AN EFFICIENT METHOD OF DOPPLER PARAMETER ESTIMATION IN TIME-FREQUENCY DOMAIN FOR A MOVING OBJECT FROM SPACEBORNE HIGH-RESOLUTION X-BAND SAR DATA

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1. ABSTRACT

Velocity retrieval of a moving object from recorded signals by a single-channel SAR is a difficult task. To retrieve a velocity of moving object, it is necessary to estimate the speeds of the object in two dimensions of range and azimuth. Both azimuth and range (or antenna line-of-sight) component of target moving motion changes the Doppler phase history of the moving object in comparison with the clutter [1]. The velocity retrieval can be achieved by estimation of two Doppler parameters, Doppler centroid and Doppler frequency rate, respectively. Here we present an efficient method of Doppler parameter estimation in the time-frequency domain from spaceborne X-band SAR data. Many algorithms have been proposed for moving target indication (MTI), and most of them are based on sensing the difference in Doppler parameter between the moving object and the stationary clutter. A Doppler filtering method was proposed by [2], which needs PRF four times larger than the clutter bandwidth. Estimation of motion parameters based upon a sequence of single-look SAR images was described by [3]. Another way that proposed by [4] is to utilize a Doppler rate map and the range migration for estimating the azimuth and range component of moving velocity, respectively. Recently, joint time-frequency analysis has been applied to measure the target motion directly from the chirp signal, and it has demonstrated the potential to extract a time sequence of motion parameters [5-8]. In our research, Wigner-Ville distribution is used for the time-frequency transform. A core idea is based upon the fact that energy from signal is mainly concentrated around a Doppler phase history line in the time-frequency power spectrum while energy from clutter is scattered. We first re-construct the Doppler spectrum by picking-up maximum or taking a mean around an anticipated Doppler phase history at each time and frequency dimension. The peaks of frequency-axis projected and time-axis projected spectra indicate a Doppler centroid and the azimuth time of closest approach, respectively. Doppler frequency rate can also be estimated by measuring the slope of the reconstructed Doppler phase history line in time-frequency domain. Simulation results using spaceborne X-band SAR systems and ENVISAT show that the retrieved velocity errors are less 5% up to 30 m/sec (or 108 km/hr) as shown in Fig. 1. The errors vary with the type of source data (range compressed or SLC), signal-to-noise ratio of the signal and range-migration correction. Range migration correction plays a key role for the precision of Doppler parameters retrieved. A full Doppler bandwidth needs to be preserved when SLC data are used. An experiment using truck-mounted corner reflectors and TerraSAR-X (Fig. 2) demonstrates the effectiveness of the proposed method. The proposed method will be applied to TerraSAR-X and KOMSAT-5 high resolution X-band SAR systems.

Key Words: Moving object, Doppler parameters, time-frequency transform, KOMPSAT-5, TerraSAR-X.

2. REFERENCES

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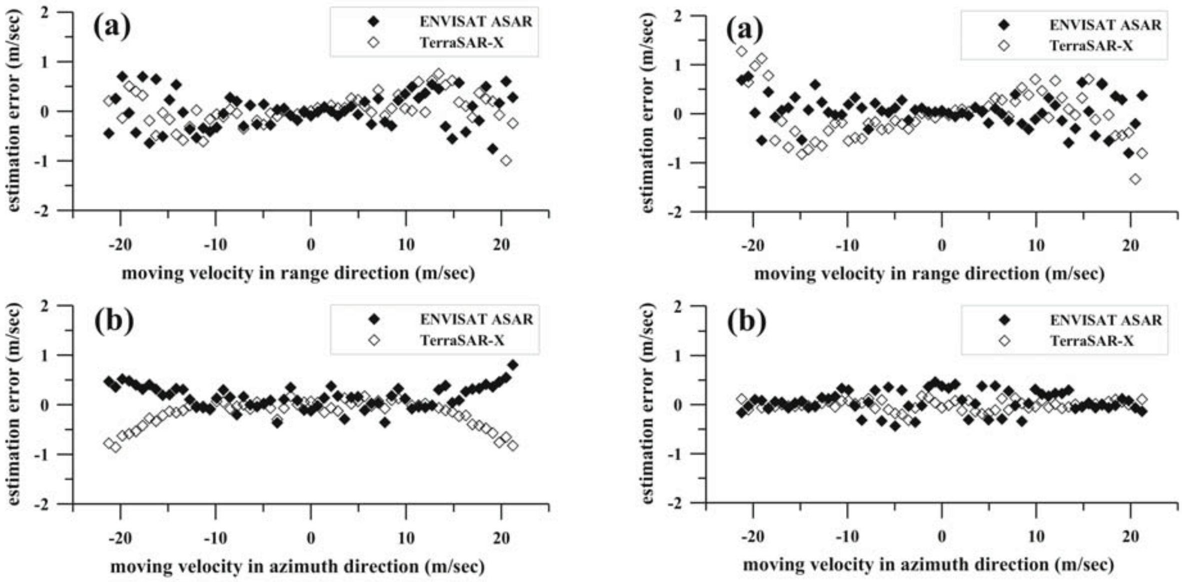

Figure 1. Result of velocity retrievals from simulated data using TerraSAR-X and ENVISAT system parameters. The errors of the retrieved velocity were less than 5% for both raw signals (left) and SLC data (right) cases.

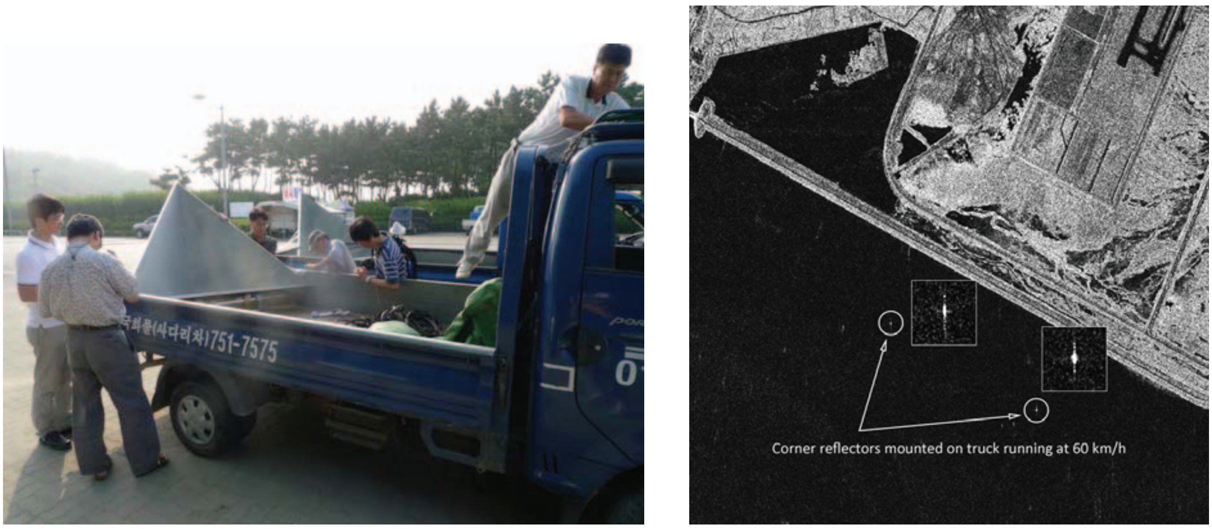

Figure 2. Installation of corner reflector on a truck (left) for field experiment and TerraSAR-X image (right) showing the two trucks moving with a speed of 60km/hr.