

Title:

Introduction to Synthetic Aperture Radar

Abstract:

Synthetic Aperture Radar (SAR) is a radar imaging mode that maps radar reflectivity of the ground. This is an important earth resource monitoring and analysis tool in the civilian and government communities, and an important intelligence, surveillance, and reconnaissance (ISR) tool for the military and intelligence communities. Proper design and analysis of radar systems is highly interdisciplinary, spanning virtually all aspects of electrical engineering as well as other engineering disciplines and physics. This tutorial is intended to provide an introduction to the physical concepts, processing, performance, features, and exploitation modes that make SAR work, and make it useful. Although mathematics will be shown in some parts of the presentation, more than enough to keep any attendee happy, the lecture will focus on the qualitative significance of the mathematics rather than dry derivations. Liberal use of example real-world radar images and other data products will be used to illustrate the concepts discussed. The presentation will be given as four distinct modules, each based on (but enhanced from) presentations developed and given by the presenter in numerous non-public forums to government, military, industry, and academic groups.

Instructor:

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Suggested Prerequisites:

An undergraduate training in engineering or science is assumed. Some familiarity with signals and systems, modulation, Fourier Transforms, and Digital Signal Processing will be very helpful.

This is an introductory course, with the intended audience being scientists, engineers, technicians, or managers who wish to learn more about radar-based imaging of land and sea surfaces.

Duration:

4 hours

Tutorial Description

The course will be taught in four principal sections, each approximately one hour in length. These sections are nominally as follows.

1. Introduction and basic SAR image formation. While other architectures are mentioned, we will focus on airborne pulse-Doppler systems. Basic data models will be developed, and several image processing algorithms will be illustrated and compared. These include a simple 2D-DFT algorithm, the Polar-Format Algorithm (PFA), and Backprojection.
2. SAR performance prediction and the radar equation. The radar equation for SAR will be developed and explored in some detail to illustrate how SAR operating parameters can be traded for performance as measured by the Signal-to-Noise Ratio (SNR) for a target, and equivalently the Noise-Equivalent Reflectivity (NER).
3. SAR phenomenology. The unique nature of range-Doppler images will be discussed, including geometric distortions due to range-Doppler imaging such as wavefront curvature effects and layover. Canonical targets for testing will be addressed. Other SAR image features such as shadows, multipath, and penetration will be discussed. In addition, examples of SAR image dependence on wavelength, polarization, and atmospheric effects will be illustrated. Lots of images will be shown.
4. SAR post-processing and exploitation. Post-image-formation processing of SAR images will be discussed, including autofocus, speckle reduction, and dynamic range compression for image display. Basic SAR image-quality metrics will be presented. Finally, a number of SAR image exploitation techniques and modes will be discussed, including Coherent Change Detection, Interferometric SAR, Polarimetric SAR, Stereo SAR, and VideoSAR. The related topic of Inverse-SAR will also be briefly compared.

References

Extensive list will be made available during the tutorial

Presenter Biography:

Dr. Armin Doerry is a Distinguished Member of Technical Staff in the ISR Mission Engineering Department of Sandia National Laboratories. He holds a Ph.D. in Electrical Engineering from the University of New Mexico. He has worked in numerous aspects of airborne radar systems' analysis, design, and fabrication since 1987, and continues to do so today. He has taught Radar Signal Processing classes (and related topics) as an adjunct professor at the University of New Mexico, and has taught numerous seminars on SAR and other radar topics to government, military, industry, and academic groups.