MIMO Radar

SIMO Equivalence and the Resulting Waveform Constraints

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Abstract

This presentation provides an introduction to short-baseline Multiple-Input Multiple-Output (MIMO) radar along with a comparison of the SNR produced with that produced when operated as a Single-Input Multiple-Output (SIMO) radar. From there, the waveform assumptions and constraints associated with MIMO operation are described.

MIMO waveforms and signal processing have the potential of increasing flexibility in surveillance radar. While a primary impetus for MIMO is to take advantage of the observability provided in inhomogeneous environments a critical factor in the acceptance of MIMO radar is demonstrating that there is not a significant degradation in performance for homogeneous environments. To obtain MIMO observability the step-scan of typical surveillance radar is replaced with wide-area persistent coverage. In homogeneous environments, for a given surveillance volume, transmitted energy, and maximum revisit or update rate, T, theory predicts that the average signal-to-noise ratio (SNR) is equal whether operated in MIMO or SIMO modes. This presentation derives this theoretical SNR for MIMO and SIMO operation by modeling the radars as a series of unitary operations in a linear vector space. The assumptions built into this theoretical model will be described whereby MIMO and SIMO radar operation produce equivalent SNR. It will be shown that assumptions are placed on the transmitted waveforms that are associated with the average transmitted energy, distribution of the energy through the surveillance region, stability of the target scattering, and the time varying nature of the environment. If these assumptions are not met, there can be a significant penalty to operating as a MIMO radar.

Meeting the assumptions for MIMO waveforms implies constraints on waveform design. Performance measures for MIMO waveforms are described and it will be clear that MIMO waveform design is more difficult than SIMO waveform design. How well these performance measures are met determines the SNR and energy-associated penalties of MIMO radar.

Biography

Dr. Frank Robey is Associate Group Leader of Group 33, Ranges and Testbeds Group in the Air and Missile Defense Division of Lincoln Laboratory. This group addresses and develops systems supporting technology development and defense system testing. Dr. Robey received a BSEE (Summa Cum Laude) in 1979 and the MSEE degree in 1980 from University of Missouri, Columbia. He received the D.Sc. EE degree in adaptive detection and beamforming in 1990 from Washington University Sever Institute of Technology, St. Louis, MO. Prior to becoming an engineer, he worked at Electro-Devices Inc. as an electronics technician. Dr. Robey began his engineering career as a Member of the Technical Staff at Hewlett Packard developing RF and high dynamic range audio instrumentation. From 1984 to 1988 he was with Emerson Electric in St. Louis where he developed airborne radar equipment before returning to school for the D.Sc. He joined Massachusetts Institute of Technology, Lincoln Laboratory in 1991. His work at Lincoln Laboratory has been in the areas of sensor systems and technology and system test and evaluation. He spent 6 years working at Kwajalein, Marshall Islands and was the co-lead for the Kwajalein Modernization and Remoting project. Since returning, he has been supporting advanced radar concept development. His research interests include adaptive and sensor-array signal processing and distributed aperture fusion and he has co-authored numerous papers. His recent passion is the development of coherent Multiple-Input Multiple-Output techniques to improve radar performance. He lives in Concord MA with his wife and they enjoy spending time at their Cape Cod beach house and with their children in Washington DC and New Orleans.