Digital Image Recovery and Synthesis

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In recent years, image science has been enriched through the development of digital techniques for synthesizing imagery from various classes of optical measurements. This has resulted in the discovery of many novel imaging techniques that owe their existence to the digital computer. In many cases, these techniques enable us to reconstruct high-quality images under conditions that would have prevented more conventional approaches from succeeding. Often, problems arise where only partial information is available from measurements. Under these conditions, one seeks signal recovery approaches that reconstruct "complete" image information with the aid of suitable constraints and other *a priori* information. Powerful insights often result in digital techniques that demonstrably improve imaging system performance—both in terms of image quality and in terms of reduced implementation cost.

The objective of this special section is to report on recent progress in three areas of research into digital image recovery and synthesis techniques. First, image recovery techniques may result from the desire to fully capitalize on the utility of novel sensor configurations. This objective is represented in four papers. Maleki and Devaney report on a novel noniterative phase-retrieval algorithm that has direct application to diffraction tomography and in-line holography with two-plane intensity measurements. Roggemann, Stoudt, and Welsh show that statistical frame selection may significantly improve the performance of partial adaptive-optics systems for image correction in ground-based astronomy. Marathay, Hu, and Shao demonstrate that complete image recovery may be obtained with an intensity interferometer and the application of higher order intensity correlations for phase retrieval. Fox, Voelz, and Shannon show how high-frequency image information may be recorded (and retrieved from) within the zero regions of the optical transfer function of sparse-array multiaperture optical imaging systems.

In a second area of research, image recovery may benefit from new mathematical insights or applications. These new insights are reflected here in four papers. Kang and Katsaggelos report on a nonlinear adaptive regularization technique for image restoration that assigns a regularization parameter to each discrete spatial frequency. Matson shows how perfect information about a portion of an object may be used to reduce the error in a noisy image of that object. The papers of Feichtinger and Strohmer and of Park and Soumekh deal with algorithmic approaches to recovering images with missing or irregularly sampled data. The former paper shows how images with missing lines or rectangular segments may be recovered with the efficient solution of iterated one-dimensional problems. In the latter, a Gram-Schmidt procedure is applied to reconstruct signals from unevenly sampled data and zero crossings and to image recovery with prescribed level crossings.

Finally, advances motivated by optical image recovery may be applied and benefit other related image processing applications. This area is represented by the paper by Fienup wherein an iterative phase-retrieval approach is applied to the correction of phase errors in inverse synthetic-aperture radar imagery.

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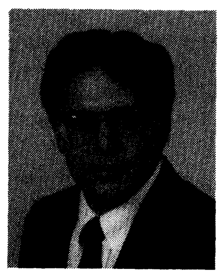

Paul S. Idell received a BS and MS in electrical engineering from Lehigh University, Bethlehem, Pennsylvania, in 1977 and the Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, in 1978, respectively. In 1986 he earned a PhD from Stanford University, where he concentrated on signal processing, statistical optics, and optical coherence. He also holds an MA in national security and strategic studies from the U.S. Naval War College, Newport, Rhode Island. Dr. Idell served for more than 15 years in the U.S. Air Force where he conducted and directed research into optical surveillance and imaging at the U.S.A.F. Rome and Phillips Laboratories. It was at the Phillips Laboratory, Kirtland Air Force Base, New Mexico, where he was awarded the laboratory's highest technical award in 1987 for the invention and demonstration of a novel laser-imaging technique employing statistical estimation and phase-retrieval methods. Last year, Dr. Idell joined the Rocketdyne Division of Rockwell International Corporation at Canoga Park, California, as a chief scientist in imaging. At Rocketdyne, he conducts applied research into optical imaging techniques relying on combinations of nonlinear optical phenomena and digital signal processing for image recovery. He is a fellow of SPIE and a member of IEEE and the Optical Society of America. He has published or presented more than 35 technical papers in the areas of optical coherence and imaging, image analysis, and digital image recovery/synthesis. He has chaired three modern imaging sessions at the Snowbird Winter Colloquia on Quantum Electronics from 1989 to 1991 and is a past chairman of several SPIE conferences including Digital Image Recovery and Synthesis I and II held in 1987 and 1993, respectively. He is currently serving as the technical program chair for the OSA Topical Meeting on Signal Recovery and Synthesis to be held at Salt Lake City, Utah, March 13–17, 1995.