PROCEEDINGS OF SPIE

Mathematics of Data/Image Pattern Recognition, Compression, and Encryption with Applications XI

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12–13 August 2008
San Diego, California, USA

Sponsored and Published by
SPIE

Volume 7075

Proceedings of SPIE, 0277-786X, v. 7075

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 Pattern Recognition, Compression, and Encryption with Applications XI*, edited by Mark S. Schmalz, Gerhard X. Ritter, Junior Barrera, Jaakko T. Astola, Proceedings of SPIE Vol. 7075 (SPIE, Bellingham, WA, 2008) Article CID Number.

ISSN 0277-786X
ISBN 9780819472953

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.

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:

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Introduction

Image compression, encryption, and pattern recognition are technologies in computer science that are emerging as crucial supports for diverse applications in many fields. Traditionally, image compression is directed toward increasing storage efficiency, effective communication channel bandwidth, and data security. Illustrative applications include videotelephony, remote sensing, and 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 reduce data prior to processing — in practice, special types of compression transforms can be employed in preprocessing to extract key features from imaging sensor datastreams.

In particular, researchers are focusing on the segmentation and understanding of digital imagery using pattern recognition technology. Examples include partitioning of remote sensing datacubes into spectral regions and features of mission-specific interest, as well as exploiting multispectral or hyperspectral signatures for medical imaging, military target recognition, or security applications that integrate compression and digital watermarking.

A key topic of interest emphasizes how spatial properties of image data support compression as well as pattern recognition. However, the union of object recognition and object-based compression increasingly offers useful insights into this challenging problem. Finally, 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 their correspondence with human evaluations of image quality, as well as the poorly understood process of semantic correspondence between images or video sequences.

This conference on the mathematics of data and image pattern recognition, compression, and encryption addresses the 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 applications and theory/practice of error measurement. Example applications include video analysis and compression (e.g., surveillance and remote sensing), as well as survivable watermarks. Thus, the first session of this conference addresses several theoretical issues in compression, in particular, model-based analysis and optimization of compression transforms for emitter location (TDOA and FDOA), object-based compression of video sequences, and optimal wavelet selection.

The second session addresses a crucial area of compression theory and algorithm design, namely, the analysis and quantification of error decompressed imagery. Theory, algorithms, and practical techniques are presented for estimating error using a perceptual model based on foveation and eye movements in the human visual system. Compression of 4D volumetric medical imagery is discussed in terms of computational cost and error, then permutation-based codebook design is explored as a technique for improving the efficiency of lossless compression.

The third and fourth sessions cover watermarking and security, which are key to commercial multimedia applications (e.g., anti-piracy measures). The identification of watermarking using adaptive model-based analysis of neural networks and embedding of watermarks in the compressed domain are featured papers. Also, watermark insertion strategies for MPEG are comparatively evaluated.

The fifth session emphasizes error analysis techniques, including computational error analysis. The first two papers concentrate on the theory of optimal filter selection in orthogonal expansions, with application to optimization of finite impulse response filter banks. The final paper in this session discusses a bit-level technique for precise estimation of arithmetic error in floating-point computations, which is germane to the assessment and prediction of compression transform error.

The sixth session focuses on hyperspectral imaging theory, in particular, analysis of biomolecular imaging and fluorescence with respect to non-linear mapping techniques. Other topics include hyperspectral imaging of non-stellar astronomical objects, including enhancement based on mixture model theory.

Throughout its 11-year history, this conference has successfully convened numerous scientific researchers from many nations in a variety of theoretical development, analysis, and test areas pertaining to pattern recognition, segmentation, image understanding, compression, coding, and encryption. Despite their success in defining and resolving several important problems in image and video representation, much research remains in the basic mathematical nature, characterization, and performance analysis of pattern recognition and compression algorithms. For example, what properties of data facilitate compression or encryption; in particular, what makes digital watermarks survivable in given data and processing contexts?

The next conference in this series, scheduled for the SPIE 2009 annual meeting, will continue the topical focus of this conference, extending the area of pattern recognition to analyze extremely low bit-rate video compression, 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. Planned areas of emphasis include, but are not limited to, forensic watermarking

that is robust to attack as well as provides a means for tracking attacks. Continued emphasis will be directed toward compression theory and algorithms for exploiting digital signals and imagery acquired via sensor networks. Hyperspectral image processing, as well as sensing and processing using compressed datastreams only, are planned topics for our 2009 conference. We also plan to continue emphasizing error analysis and performance metrics for compression, computation, and image/video perception. Related illustrative application areas will emphasize environmental, forensic, law enforcement, military, and medical image and signal compression and encryption.

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