Moving Target Detection in Dual-Channel SAR by Adaptive DPCA Clutter Removal

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This poster begins by introducing the Engineering Doctorate project behind this work, which aims to develop practical algorithms for the detection of moving objects in Synthetic Aperture Radar (SAR) images, in collaboration with Selex ES. The poster then goes into detail on a recently implemented technique that detects moving object smears in two-channel SAR images recently gathered with Selex ES's PicoSAR system. This interferometric algorithm applies an adaptively derived phase-shift to one channel to correct the phase difference between the channels. By subtracting one channel from the other, the stationary clutter is removed leaving only moving objects in the image. This work in is the early stages but initial results are presented along with ideas for further investigations.

"…initial results of a technique that detects moving object smears in two-channel SAR images"

Engineering Doctorate in SAR-MTI with Selex ES

This Engineering Doctorate project concerns the detection of slow-moving targets in Synthetic Aperture Radar images (SAR) using multi-channel receivers. Such targets are known to be badly focused and often appear at the wrong position in standard SAR processors that do not account for the targets' motion. The work takes a fresh look at the issue of combining Moving Target Indication (MTI) and Synthetic Aperture Radar (SAR) imaging from the perspective of a multi-channel receiver to allow detection of a broader range of targets.

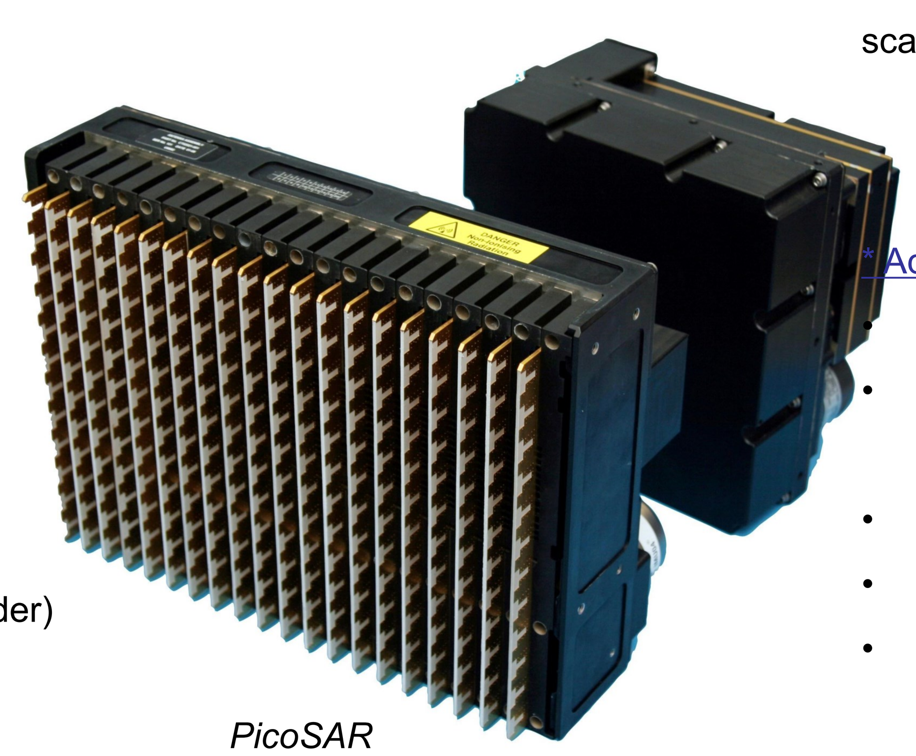
"…look at combining MTI and SAR from the perspective of a multi-channel receiver…"

Project Focus

- Industrial relevance
- Practical algorithms
- Two channels only

Applications for SAR-MTI

- Fill surveillance capability hole between stationary SAR and exo-clutter MTI
- Dismounted combatants
- Perimeter protection (military, civil and border)
- Monitoring people at disaster areas and public events
- Monitoring animals in conservation areas



PicoSAR

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Adaptive DPCA Clutter Removal Algorithm

The phase of the cross-correlation of two SAR images from a dual-channel system is a measure of the direction-of-arrival (DoA) which can be used to determine cross-range independently from Doppler. The cross-correlation averaged over a rolling window of range gates produces a correction factor that "aligns" the two channels in space. After this correction, stationary scatterers contribute the same signal to both channels. Moving targets are different in the two channels due to their Doppler/DoA mis-match. Subtracting one channel from the other removes the stationary scatterers and leaves only the moving targets*. An initial algorithm has been developed to then detect the smear typical of moving targets.

"…a range-averaged cross-correlation factor that 'aligns' the two-channels…"

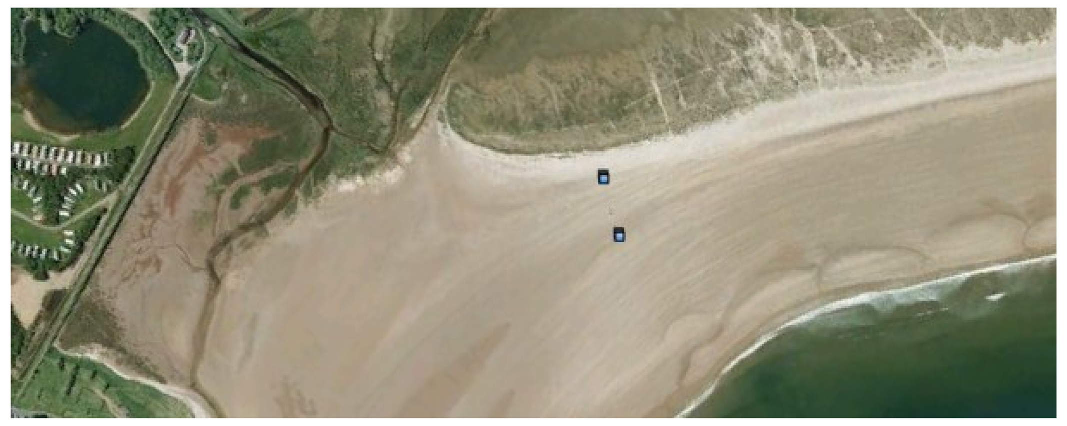
*Additional Issues

- Moving clutter (eg. foliage)
- Tall clutter (further alters Doppler/DoA relationship)
- Clutter discretes (no analysis of this currently)
- Many movers biasing the cross-correlation
- Errors in channel alignment

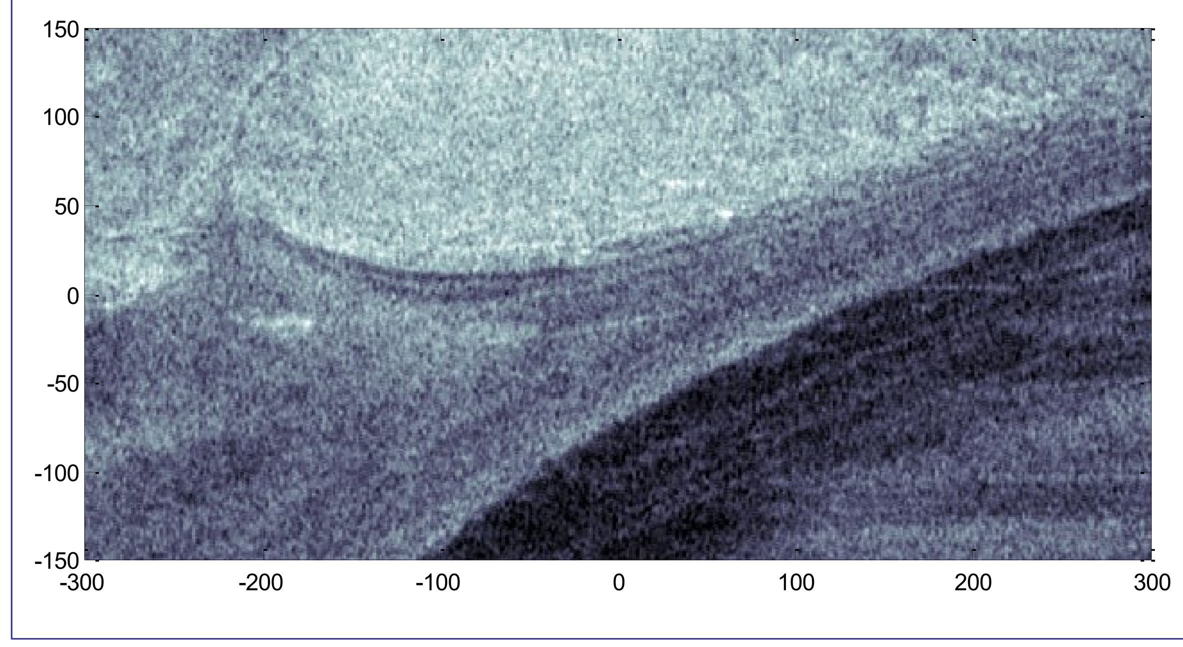
Trials Results

After being developed and validated on simulated multichannel SAR data, the algorithm was tested on trials data collected in East Lothian by Selex ES using their lightweight PicoSAR system mounted on a helicopter. Two cooperative walking targets are moving along-track over the beach in opposite directions. GPS ground truth confirms the location of the targets. The trials results clearly show clutter suppression and increasing moving target visibility.

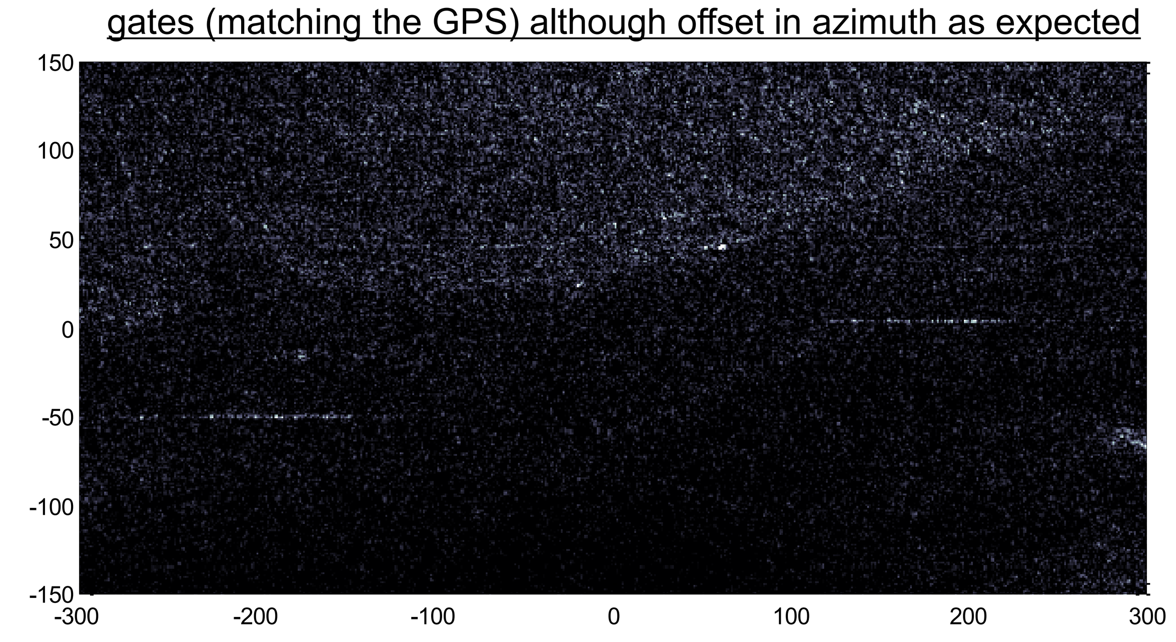
Image of wider area showing target GPS (Google™earth)



SAR image zoomed into the targets' area (Selex ES)



Moving targets highlighted from clutter and shown in the correct range gates (matching the GPS) although offset in azimuth as expected

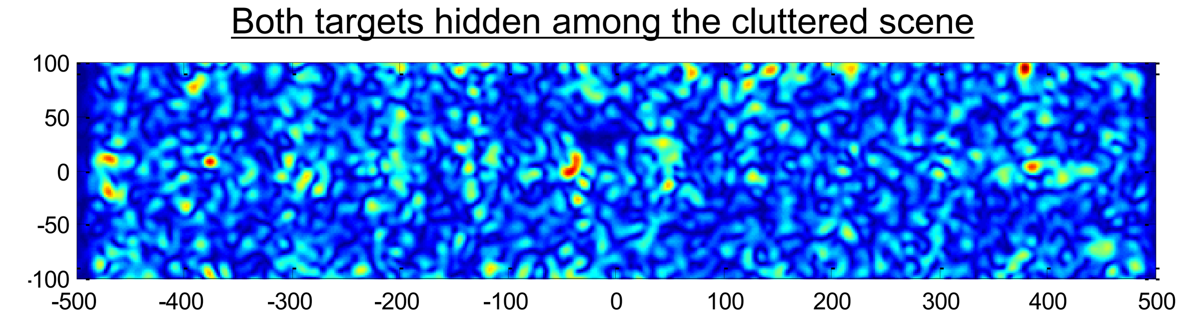


Simulation Results

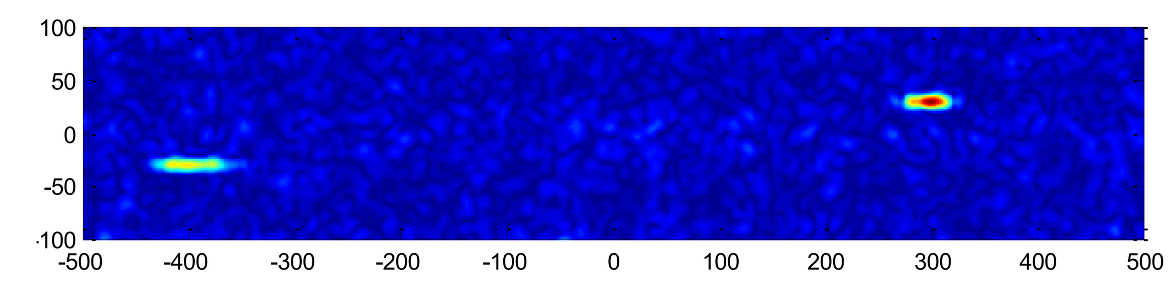
A simulation was carried out that included many errors that are known to be present in real data. This narrows the gap between the simulation environment and reality.

- Background clutter of multiple random scatterers per resolution cell
- Shadowy, thermal-noise-only areas of clutter
- Varying terrain height that is not considered in the image formation
- Unknown, uncorrected navigation error in platform position
- Imaging parameters typical of PicoSAR mounted on a helicopter
- Two slow targets moving approximately across-track, in opposite directions, at a smoothly varying velocity

Both targets hidden among the cluttered scene



After clutter cancellation, targets clearly visible



Target Detection

After clutter cancellation, moving target smears are clearly distinguishable from the clutter as they exhibit a unique combination of characteristics that enable detection over other bright pixels (orientation, length, continuity). A detection algorithm has been developed based on these attributes. It does not exploit phase information; adding this is a possible improvement.

"A detection algorithm has been developed based on the orientation, length and continuity of moving target smears."

Further Work

It is expected that the false alarms can be reduced by adding an iterative step to the algorithm: after detecting range gates containing targets, the algorithm could be re-run excluding the target cells and a guard from the estimation of the covariance matrix.

It is also hoped to test the algorithm on further trials to validate these results. Analysis of the situations in which the detection performs better than normal should help to identify the practical strengths of this approach and identify situations in which the algorithm needs improvement.

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