Advanced Motion Compensation for Airborne Platforms: Application to UAVSAR

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Topography and Azimuth-Dependent Motion Compensation

Flight track is more difficult to repeat in an aircraft:
- Requires knowledge of aircraft motion and position to ~few cm level.

(SOLUTION: combine INS and differential DGPS measurement for increased position and orientation accuracy)

- Large repeat track baselines lead to decorrelation. (SOLUTION: precision control of flight track to ±5 meters)

- Residual motion smaller than the detected motion must be estimated to achieve sub-centimeter deformation accuracy. (SOLUTION: advanced processing algorithms to estimate residuals from image offsets between repeat tracks)

Aircraft attitude angles depend upon variable flight conditions:
- Variable wind conditions can cause the aircraft yaw angle to change on a timescale smaller than the synthetic aperture formation time during a flight line. (SOLUTION: adaptively steer antenna during a flight line to compensate yaw variation)
- Both yaw and pitch can be different between repeat tracks because of wind, fuel load, velocity, and initial conditions. (SOLUTION: Adaptive steering to planned flight track, plus process data to the doppler angle that maximizes spectral overlap between the data from the different tracks)

Additional Challenges for High Precision Repeat Track Interferometry

The advanced mocomp algorithm is implemented after standard motion compensation and before azimuth compression.

- The data from a single patch is separated into blocks to account for fast attitude changes.

- The data is Fourier transformed in the azimuth direction to obtain the doppler angle-dependence. The azimuth angle is determined from the frequency of each bin in the inverse FFT azimuth frequency spectrum.

- The terrain height is determined from the intersection of the doppler cone, the surface ellipsoid and the slant range sphere, iterating to match the DEM height at the intersection point.

- The interferometric phase correction is calculated with the new look direction and baseline.

Effect on UAVSAR Repeat Track Interferometric Results

Residual Motion Estimation

The unknown motion residuals that remain after processing with the advanced motion compensation algorithm are estimated from the measured offsets in range and azimuth between the images for the two tracks.

\[
\Delta x = (\hat{\psi} \times s) - \left( \hat{B} \times \hat{n}_{Doppler} \right)
\]

\[
= \rho_{2} \frac{\partial B}{\partial x} + \rho_{1} \frac{\partial B}{\partial x}
\]

\[s = \text{along track (azimuth)}
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\[c = \text{across track}
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\[h = \text{vertical}
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