Introduction to Inverse Synthetic Aperture Radar

Instructor:
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Abstract:
Inverse Synthetic Aperture Radar (ISAR) is a technique used for reconstructing radar images of moving targets. Often, modern high-resolution radars implicitly offer the system requirements needed for implementing ISAR imaging. ISAR images can be obtained by means of a signal processing that can be enabled both on and off-line by using dedicated image formation algorithms. Automatic Target Recognition (ATR) systems are often based on the use of radar images because they provide a 2D electromagnetic map of the target reflectivity. Therefore, classification features that contain spatial information can be extracted and used to increase the performance of classifiers. The understanding of ISAR image formation is crucial for optimizing ATR systems that are based on such images.

As a special offer, proof of registration for this tutorial will entitle attendees to a 40% discount on copies of Dr. Martorella’s new Inverse Synthetic Aperture Radar Imaging book (ref: https://sci.presswarehouse.com/Books/BookDetail.aspx?productID=369891) if purchased at the conference.

Intended Audience:
Attendees should have some knowledge of radar fundamentals as well as simple radar signal processing.

Learning Outcome:
In this tutorial, the following elements will be provided:
- Basic concepts of radar imaging,
- Deep understanding of the significant differences between Synthetic Aperture Radar (SAR) and Inverse Synthetic Aperture Radar (ISAR) and how ISAR techniques work where SAR techniques fail,
- Various applications of radar imaging,
- Ad hoc radar imaging signal processing techniques,
- Elements for the implementation ISAR imaging algorithms,
- Advanced ISAR techniques.
- Classification/recognition features that may be extracted from radar images and the role of ISAR in non-cooperative target recognition (NCTR) schemes

Detailed Description:
This tutorial aims at providing an introduction to ISAR. The lecture is divided in three parts: the first part deals with principles of ISAR, the second part concerns ISAR processing and the third part focuses on advanced ISAR systems, such as bistatic, passive and multistatic ISAR systems. The ISAR system is introduced by defining the radar-target geometry and by considering simple radar concepts. The derivation of the ISAR processor is obtained by defining the signal model and by interpreting it in the Fourier domain. Differences between ISAR and SAR are also highlighted in order to better understand ISAR concepts.

Basic and advanced techniques are presented in order to provide an overview of the current methods used for implementing ISAR and improving its performance. In particular, the
problem of ISAR image autofocus is analyzed in details and several solutions are presented. Bistatic and multistatic ISAR will also be introduced together with suitable ISAR techniques that aim at forming bistatic and multistatic ISAR images.

Several examples with simulations and real data are provided throughout the tutorial in order to demonstrate the effectiveness and potentiality of ISAR imaging. A list of this tutorial contents follows.

1. Introduction
   1.1. Synthetic Aperture Radar (SAR)
   1.2. Inverse Synthetic Aperture Radar (ISAR)
   1.3. ISAR system
   1.4. Examples of applications
2. Signal modelling
   2.1. Radar-target geometry
   2.2. Transmitted signal
   2.3. Received signal (Time-Frequency representation)
   2.4. Radial motion compensation
   2.5. Interpretation of the received signal in the Fourier Domain
3. ISAR image reconstruction
   3.1. Image formation
   3.2. Point Spread Function (PSF)
   3.3. Image Resolution
   3.4. Analogies and differences with SAR
4. ISAR image Autofocus
   4.1. Hot Spot (HS) or Prominent Point Processing (PPP)
   4.2. Phase Gradient Autofocus (PGA)
   4.3. Image Contrast Based Autofocus (ICBA)
   4.4. Image Entropy Based Autofocus (IEBA)
5. Time window selection
   5.1. Max Image Contrast (IC) method
   5.2. Ad-hoc techniques for ISAR imaging of ships
6. Bistatic and Multistatic ISAR
   6.1. Geometry and signal modelling
   6.2. Bistatically equivalent monostatic geometry
   6.3. Examples: Passive ISAR (P-ISAR) and Emulated Bistatic ISAR
   6.4. Multi-channel/Multi-static ISAR (M-ISAR): co-located and distributed M-ISAR
   6.5. Multistatic ISAR image autofocus

Prior Presentations:
This ISAR Tutorial has been previously presented as:
- “Introduction to Inverse Synthetic Aperture Radar”; IET 2011 Radar Conference, Chengdu, China
- “Introduction to Inverse Synthetic Aperture Radar”; IEEE 2012 Radar Conference; Atlanta, Georgia, USA
- “Introduction to Inverse Synthetic Aperture Radar”; IEEE 2013 Radar Conference; Adelaide, Australia
• “Introduction to Inverse Synthetic Aperture Radar”; IEEE 2013 Radar Conference; Ottawa, Canada
• “Introduction to Inverse Synthetic Aperture Radar”; IEEE 2014 Radar Conference; Cincinnati, Ohio, USA
• “Bistatic and Multistatic Radar Imaging”; IEEE 2013 Radar Conference; Arlington, Virginia, USA (with elements of bistatic and multistatic ISAR)

Bio-sketch:

Dr. Marco Martorella received his Laurea degree (Bachelor & Masters) in Telecommunication Engineering in 1999 (cum laude) and his PhD in Remote Sensing in 2003, both at the University of Pisa. He is now an Associate Professor at the Department of Information Engineering of the University of Pisa where he lectures “Fundamentals of Radar” and “Digital Communications” and an external Professor at the University of Cape Town where he lectures “High Resolution and Imaging Radar” within the “Masters in Radar and Electronic Defense”. He is a regular visiting Professor at the University of Adelaide and at the University of Queensland in Australia. He is author of more than a hundred international journal and conference papers and three book chapters. He has presented several tutorials at international radar conferences including tutorials on Inverse Synthetic Aperture Radar and IEEE radar conferences and organized a special issue on Inverse Synthetic Aperture Radar for the Journal of Applied Signal Processing. He is a member of the IET Radar Sonar and Navigation Editorial Board, a senior member of the IEEE and a member of AFCEA. He is also chair of the NATO SET-196 on “Multichannel/Multistatic radar imaging of non-cooperative targets”. He has been recipient of the 2008 Italy-Australia Award for young researchers, the 2010 Best Reviewer for the IEEE GRSL and the IEEE 2013 Fred Nathanson Memorial Radar Award. His research interests are mainly in the field of radar imaging, including passive, multichannel, multistatic and polarimetric radar imaging.