Forward-looking SAR moving target imaging via joint time-frequency transform and interferometric processing

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Forward-looking synthetic aperture radar (SAR) target imaging has many applications related to situational awareness for moving platforms, including collision avoidance, runway imaging, and forward-looking reconnaissance. The goal for this technology is to create a high-resolution radar image of a conducting man-made structure located near the velocity vector of the radar platform from which useful geometrical data such as target extent or pose may be extracted.

Complications arise when the target of interest is moving at a significant speed during the radar data acquisition. If the velocity vector of the target is not known *a priori*, the target image will become unfocused. Estimating the three-dimensional target velocity vector is thus useful not only for determining the target location as a function of time, but also for refocusing the SAR image and thereby enabling more accurate geometrical data extraction. Estimating the target Doppler centroid is in general insufficient for this purpose, as target three-dimensional motion data may be desired for the applications of interest.

We propose a two-stage technique for estimating the target velocity vector directly from the collected SAR data that is effective in forward-looking imaging geometries. In the first stage, we replace the cross-range compression step of the SAR image formation process with a joint time-frequency transform from the reduced interference distribution (RID) class. This allows for the creation of a sequence of intermediate SAR images for desired instances in slow-time with cross-range resolutions that are comparable to those achieved via full aperture processing. In the second stage, we apply three-dimensional interferometry to the intermediate images across multiple receivers in order to estimate the change in position of the scattering centers on the target as a function of slow-time. This last step requires a reformulation of the conventional SAR interferometric technique, as the RID and the forward-looking data collection geometry alter the conventional interferometric relationships between receivers. The high cross-range resolution achievable via the RID is important for the success of the interferometric step, as it decreases the probability of interferometric errors caused by interfering scattering centers.

In this presentation, we first describe the mathematical formulation of the proposed technique. We then generate simulated data for a variety of imaging scenarios with moving targets. We apply the simulated data to the technique and compare the resulting estimated velocity vectors to truth. Lastly, we demonstrate refocusing of the blurred full-aperture forward-looking SAR images using the estimated target velocity vectors.

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