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Hyperspectral Imaging Systems

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Since the time of Newton and Hershel, humans have understood that light can communicate beyond what can only be seen, and over the next 300 years, remote sensing of spectroradiometric information has been perfected by astronomers. In the last 50 years, those methods and techniques have been turned nadir, to better understand the inner space of earth. Compared to astronomy, hyperspectral remote sensing for earth science is in its infancy, but the rate at which it has accelerated our knowledge of forestry, agriculture, bathymetry, and geology, to name a few, will continue to grow exponentially as the challenges facing mankind require more optimal uses of natural resources.

Over the past two decades spectral techniques that employ tens to hundreds of narrow spectral bands have advanced from laboratory-based concepts and hardware into a practical and significant tool in applications as diverse as natural resource exploration, environmental monitoring, search and rescue, and military sensing. Advances in processing algorithms and techniques have resulted in enormous reductions in false alarm rate in the detection and identification of classes of material (solid, liquid, and gas) and in improvements in discrimination between classes, e.g., man-made versus natural. Additional algorithmic advances have allowed performance over a wide range of environmental conditions. Advances in optics and computational power have enabled real-time processing of large hyperspectral data "cubes," and packaging of ruggedized instruments into compact forms suitable for airborne and space platforms. The current challenge is to maintain the trajectory of capability growth. Because of the multidimensional nature of hyperspectral imagery, coverage rates are necessarily lower than for pan-chromatic systems. The advent of persistent sensing small platforms is a driver for even more-compact hyperspectral systems. The employment of hyperspectral imagery to highly variegated scenes (such as urban scenes) necessitates the development of improved algorithmic approaches for discrimination of true targets from a very high level of clutter. This special section consists of twenty papers that cover a broad array of topics, including:

- new algorithmic techniques to greatly improve separation of targets from clutter (e.g., papers by Schaum et al. and Theiler),
- advances in compensation of atmospheric effects in hyperspectral detection (e.g., papers by Bernstein et al. and Perkins et al.),
- a number of papers on improved instrumentation, such as compact instruments and interferometric approaches,
- signal and noise analyses and simulation of hyperspectral instruments,
- novel applications of hyperspectral techniques to agriculture, manufacturing processes, and gas detection.

We hope this special section will stimulate future developments in these and other topics.



John N. Lee is a senior staff member of the Applied Optics Branch of the Optical Sciences Division at the U.S. Naval Research Laboratory (NRL). He has been at the Naval Research Laboratory since 1980. His recent research and development activities at NRL involve development, demonstration, and fielding of prototype electro-optic, infrared, and hyperspectral reconnaissance and surveillance systems. His system expertise encompasses advanced optical and hyperspectral sensors, advanced data links, airborne and ground processing station development, and the employment of these elements in secure net-centric architectures. He has authored or coauthored numerous papers and several book chapters and is the editor of two books. He is a member of the Optical Society of America and a Senior Member of the Institute of Electrical and Electronic Engineers. He received his B.S. degree in physics (1966) from Union College, New York, and M.S. and Ph.D. degrees in physics from Johns Hopkins University in 1968 and 1971, respectively. From 1971 to 1980 he was employed at the U.S. Army Harry Diamond Laboratories.

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