairs

- 1 Imaging Theory I, with Applications
Mark S. Schmalz, University of Florida (United States)
- 2 Imaging Theory II, with Applications
James F. Scholl, HNU Photonics (United States)
- 3 Pattern Recognition Theory I, with Applications
Lifford McLauchlan, Texas A&M University-Kingsville (United States)
- 4 Pattern Recognition Theory II, with Applications
Mark S. Schmalz, University of Florida (United States)
- 5 Compression I
Mark S. Schmalz, University of Florida (United States)

- 6 Error Modeling and Analysis I
Lifford McLauchlan, Texas A&M University-Kingsville (United States)
- 7 Compression II
Mehrübe Mehrübeoglu, Texas A&M University-Corpus Christi
(United States)
- 8 Error Modeling and Analysis II
Mark L. Fowler, Binghamton University (United States)

Introduction

Image compression, encryption, and pattern recognition are emerging as crucial supporting technologies for numerous applications in diverse fields. Traditionally, image compression is directed toward decreasing data burden, thus increasing storage efficiency, effective communication channel bandwidth, and data security. Illustrative applications include videotelephony, remote sensing, Internet delivery of still imagery and video, as well as storage, retrieval, and processing of medical, military, or environmental image processing. Increasingly, image compression is being used to precondition data prior to processing – a wide range of research has addressed the benefits of developing special compression transforms that extract key object features from compressed sensor datastreams.

Researchers are focusing, in general, on the quantification of error in compression and, in particular, error in decompressed imagery. An example of this is the development of theory for successive approximations that support iterative or recursive representation of imaging data, and partitioning of remote sensing datacubes into spectral regions and features of mission-specific interest. Although numerous perceptual measures have been developed for assessing image quality in decompressed imagery, there remain few measures that address non-perceptual problems such as local (e.g., feature-specific) distortion in objects or classes of objects typically present in medical or military images. Additional problems in image and video quality measures include correspondence with human evaluations of image quality, as well as the poorly understood phenomenon of semantic correspondence between images or video sequences. Illustrative applications in medical imaging, military target recognition, or security applications integrate compression and digital watermarking.

A key topic of interest emphasizes how semantic properties of image data jointly support compression and pattern recognition. As shown in our previous conferences, the union of semantic pattern recognition and compression increasingly offers useful insights into this challenging problem.

This conference on the mathematics of data and image pattern recognition, compression, and encryption addresses theory, design, analysis, and testing of pattern recognition, compression, and encryption (e.g., watermarking) algorithms. In response to conference presenters' and attendees' requests in this and previous years, we continue to emphasize security, watermarking, and theory/practice of error measurement. Example applications include semantic analysis and compression (e.g., for surveillance and remote sensing data and imagery), as well as survivable watermarks. Thus, the first session of this conference addresses several theoretical issues in imaging theory, in particular,

model-based analysis and optimization of perspective and reconstruction transforms, hyperspectral imaging, and image indexing.

The second session continues the initial theme of imaging theory, with models for Wiener and adaptive state estimation for adaptive radar processing, as well as information-theoretic analysis of edge detection. A summary of ongoing research in the theory of image algebra, with implementation in terms of the Matlab language, is also given.

The third and fourth sessions address pattern recognition theory, emphasizing techniques for successive approximation applied to the design of metamaterials, and 3D object recognition with little information. Classification based on decision trees for character recognition and online video indexing is also featured.

The fifth session addresses crucial areas of compression theory and algorithm design, namely, the analysis of compression transforms for emitter location (TDOA and FDOA), fast Fourier transformation for compression, and efficient, lossless compression of hyperspectral data. A tutorial overview of semantic compression is also given. Session six continues this emphasis with theoretical developments in error modeling and analysis. Topics include running approximation theory for extended filter banks with nonlinear analysis filters, error analysis of filtering in medical imaging, and image registration using pattern recognition theory.

The seventh and eighth sessions return to the central theme of compression and error estimation theory, with wavelet and cosine transform embedded watermarking, error reduction in three-dimensional metrology, and error analysis with performance estimation for image registration. Papers in these areas are well represented in the poster session.

Throughout its 13-year history, this conference has successfully convened numerous scientific researchers from international institutions to discuss development of theory, analysis, and test technology for data/image pattern recognition, segmentation, understanding, compression, coding, and encryption. Despite their success in defining and resolving several important problems in image and video representation, as well as very low-rate compression, much research remains in the basic mathematical nature, characterization, and performance analysis of pattern recognition and compression algorithms. For example, how can data semantics be best represented to facilitate semantic analysis and compression of digital imagery, as well as fast reconstruction? A continuing topic of interest is the survivability of digital watermarks in practical image processing contexts.

The next conference in this series, scheduled for SPIE Optics + Photonics 2011, will continue the topical focus of this conference, extending the area of pattern recognition to further analyze semantic compression of still images and video, as well as forensic watermarking. The continued emphasis on theory and algorithms

for data security will motivate engineers, scientists, and algorithm designers to investigate new areas of compression, coding, and encryption technologies. Further emphasis will be directed toward theory and algorithms that support exploitation of compressed digital signals and imagery from sensor networks. Sensing and processing using compressed hyperspectral datastreams are planned topics for our 2011 conference. We also plan to continue emphasizing error analysis and performance metrics for compression, computation, and image/video perception, with illustrative examples in military, law enforcement, medical, environmental, and commercial imagery and video.

Mark S. Schmalz
Gerhard X. Ritter
Junior Barrera
Jaakko T. Astola

