

University Defence Research Centre (UDRC) In Signal Processing



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[O04] Advanced High Resolution Methods for Radar Imaging and micro-Doppler Signature Extraction

Theme: Classification and Multimodal Fusion

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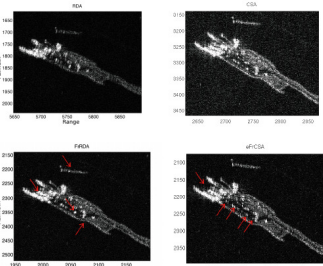
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Aim

- Development of novel high resolution imaging algorithms for bistatic synthetic aperture radar (BiSAR).
- Micro-Doppler signature extraction in bistatic SAR.

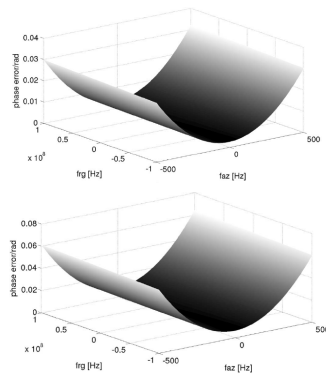
State of the art

- Accurate frequency domain focussing algorithms were not available for bistatic SAR.
- Micro-Doppler signatures have been extracted from radar and from monostatic SAR but a model for the bistatic case was required.
- Micro-Doppler extraction suffers of problems such as affecting the signature while removing the clutter.
- Bistatic SAR introduces technical and strategic advantages, such as reduction of the dynamic range and a minor vulnerability to Anti Radiation Missiles.



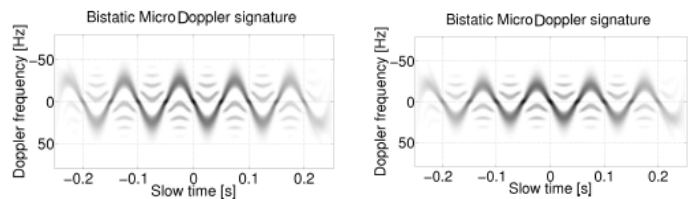
•Development of high resolution algorithms for SAR imaging using Fractional Fourier Transform. The FrFT has been applied to obtain higher resolution on LFM signals presents in the SAR received signal. However the proposed algorithms showed a higher computational burden.

- Chebyshev approximation increased the final accuracy of the point target spectrum used to develop bistatic SAR focussing algorithms. The proposed approach improved the bistatic point target spectrum (PTS) based on the method of series reversion using Chebyshev polynomial approximation. The accuracy of the bistatic point target spectrum is limited by numerical errors.

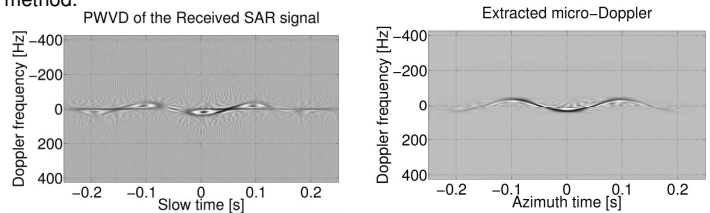


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- Carmine Clemente, John J. Soraghan, "Fractional RDA and Enhanced FrCSA for SAR Imaging", Signal Processing For Defence, SSPD-2010, 29-30 September 2010, London
- Sherif Elgamel, Carmine Clemente, John J. Soraghan, "Radar Matched Filtering using the Fractional Fourier Transform", Sensor Signal Processing For Defence, SSPD-2010, 29-30 September 2010, London
- Carmine Clemente, John J. Soraghan, "Fractional Range Doppler Algorithm for SAR Imaging", European Radar Conference, Eurad-2010, September 26- October 1, Paris
- Carmine Clemente, John J. Soraghan, "Bistatic Slant Range Approximation using Chebyshev Polynomials", IEEE Radar Conference 2011, Radarconf2011, May 23-27, Kansas City, USA

- The micro-Doppler effect in bistatic SAR has been modeled and analyzed. The effect on the focused image and the advantages provided by the use of a bistatic configuration has been analyzed. Micro-Doppler in multistatic SAR is geometry dependent, it can be useful in cases where monostatic micro-Doppler cannot be measured.



- Existing Micro-Doppler extraction methods do not extract the micro-Doppler signature without affecting it. A new extraction method based on SVD has been applied to extract micro-Doppler from SAR. SVD, in the form of Singular Spectrum Analysis allows to separate m-D from clutter and noise in a SAR image. An accurate analysis of the spectrum of the eigenvalues is required in the SVD extraction method.



Summary

- This research project has developed novel techniques for monostatic and bistatic SAR imaging.
- Micro-Doppler models for the bistatic SAR acquisition mode were developed and the advantages provided by the use of a bistatic configuration were analyzed.
- A micro-Doppler extraction technique based on the singular value decomposition has been applied to SAR data providing excellent results.

Exploitation & military relevance

- The amount of information that can be extracted from multistatic SAR is greater than from monostatic.
- The acquisition can be safer and more stealthy
- Micro-Doppler signature provide key information about the target fundamentals for automatic target recognition
- Micro-Doppler analysis can be exploited in both active and passive MIMO distributed sensor systems
- Multistatic 3D SAR imaging can be a powerful future field of investigation.

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- Carmine Clemente, John J. Soraghan, "Approximation of the Bistatic Slant Range Using Chebyshev Polynomials", IEEE Geoscience and Remote Sensing Letters (in Press).
- Carmine Clemente, John J. Soraghan, "Vibrating Target Micro-Doppler Signature in Bistatic SAR with a Fixed Receiver", IEEE Transactions on Geoscience and Remote Sensing. (in Press)



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