A Velocity Vector Estimation Algorithm Tested on Simulated SAR Raw Data

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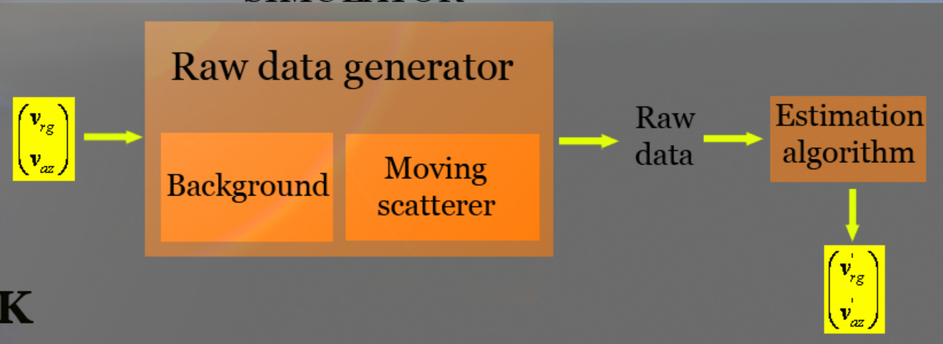
WORK DONE

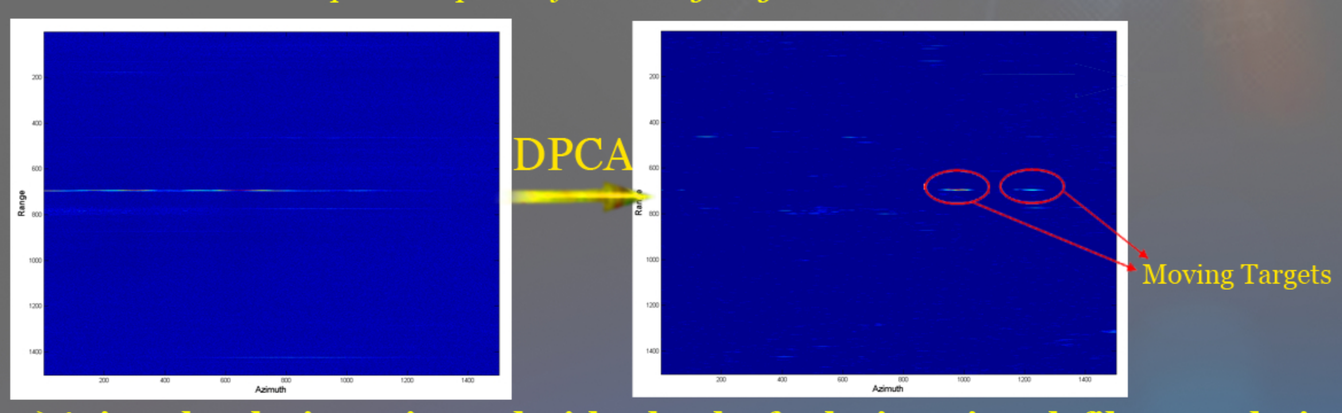
Work developed:
a) Dual-channel split-antenna SAR raw data simulator;
b) SAR processor;
c) velocity vector estimation algorithm
d) Testing on simulated and real data

WORK SCHEME

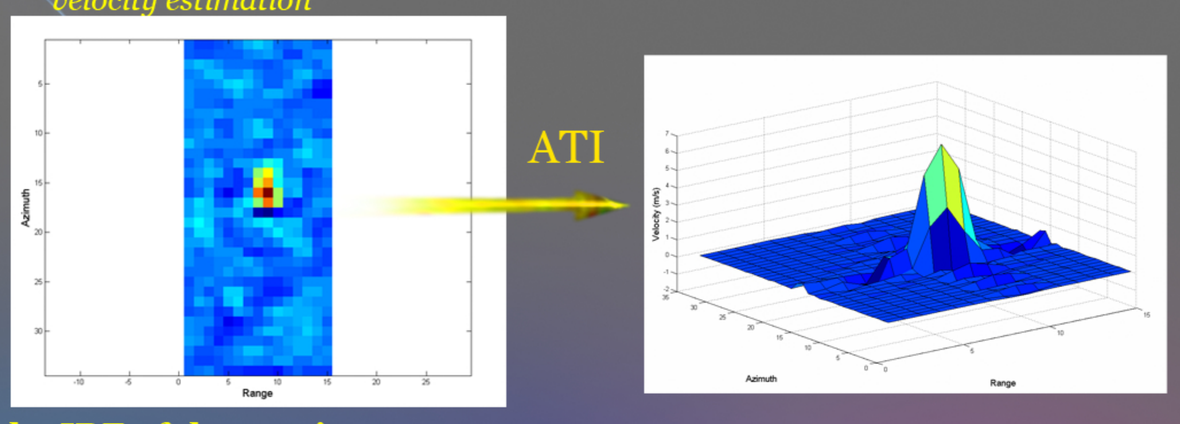


USED PROCEDURES IN THE WORK

1) Moving targets detected by DPCA (Displaced Phased Centre Antenna)
DPCA: applied on the range compressed domain, it is a robust technique and optimal for moving target detection



2) Range velocity estimated by ATI (Along-Track Interferometry)
ATI: applied on the focused data, it is very sensitive and optimal for range velocity estimation



3) Azimuth velocity estimated with a bank of velocity azimuth filter, analyzing the IRF of the moving scatterer.

VELOCITY ESTIMATION ALGORITHM

Four-steps improved velocity vector algorithm

1. **Azimuth component estimated with a coarse bank of azimuth matched filters.**
2. **Range velocity estimated by ATI, with a subsequent refinement which uses a bank of range velocity filters centred around the first estimate.**
3. **New estimate of the azimuth velocity with a fine bank of filters centred on the previously estimated range and azimuth velocity.**
4. **Moving target azimuth replacement in function of the range velocity.**

SIMULATION RESULTS

Test velocity vectors

Vector Number	Range velocity	Azimuth velocity
1	5.1 m/s	8.2 m/s
2	10.2 m/s	16.5 m/s
3	15.4 m/s	24.7 m/s
4	20.7 m/s	33 m/s

Different backgrounds generated;
1) Reference background with constant backscattering intensity, (Signal-to-Clutter Ratio –SCR- of 30 dB).
2) Sea background (SCR= 18 dB) for ship traffic monitoring.
2) Shrubs background (SCR=9 dB) for vehicle traffic monitoring.

Results for the background with constant backscattering

Vector number	Range error mean (%)	Azimuth error mean (%)	Range standard deviation (m/s)	Azimuth standard deviation (m/s)
1	7.1	18.4	0.1	0.9
2	6.3	2.7	0.1	1.5
3	6.8	7.7	0.1	2.5
4	6	12.3	0.1	4.1

Results for the sea background

Vector number	Range error mean (%)	Azimuth error mean (%)	Range Standard deviation (m/s)	Azimuth Standard deviation (m/s)
1	13.5	9.7	0.3	3.2
2	23.4	13.8	0.6	3.5
3	24.8	19.6	0.3	2.9
4	26	6.3	0.1	3.6

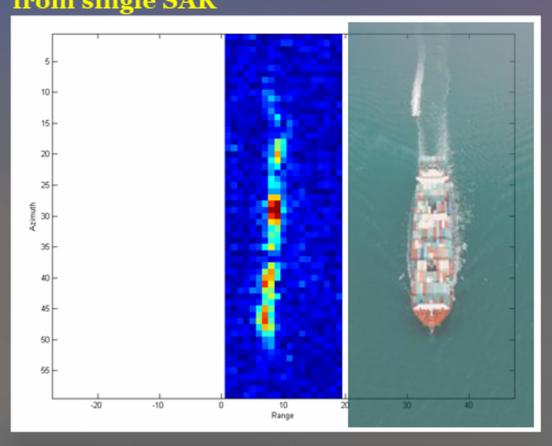
Results for the shrubs background

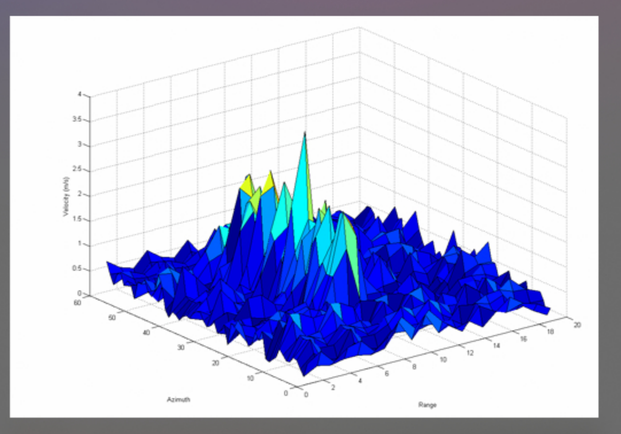
Vector number	Range error mean (%)	Azimuth error mean (%)	Range standard deviation (m/s)	Azimuth standard deviation (m/s)
1	61.9	30.7	0.4	8.3
2	14.8	20.9	1	2.7
3	29	20	0.4	8.6
4	34.5	28.5	10.2	8.8

EXPERIMENTAL RESULTS

Raw data related to a scene centred in Anzio (Italy).

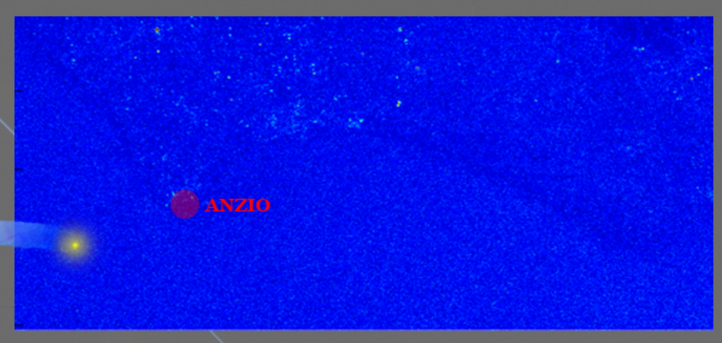
Application of look filtering to the range compressed data to obtain two channels from single SAR





1. Geographics coordinates of the ship
   Lat: 41° 26′ 32.95″
   Lon: 12° 39′ 0.50″
2. Velocity on the Azimuth-Range plane
   azimuth -9.6 m/s
   range 1.6 m/s
3. Velocity on the north south- east west plane
   north south- 9.5 m/s
   east-west 1.4 m/s
   ship direction: 351.7°
4. Azimuth shift: 113 m

The algorithm minimizes the velocity estimation error compared to a separate estimation of the two velocity components!



CONCLUSION

1- The algorithm developed estimates the velocity vector without a-priori information.
2- This technique can be implemented for a single antenna SAR in a split-aperture mode.