Advanced Inverse Synthetic Aperture Radar Imaging

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 e.m. 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 optimising ATR systems that are based on such images. This tutorial will start with an introduction of ISAR imaging and will then focus on a number of advanced ISAR techniques and applications, including but not limited to Passive ISAR (P-ISAR), Polarimetric ISAR (Pol-ISAR), Compressed-Sensing-Based ISAR (CS-ISAR) and Three-dimensional ISAR (3D-ISAR).

Intended Audience:
Attendees should have an introductory understanding of radar concepts and systems, radar phenomenology, and signal processing.

Learning Outcomes:
In this tutorial, the following elements will be provided:

- Basic concepts of ISAR 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
- Passive ISAR
- Polarimetric ISAR
- Compressed-Sensing based ISAR
- 3D-ISAR

Detailed Description:
This tutorial aims at providing advance ISAR imaging processing and technology. The lecture is divided in two parts: the first part deals with principles of ISAR and ISAR Image formation whereas the second part concerns advanced ISAR processing and applications.

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

1. Introduction
    a. Inverse Synthetic Aperture Radar (ISAR) concept
    b. ISAR image examples
    c. Examples of applications

2. Signal modelling and image formation
    a. Radar-target geometry
    b. Received signal model (Time-Frequency representation)
    c. Image formation
    d. Point Spread Function (PSF)
    e. Image Resolution
    f. Analogies and differences with SAR

3. Pol-ISAR
    a. Principles of radar polarimetry
    b. Full-Pol ISAR imaging
    c. Polarimetric decomposition and Pol-ISAR image understanding

4. 3D-ISAR
    a. Dual radar interferometer
    b. 3D-ISAR geometry and signal modelling
    c. 3D-ISAR image formation
    d. 3D-ISAR image fusion
        i. Multi-temporal 3D-ISAR
        ii. Multi-static 3D-ISAR
        iii. Multi-temporal/Multi-static 3D ISAR

5. P-ISAR
    a. Passive radar concept
    b. Passive ISAR imaging

6. CS-ISAR
    a. ISAR images and sparsity
    b. CS-ISAR imaging
    c. Applications
        i. Data compression
        ii. Gapped data
        iii. Super-resolution

Prior Presentations:

This is new tutorial although the first introductory part (Sections #1 and #2 in the above content list) has been presented previously at IEEE and IET Radar conferences.

Biosketch:

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” an external Professor at the University of Cape Town where he lectures “High Resolution and Imaging Radar” and “Introduction to Radar” within the “Masters in Radar and Electronic Defence”. Prof. Martorella is also Director of the CNIT’s National Radar and Surveillance Systems Laboratory. He is author of more than 200 international journal and conference papers, more than 10 book chapters, a book entitled “Inverse Synthetic Aperture Radar Imaging: Principles, Algorithms and Applications” and another book entitled “Radar Imaging for Maritime Observation”. He has presented several tutorials at international radar conferences, has lectured at NATO Lecture Series and organised international journal special issues on radar imaging topics. 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 a member of the IEEE AES Radar Systems Panel, a member of the NATO SET Panel, where he sits as co-chair of the Radio Frequency Focus Group, and a member of the EDA Radar Captech. He is currently the chair of the research task group NATO SET-250 on “Multidimensional Radar” and co-chair of NATO SET-236 on “Robust compressive sensing techniques for radar and ESM applications”. He was also chair of the SET-196 on “Multichannel/Multistatic radar imaging of non-cooperative targets” and of the specialist meeting NATO SET-228 on “Radar Imaging for Target Identification”. He has been principal investigator of more than 20 research projects. He has been recipient of the 2008 Italy-Australia Award for young researchers, the 2010 Best Reviewer for the IEEE GRSL, the IEEE 2013 Fred Nathanson Memorial Radar Award, the 2016 Outstanding Information Research

Foundation Book publication award for the book “Radar Imaging for Maritime Observation” and the 2017 NATO Set Panel Excellence Award. He is co-founder of a radar systems-related spin-off company, namely ECHOES.