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Application of L1 Minimization Techniques to Radar Cross-Section Diagnostic Imaging and Error Mitigation

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Abstract

Inverse synthetic aperture radar (ISAR) imaging is a powerful tool for analyzing radar cross-section (RCS) measurements of complex targets. In particular, the ability to extract portions of an ISAR image and reconstruct their associated RCS can provide insight into the individual scattering sources comprising the target's signature, as well as the ability to remove undesired contamination such as clutter and noise from the data. Unfortunately, while analytically elegant and computationally efficient, conventional ISAR image edit and reconstruction (IER) techniques suffer from errors in the predicted RCS due to "edge effects" from the editing masks, particularly when the target's scattering sources are not well-resolved or when the contamination is smeared throughout the image. In this talk, we present the use of the basis pursuit (BP) L1 minimization technique to overcome these and other shortcomings of conventional ISAR IER techniques. We begin with a review of the RCS measurements and ISAR imaging, followed by a brief discussion of L1 minimization and its ability to find "sparse" representations for measured data. This is followed by examples of how the application of BP to ISAR measurements can provide enhanced RCS reconstruction of individual target scattering sources and improved isolation of contamination from undesired error sources.

BIOGRAPHY

Ivan J. LaHaie received his BS degree in electrical engineering from Michigan State University in 1976, and his MS and Ph. D. degrees, also in electrical engineering, from the University of Michigan in 1977 and 1981, respectively. He joined the Environmental Research Institute of Michigan (ERIM) in 1980 and worked there for 30 years during its various incarnations as ERIM International, Veridian Systems, and General Dynamics Advanced Information Systems. He joined Integrity Applications Incorporated (now Centauri) in 2010, where he is currently a Senior Principal Scientist responsible for technical innovation, business development, and program management for the RF and Signature Technology (RFST) team in the Sensors and Analysis Sector. Dr. LaHaie's interests lie in the application of electromagnetics, inverse scattering, and signal processing techniques to problems in radar cross-section (RCS) modeling, analysis, and measurements, synthetic aperture radar (SAR) systems and phenomenology, and unconventional RF and optical imaging. He is a nationally-recognized authority in the development of techniques for RCS measurement error mitigation, near field-to-far field RCS transformations, low observable (LO) signature diagnostics, and RCS uncertainty analysis, and has participated in several government advisory and technical evaluation panels.

Dr. LaHaie is a life fellow of the Institute of Electrical and Electronics Engineers (IEEE), a fellow of the Antenna Measurement Techniques Association (AMTA) and a member of the Optical Society of America (OSA). In 1991, he received the IEEE Aerospace and Electronic Systems Society Radar Systems Panel Award (now the Fred Nathanson Memorial Radar Award) for his contributions to synthetic aperture systems and electromagnetic modeling. The award is given annually to the nation's leading radar engineer under 40 years of age. He received the AMTA Distinguished Achievement award in 2004 for his pioneering work in the development of automated radar signature imaging technology, RCS measurement technology and standards, the design and evaluation of electromagnetic interference and error source mitigation techniques, and for his contributions to the field of radar signature target support interaction modeling.