GEOMETRICAL AUTO-FOCUSING FOR UAV SAR TOMOGRAPHY OF NATURAL SCENARIOS

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GEOPHYSICAL AND ATMOSPHERIC RETRIEVAL FROM SAR DATA STACKS OVER NATURAL SCENARIOS

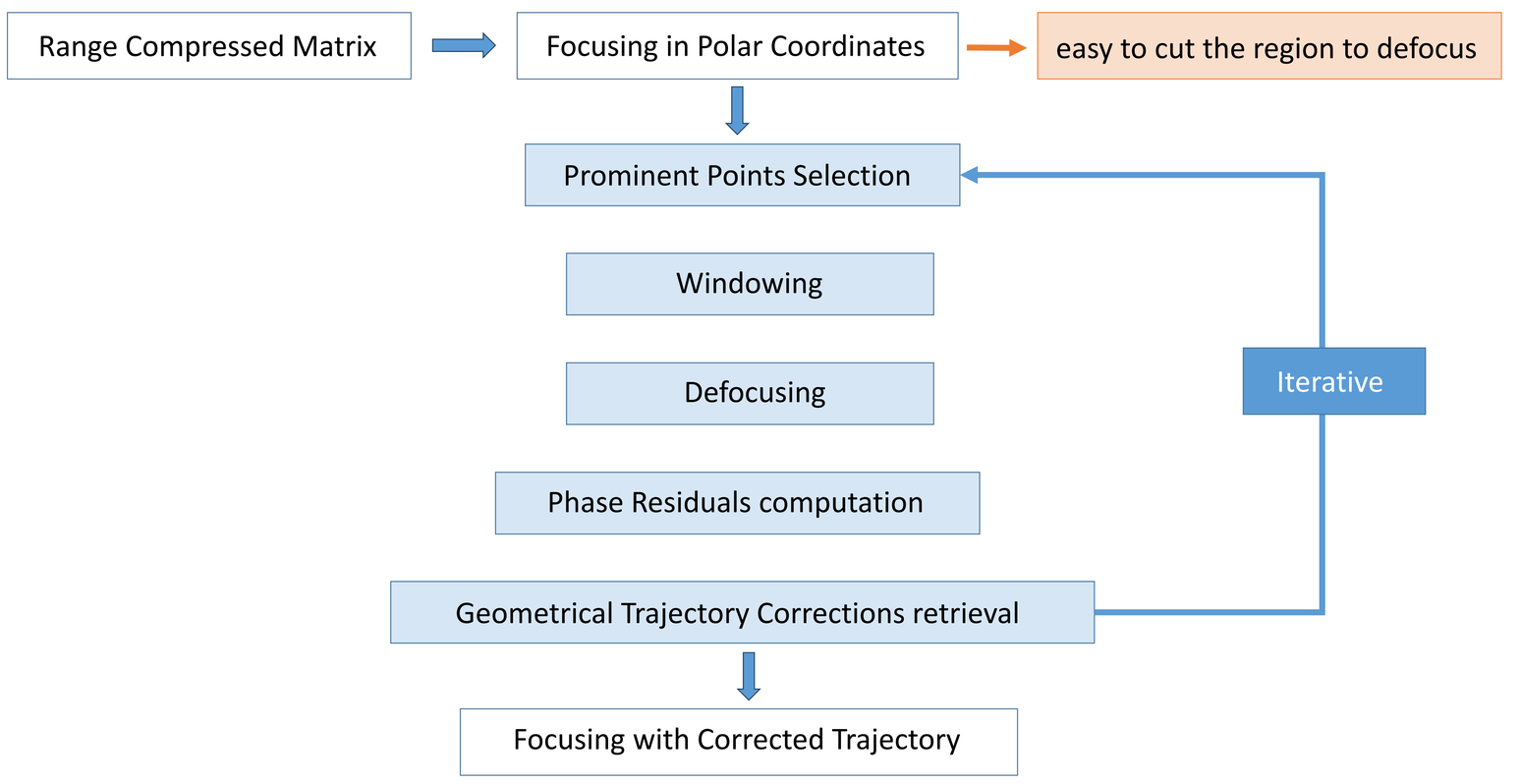
1. Abstract

The introduction of Synthetic Aperture Radar (SAR) tomography (TomoSAR) has opened the way to a completely new approach to look at SAR data, providing evidence of the possibility to directly image the 3D structure of natural media such as forests, snow, and ice. In this context, activities are being carried out at Politecnico di Milano to develop specific signal processing algorithms for the implementation of a tomographic demonstrator based on the use of a small fleet of Unmanned Aerial Vehicles (UAVs) carrying Radio-Frequency devices. Specifically, in this poster we introduce a novel approach to solve the problem of focusing SAR data on presence of a poor knowledge of platform trajectory, this is especially the case of UAV-based systems with low-cost navigational units. The presented algorithm is a geometrical evolution of the well-known Phase Gradient Autofocus (PGA), aimed at a **direct retrieval of platform trajectory**. The final focused image is the result of the focusing considering the new corrected platform trajectory.

2. Objective

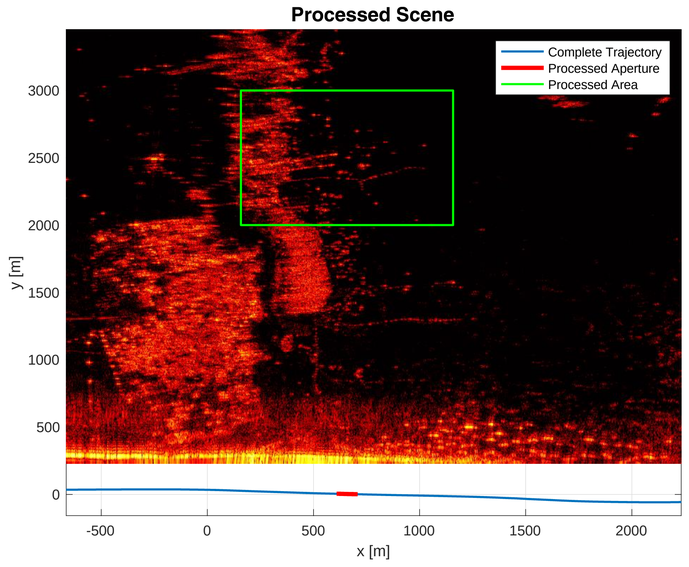
As of today, the benefit of TomoSAR has been demonstrated experimentally based on airborne data in the context of different environmental applications, including estimation of forest height and Above Ground Biomass, retrieval of snowpack depth, density, and internal layering, and monitoring the internal structure of alpine glaciers and ice sheets. Despite the many successful experimental campaigns, spaceborne tomography is yet to come, mainly due to possibility to fly multiple sensors at the same time. UAV-based systems opened the way for a low-cost SAR platform involving multiple sensors acquiring with different elevation angles, so giving the required vertical resolution. In this scenario, motion estimation and correction algorithms are necessary to mitigate unprecise navigational information. In this poster is reported a **low complexity geometrical autofocusing** method to overcome this problem.

3. Method overview



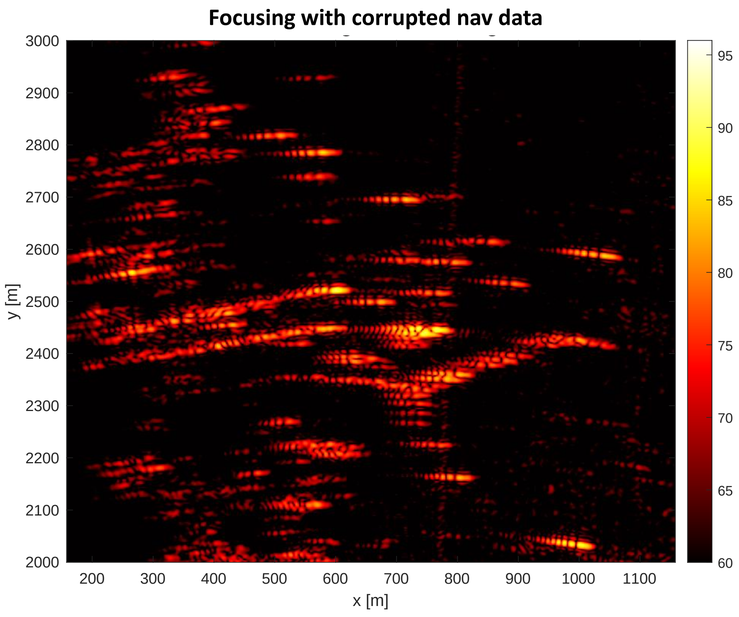
4. Results

[1]*Perna, S.; et al. The ASI Integrated Sounder-SAR System Operating in the UHF-VHF Bands: First Results of the 2018 Helicopter-Borne Morocco Desert Campaign. Remote Sens.* ***2019****, 11, 1845.*

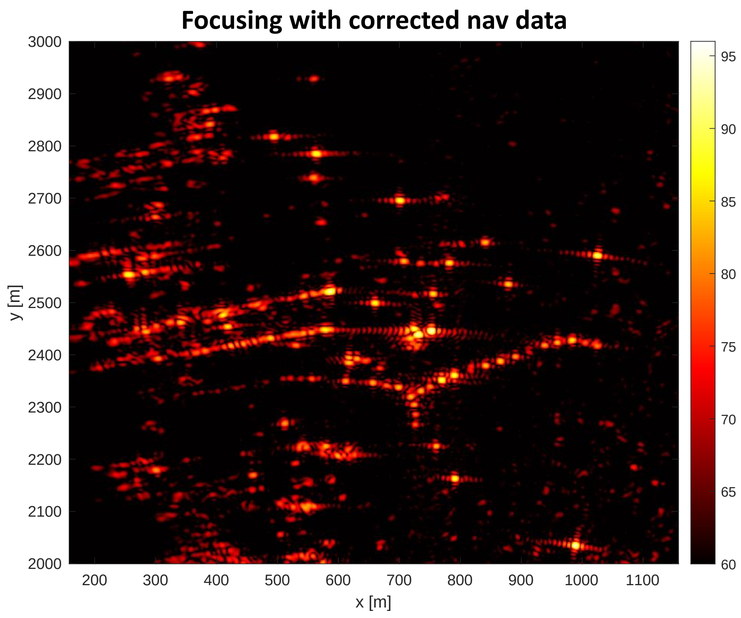


5. Discussion

The algorithm was initially tested using simulated data both for bistatic and monostatic case. Here is reported an application to real-world data acquired in 2018 by CORISTA during a **monostatic P-Band helicopter-borne campaign in the Morocco Desert**, in the context of research activities supported by the Italian Space Agency[1]. The proposed algorithm was performed to an artificially-blurred image. After few iterations, the result of the processing gives the **geometrical compensations** to be applied to the nominal trajectory given by the on-board localization system. It is important to mention that **trajectory deviations comparable to the wavelength can severely affect the final focused image quality**. Once estimated the corrected travelled path, the range compressed data are re-focused. The quality of the focused image after autofocusing is clearly enhanced, the targets are more defined, the blurring caused by localization inaccuracy is significantly reduced. The sharpness comparison of the two images was quantified by evaluating the **Integrated SideLobe Ratio** (ISLR), which results remarkably reduced after the processing.



Before Autofocusing



After Autofocusing

6. Conclusions

- The novelty introduced in this for work is a low complexity method for the computation of the geometrical trajectory corrections, instead of the phase corrections.
- It can be generalized for **all SAR platforms**.
- Results indicate that the proposed approach can successfully correct trajectory errors when present, while it does not produce further degradation in the case where navigational data are accurate.
- Further developments and refinements of the algorithm are still ongoing:
  - New methods for the detection of prominent points in the image.
  - Automatic window length computation for the selection of the blurred data in the polar image.