PROCESSING MULTIPLE SAR MODES WITH BASEBAND AZIMUTH SCALING

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1. INTRODUCTION

This paper presents an efficient phase preserving processor for the focusing of data acquired in three different modes, namely sliding-spotlight, TOPS (Terrain Observation by Progressive Scans) and ScanSAR. Existing approches for the azimuth processing can become inefficient due to the additional processing to overcome the folding in time. In this paper, baseband azimuth scaling is used to perform the azimuth processing in an efficient way. The kernel is exactly the same for the three modes, where the computation of the scaling and rotation vectors is slightly different only for the ScanSAR case. A discussion concerning staring-spotlight is also included. Real data acquired by TerraSAR-X in sliding-spotlight, TOPS and ScanSAR modes are used to validate the processor.

2. BASEBAND AZIMUTH SCALING

The formulation of baseband azimuth scaling (BAS) was already presented in [1] to process data acquired in the TOPS mode. However, exactly the same kernel can be used to process sliding-spotlight data due to its similarities with the TOPS mode. Sliding-spotlight and TOPS share in common a linear variation of the Doppler centroid along the azimuthal dimension, which is due to the steering of the antenna throughout the data take. Consequently, the total azimuth signal bandwidth might span over several PRF (pulse repetition frequency) intervals. An efficient solution to overcome this insufficient sampling is the use of sub-apertures [2]. This approach takes advantage of the higher PRF with respect to the instantaneous azimuth bandwidth, allowing the selection of (in many cases) large portions of raw data to perform the range-variant processing. Afterward, the sub-apertures are recombined, so that only the full resolution azimuth focusing is left. However, if classical matched filtering is used, a large reference function is needed, provided that the azimuth spectrum has been extended to accommodate for the whole azimuth bandwidth. This turns out to be an inefficient solution. Azimuth scaling with SPECtral ANnalysis (SPECAN) was proposed in [2] in order to avoid the use of a large reference function. However, some inconveniences arise in the sliding-spotlight mode. First, extra steps are needed in order to accurately perform the azimuth weighting, and second, folding in the focused domain (i.e. wrap around in the azimuthal dimension) might result when using the SPECAN approach. Similarly, the TOPS mode will result in most cases in folding in time when using SPECAN. BAS overcomes this problem in an efficient way using a modified azimuth scaling approach. The block diagram of the processor is shown in Fig. 1. The range-variant processing is performed for every sub-aperture using the phase functions of ECS (H_1, H_2 and H_3), but any other algorithm is valid for this purpose. Then, BAS continues with the phase functions H_4, H_5, H_6 and H_7. The modifications in the azimuth signal can be observed in the time-frequency diagrams of Fig. 1 for both sliding-spotlight and TOPS. The removal of the hyperbolic phase history and insertion of a quadratic one (H_4) provokes a slight scaling of the azimuth signal with respect to the scene center. Then, the de-rotation function (H_5) basebands the signal, so that now azimuth compression and weighting can be efficiently performed in the Fourier domain (H_6). Finally, H_7 is necessary to achieve phase preservation.

Both sliding-spotlight and TOPS acquisitions have a rotation center, which in the former case lies beyond the swath, and in the latter behind the sensor. Indeed, ScanSAR is a particular case compared to the other two modes, as no explicit rotation range exists. However, one can profit from the fact that changing the Doppler rate shifts the signals as a function of their squint angle and beam-center offset time. In this way, an artificial rotation range is introduced, which can then be used to focus the signal using BAS, as depicted in Fig. 2. However, the proposed approach cannot process data acquired in staring-spotlight mode, as

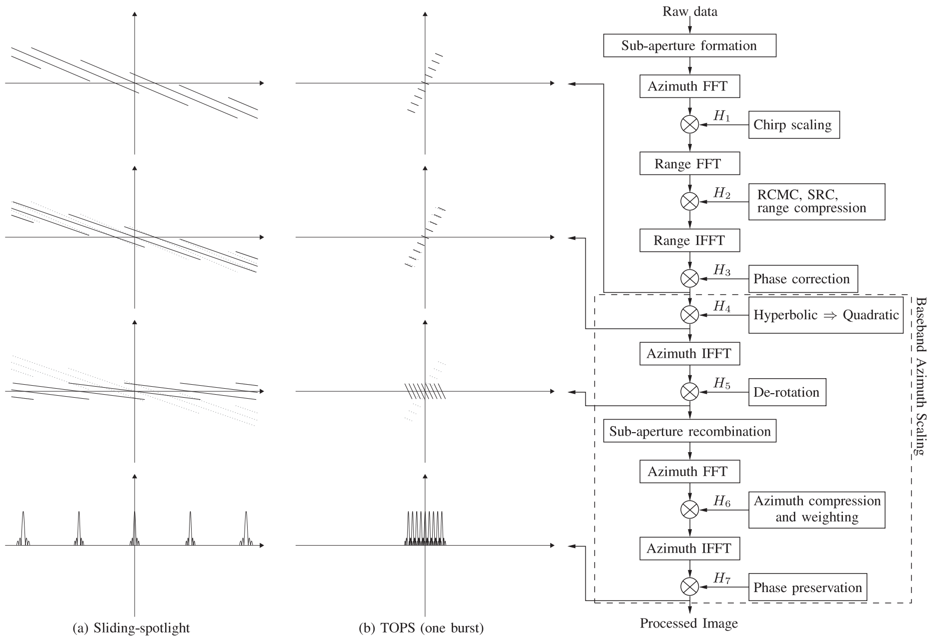
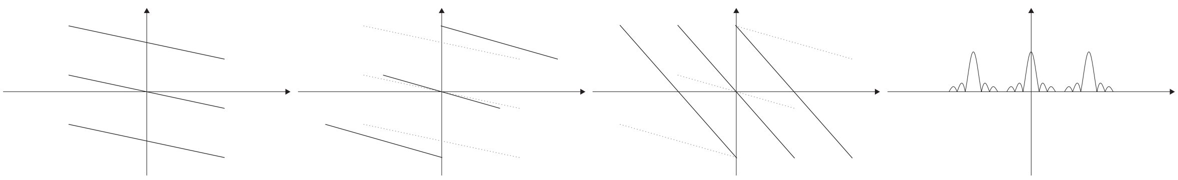


Fig. 1. Block diagram of the proposed processor for sliding-spotlight and TOPS imaging modes.



(a) (b) (c) (d)

Fig. 2. Diagrams of a ScanSAR burst before and after each step of BAS.

after the de-rotation function no azimuth modulation is left on the targets, i.e. a de-ramping is performed, hence preventing the use of a matched filter afterward. The closer the rotation center to the swath, the worser the performance of BAS. Therefore, the paper will include a criterion in order to tell whether BAS can properly process an image acquired in the sliding-spotlight mode. Nevertheless, if a modular approach is considered when implementing the processor, it is straightforward to include the phase functions of azimuth scaling+SPECAN in order to also process staring-spotlight data.

3. AFTERWORD

A processing algorithm to focus data acquired in sliding-spotlight, TOPS and ScanSAR will be presented, including a detailed description of the different phase functions. The kernel of BAS is used to efficiently perform the azimuth processing of the signal. By including the option to use the phase functions of the classical azimuth scaling+SPECAN, a modular and versatile processor can be obtained, capable of processing four processing modes other than stripmap. Real data acquired by TerraSAR-X in sliding-spotgliht, TOPS and ScanSAR will be used to validate the performance of the proposed approach.

4. REFERENCES

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