GUEST EDITORIAL

Special Section on Advances in Mathematical Imaging

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Current developments in imaging sensors, multisensor data fusion, and image processing hardware and algorithms have led to an explosive growth in the interdisciplinary field of imaging science. Mathematics plays an important role in this growth. Highly sophisticated mathematical models and theories provide a rigorous basis for imaging science.

This special section focuses on the recent advances in mathematical imaging. All the papers in this special section place emphasis on innovative mathematical techniques applied to image processing and computer vision problems. Some of the papers in this special section are based on the conference papers presented at the 1996 annual conferences under SPIE's Program on Mathematical Imaging.

The first three papers apply geometric theory and techniques to problems related to computer vision. Bertrand, Everat, and Couprie consider a cross-section topology defined on gray scale images. A basic notion related to this topology is that a homotopic kernel may be seen as an ultimate topological simplification of an image. They show how to obtain the homotopic kernel from an image and how to use an iterative method to selectively simplify the topology, leading to an algorithm for segmenting gray scale images without the need of defining and tuning parameters. Reveillès and Yaacoub propose a new way of computing exactly the normal vector, or gradient, at regular points of an image by interpreting the 3×3 neighborhood of each point as 3-D digital surfaces. They then derive a new discrete edge detection algorithm based on maximum area triangles contained in 3×3 masks. Their algorithm can make a finer distinction between regular and singular points of an image and give softer boundaries. Veelaert discusses how to use feature detectors to improve the computation of tangents, curvature, and surface normals for digitized curves and surfaces. For each part of the surface, the feature detectors determine which difference operator yields the best approximation for the differential. He studies functional decomposition and the combination of multiple feature detectors in a rigid mathematical structure.

The next two papers explore the state-of-the-art concepts and trends in statistical and stochastic methods for image processing. Payot et al. introduces an approach based on constrained optimization for 3-D reconstruction from an incomplete data set. They provide a mathematical framework for selecting a specific solution from the set of feasible solutions through minimizing some criteria depending on prior densitometric information. They derive a global optimization scheme using a deterministic relaxation algorithm based on Bregman's algorithm associated with half-quadratic minimization techniques. They demonstrate the advantages of their algorithm over standard algorithms in reconstruction of a 3-D vascular network from 2-D digital subtracted angiography data. The paper by Melnik et al. proposes an adaptive approach to the restoration of images corrupted by blurring, additive, multiplicative, and impulsive noise. Their approach is based on the combination of nonlinear filters, iterative filtering procedures, and the principles of local adaptation.

The third group of two papers apply wavelet theory to problems in computer vision and signal and image processing. He and Lai discuss bivariate box splines for image interpolation, enhancement, digital filter design, subband coding bank, and hexagonal filtering. A computational method is proposed for box spline image interpolation and box spline digital filters. Chen, Chen, and Parker propose a novel and efficient approach to adaptive mammographic image feature enhancement using wavelet-based multiresolution analysis. Their approach exploits the spatial coherence of images and the principle of the human psychovisual mechanism to adaptively enhance local edge features, suppress noise, and improve global visualization of mammographic image features.

The last authors, Casazza and Christensen, discuss the approximation of frame coefficients using finite-dimensional methods. They derive conditions for convergence of the approximate solutions to the correct solutions. Particularly, they consider Weyl-Heisenberg frames and wavelet frames. They also apply their methods to the moment problem.

The diverse topics exhibited by the papers of this special issue bear witness to the increased interaction of the diverse scientists working in the interdisciplinary field of mathematical imaging. The interaction will further make significant advances in imaging science.

Gerhard X. Ritter is a professor and the chair of the computer and information science and engineering department at the University of Florida. He is also a professor of mathematics and the director of the Center for Computer Vision and Visualization at the same university. His current research interests include computer vision, pattern recognition, neural networks, and image algebra. He has published more than 80 research publications including several books and chapters in computer vision, mathematics, applied mathematics related to computer vision, and pattern recognition. He is a member of the editorial board of the *Journal of Pattern Analysis and Applications,* the editor-in-chief of the *Journal of Mathematical Imaging and Vision*, and a member of the SPIE Publications Committee. He is a fellow of SPIE, a member of the Board of Directors of SPIE, and the program chair of SPIE's annual Program on Mathematical Imaging.

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