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

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Introduction

Image compression and pattern recognition are emerging technologies in computer science that are increasingly crucial to the success of diverse applications. For example, image compression is directed toward increasing storage efficiency, effective communication channel bandwidth, and data security. Example applications include, but are not limited to, videotelephony, remote sensing, Internet delivery of still imagery and video, as well as storage, retrieval, and processing of medical, military, or environmental imagery. Increasingly, researchers are focusing on the segmentation and understanding of digital imagery using pattern recognition technology. Example applications include the partitioning of remote sensing datacubes into spectral regions and derivation of endmembers, as well as medical image segmentation, military target recognition, or security applications that integrate compression and digital watermarking.

Despite approximately four decades of progress in theoretical and algorithm development for digital data/image compression, it is still not exactly known how the spatial properties of image data support compression as well as pattern recognition. However, there is increasing promise that the union of object recognition and object-based compression may offer useful insights into this challenging problem. Finally, there continue to be few objective performance measures for compression transforms or pattern recognition operations 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.

This conference on the mathematics of data and image pattern recognition, compression, and encryption addresses the theory, design, analysis, and testing of pattern recognition and compression algorithms. In response to conference presenters and attendees requests, we continue to shift emphasis toward higher-level processing, for example, object detection and pattern recognition in conjunction with compression. Example applications include video analysis and compression (e.g., surveillance and remote sensing applications), as well as security applications such as watermarking. Thus, the first session of this conference addresses several theoretical issues in compression, in particular, model-based analysis and optimization of compression transforms for remote sensing and astronomy, as well as object-based compression of video sequences. Since audio coding is increasingly important in multimedia compression, this session includes a paper on subband coding of audio signals using multirate processing techniques.

The second session addresses a crucial area of compression theory and algorithm design, namely, the analysis and quantification of error in compression and decompression transforms. Theory is presented for estimating time-limited worst-

case error measures, then applications are discussed in terms of error analysis of PDEs with large gradients, and perceptual assessment of image quality in multimedia technology.

The third session covers watermarking and security, which are key to commercial multimedia applications (e.g., anti-piracy measures) and Homeland Security initiatives. The identification of watermarking using adaptive model-based analysis of neural networks and watermarking in the compressed domain (i.e., integration of watermarking and compression) are featured papers. Also, moment-preserving thresholding for robust digital watermarking was presented in the poster session.

The fourth session concentrates on the theory of pattern recognition including emerging technologies such as training of self-organizing Kohonen neural networks and lattice-independent vector sets for pattern classification applications. Germane to the Kohonen net paper is an analysis of K-means pyramid clustering, as well as optimization of pattern clusters by evolutionary (genetic) algorithms. The latter technique is applied to feature selection in multi- and hyper-spectral image analysis.

The fifth and sixth sessions focus on applications in medical imaging and multimedia. Analysis of biomolecular imaging and automated diagnosis of lung disease in computed tomography are featured medical applications. Feature classification is emphasized in the paper on recognition of Compton scattering patterns, while an interesting paper on interactive television coverage of French parliament meetings concludes the final session.

Throughout its ten-year history, this conference has successfully convened international scientific researchers 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 segmentation and representation, much research remains in the mathematical nature, characterization, and performance analysis of both pattern recognition and compression algorithms. Additional topics of interest include properties of data that facilitate encryption, as well as cryptographic strategies that employ patterns to hide information, such as watermarking, steganography, and steganalysis.

The next conference in this series, scheduled for the SPIE 2008 Optics and Photonics meeting, will continue the topical focus of this conference, extending the area of pattern recognition to analyze model-based compression, as well as nonlinear watermarking. The continued emphasis on security will bring together engineers, scientists, and algorithm designers interested in the individual or joint application of compression, coding, and encryption technologies. Planned areas of emphasis include but are not limited to audio and video watermarking that is

robust to piracy attempts. We also plan to emphasize compression theory and algorithms that exploit properties of digital signals and imagery acquired via sensor networks, hyperspectral imaging, spread-spectrum watermarking and other types of encryption transforms. We plan to continue emphasizing error analysis and performance metrics for both pattern recognition and compression, in particular, the description of transforms in terms of the error characteristics of their respective outputs. Related illustrative applications areas will emphasize environmental, forensic, law enforcement, military, and medical image and signal compression and encryption.

Mark S. Schmalz