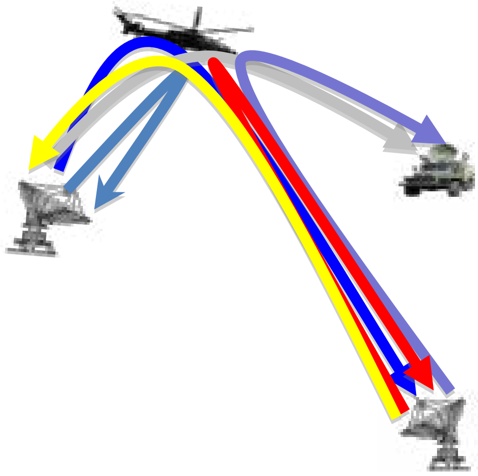
University Defence Research Collaboration in Signal Processing

LSSC Consortium White Paper

Enabling Distributed Radar

Introduction

Distributed radar systems, including statistical MIMO and passive radars have potential capabilities in terms of enhanced detection, target characterization and area coverage. Despite these potential performance advantages, issues such as hardware cost, resource management and algorithm design require further investigations in order to make the exploitation of distributed radar sensors practical and worthwhile.



Frequency management, computational costs and algorithms that are capable of coping with different acquisition conditions are challenges that need to be addressed before employing effectively distributed radar networks.

Our research focuses on developing signal processing techniques able to address these challenges by improving frequency management through inter-system and intra-function bandwidth sharing, reducing bandwidth requirements, increasing robustness and reliability of algorithms designed for these systems.

Figure 1 Example of a distributed radar scenario

Method

In order to allow efficient inter-system frequency usage we developed a novel approach to generate radar waveform libraries [1] through the use of the fractional Fourier transform. The developed libraries can be used in MIMO or distributed radar systems providing waveform diversity and limited interference. The waveform libraries have constant envelopes and were successfully tested using autonomous waveform generators and MIMO software defined radio receivers. Additional potential usage of this approach to generate waveforms is in low probability of intercept radars and in multi-function radars able to embed information in the fractional waveform.

Another requirement in distributed radar is the capability of distributed sensors to share information among the. This is a bandwidth demanding task and for this reason we have developed a solution for radar data compression [2] exploiting a new signal processing technique that is a physics-inspired approach and called Anamorphic Stretch Transform. The algorithm transforms the image into a warped (anamorphic) Fourier domain representation that

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requires fewer samples to represent than the original image; hence it is conductive to image compression. The developed algorithm allows lossless compression of complex images as Synthetic Aperture Radar ones. The approach has been demonstrated on SAR images obtained from both spaceborne and airborne systems showing increased capabilities in image compression and phase preservation than using JPEG2000 [3]. Figure 2 shows the performance achievable when using the novel algorithm to compress SAR images.

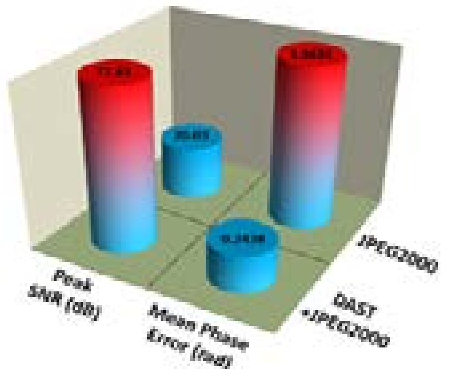
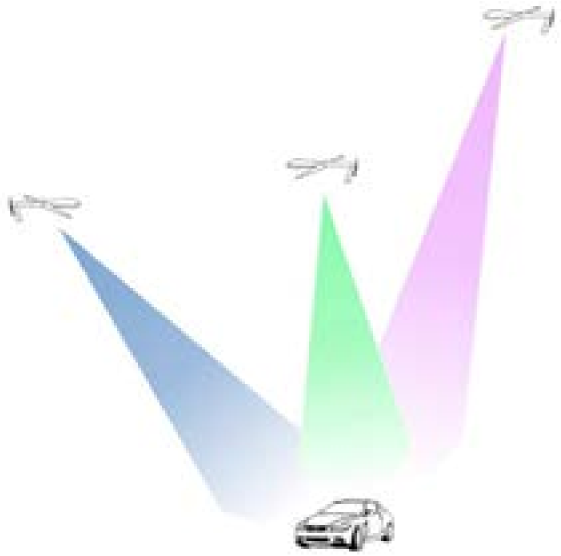


Figure 2 Performance achievable with the novel compression technique on SAR images



The use of spatially separated radars creates the need for algorithms able to cope with characteristics of targets that are dependent on the aspect angle, especially when the ultimate objective is target recognition. In order to provide invariant features a low computational approach based on orthogonal image moments has been developed [4-7] and applied to the context of SAR images for automatic recognition of civilian and military vehicles and to micro-Doppler based recognition of humans, animals, helicopters and other targets. Depending on the specific application the image moment can provide scale, translation and rotation invariance, for example the maximum Doppler shift in a micro-Doppler signature can be made independent of the aspect angle as well as of the pose in the image plane of a vehicle in a SAR image.

Figure 3 Multi-Frame SAR ATR scenario

References:

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