University Defence Research Collaboration (UDRC)
Signal Processing in a Networked Battlespace

L_WP4: MIMO & Distributed Sensing

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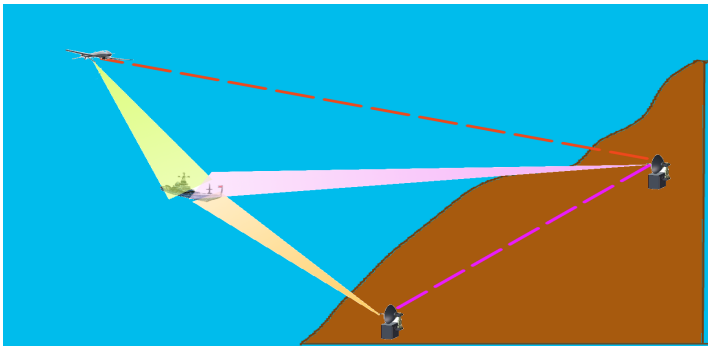
Introduction:

The nature of the modern battlefield is changing dramatically. Electronic communication is allowing unprecedented interchange of data and information between platforms. Advances in electronics offer the possibility of low cost networked unattended sensors. Intelligent and robust processing of the very large amount of multi-sensor data acquired from various networked communications and weapons platforms is, therefore, crucial to retain military advantage and mitigate smart adversaries who present multiple threats within an anarchic and extended operating area (battlespace).

The work package that will be developed will involve the investigation of advanced signal processing methods for active/passive Distributed MIMO Radar Systems (DMRS).

Objective:

To develop novel paradigms for DMRS. Advanced signal processing methods for active/passive DMRS will be investigated. The approaches aim to improve performance, reduce system requirements with the result of producing a set of algorithms suitable for robust applications in a cluttered networked battlespace.



Example of DMRS Scenario

L_WP4.1 MIMO & Distributed Sensing Systems

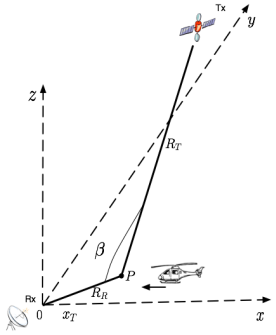
Inspired by major benefits gained from MIMO communications, coherent and incoherent DMRS will allow dramatic increase in detection, tracking and classification performance only if an optimal set of signal processing techniques are applied.

Waveform Design [1]:
-Double Dispersion
-Waveform Reuse
-Covertness

Sparse Sensing for Reduced:
-Bandwidth and Memory Requirements

Active Systems:
-Co-located
-Distributed
-Coherent & Incoherent

Passive Systems [4]:
-Increased Covertness
-Reduced Costs
-Opportunistic Sources



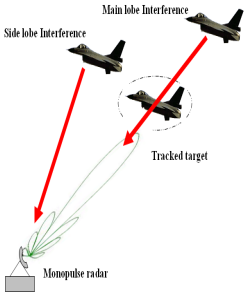
L_WP4.2 MIMO & Distributed Sensing Applications

DMRS offers enhanced anti-clutter and anti-jamming potentials. Novel signal processing methods for jamming and clutter mitigation in high cluttered and distributed environments will be developed. Novel ATR algorithms for DMRS will be also developed .

Signal Processing Methods [2]:
-Clutter Reduction Techniques
-Anti Jamming Methods
-FrFT & EMD in DMRS

Microdoppler (MD) Analysis [3]:
-Multidimensional MD Signature Extraction

Information Target Fusion:
-Reflectivity Profiles
-Identification & Classification
-Tracking



L_WP4.1 Ongoing Activities

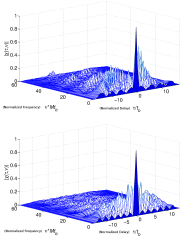
-Novel waveform libraries have been developed starting from known and well assessed radar waveforms;

-FrFT based waveform libraries are under construction;

-Waveforms require no additional system resources;

- Possible applications are: agile radar systems and high-density MIMO radars;

- The prototype of a novel concept of PBR [4] for micro-Doppler based ATR is under development;



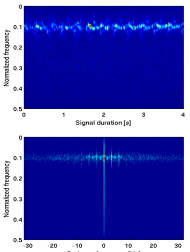
Ambiguity Functions for Frank and Barker Codes

L_WP4.2 Ongoing Activities

- Novel micro-Doppler feature extraction techniques have been developed, providing classification results robust on real datasets;

- Translational, rotational and scale independent micro-Doppler features are under investigation with the opportunity to integrate clutter mitigation techniques;

-Applications of compressed sensing for ATR are under investigation.



Dstl Challenges:

-Enhancing Electronic Surveillance Performance in high Signal Densities;
-3D Synthetic Aperture Radar (SAR) Processing;
-Recognition of Orthogonal Frequency Distribution Multiplexing (OFDM) in Low SNR and Dense Environments;
-MIMO Signal Processing for Perimeter Defence & Base Protection;
-Decentralised Signal Processing Across Sparsely Distributed, Low-Bandwidth, Heterogeneous Networks; -Robust association of signals from passive sensors with known location;
-Theoretical Techniques to Counter SAR Jamming.

Collaborations:

- Selex-ES, L_WP4 Industrial Partner, on ATR systems;
- Dstl on novel SAR sensors applications and challenges;
- Ohio State University on bio-inspired waveform design;
- University of Naples on robust and effective micro-Doppler classification.

L_WPs Links:

Links to L_WP1 & L_WP2 through anomalies, L_WP2 through Game Theory for MIMO Radar; L_WP3 through exploiting sparsity and L_WP5 for decentralised processing.

References:

[1] A.S. Amein, and J.J. Soraghan, "Fractional chirp scaling algorithm: mathematical model", IEEE Trans. Signal Process., 55(8), pp. 4162-4172, 2007;
[2] Elgamel, Sherif A.; Soraghan, J.J., "Using EMD-FrFT Filtering to Mitigate Very High Power Interference in Chirp Tracking Radars," Signal Processing Letters, IEEE , vol.18, no.4, pp.263,266, April 2011;
[3] Clemente, C.; Soraghan, J.J.,"Vibrating Target Micro-Doppler Signature in Bistatic SAR With a Fixed Receiver," Geoscience and Remote Sensing, IEEE Transactions on, vol.50, no.8, pp.3219,3227, Aug. 2012;
[4] C. Clemente, J. J. Soraghan ,"GNSS Based Passive Bistatic Radar for micro-Doppler analysis of helicopter rotor blades", IEEE Transactions on Aerospace and Electronic Systems, Vol. 50, issue 1, January 2014.

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