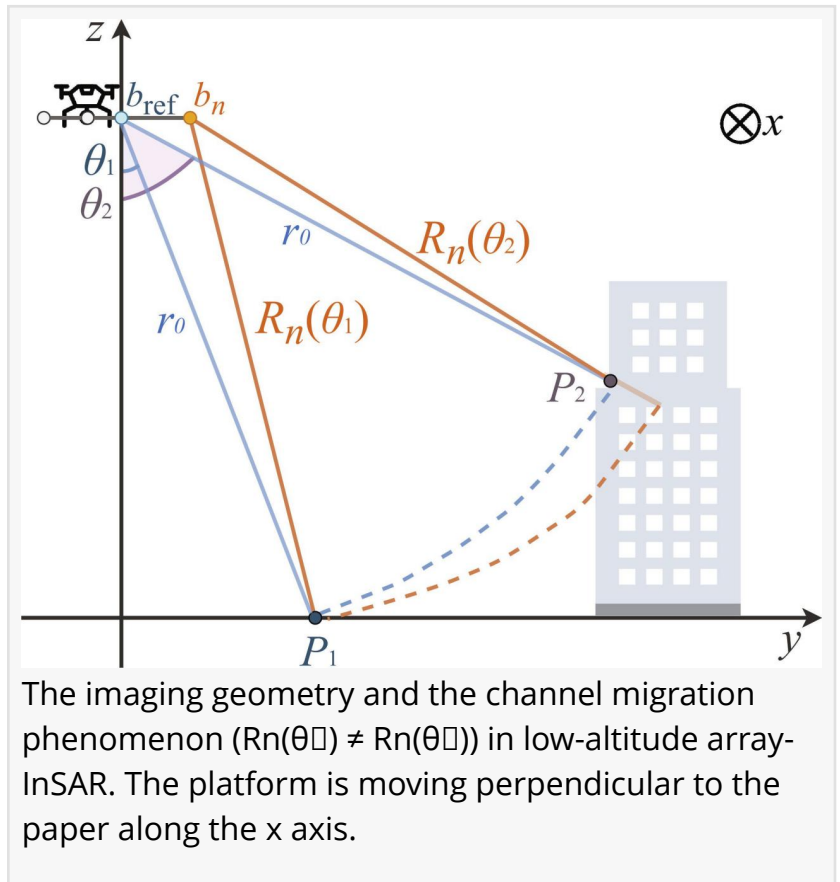


Sharper 3D radar for low-altitude UAVs

GA, UNITED STATES, June 12, 2026 /EINPresswire.com/ -- A new imaging framework improves how unmanned aerial vehicle (UAV) radar systems reconstruct three-dimensional (3D) scenes in complex urban environments. By combining three-dimensional back projection with compressive sensing, the method overcomes a long-standing low-altitude imaging problem known as channel migration. The result is more accurate 3D reconstruction of buildings and ground features, with stronger resolution, lower error, and better structural recovery than conventional methods.

Synthetic aperture radar (SAR) can capture detailed images under conditions where optical systems often struggle, but standard SAR compresses real three-dimensional (3D) structures into two-dimensional (2D) images. This creates problems such as layover and shadowing, especially in cities where buildings, ground objects, and vertical structures overlap in the radar signal. Existing 3D SAR methods, including tomographic SAR and array interferometric SAR (array-InSAR), can help separate overlapping targets, but low-altitude unmanned aerial vehicle (UAV) platforms introduce severe geometric inconsistencies across channels. Once channel migration becomes large enough, conventional coregistration-based methods can fail entirely. Based on these challenges, in-depth research is needed on robust low-altitude 3D SAR reconstruction methods.

Researchers from the National Key Laboratory of Microwave Imaging Technology and the Aerospace Information Research Institute of the Chinese Academy of Sciences, together with collaborators from the University of Chinese Academy of Sciences, Tongji University, and the Suzhou Aerospace Information Research Institute, reported (DOI: 10.34133/remotesensing.1032) the method on March 25, 2026, in the Journal of Remote Sensing. Their study introduces 3DBP-CS, a new framework designed to solve low-altitude UAV-borne array-InSAR imaging errors



caused by channel migration, a problem that reduces the reliability of conventional 3D radar reconstruction in urban scenes.

The proposed method replaces antenna-oriented coregistration with target-oriented interpolation, then performs super-resolution reconstruction using an expanded sensing matrix. This design is important because low-altitude UAV observations no longer satisfy many assumptions used in high-altitude radar imaging. The team built a hybrid polar-Cartesian coordinate model, introduced an optimized 3D interpolation strategy to reduce multipath interference, and used compressive sensing to recover high-resolution elevation information. In simulations, the method consistently outperformed direct 3D back projection and conventional compressive-sensing approaches, especially when overlapping targets had large height differences or were near the Rayleigh resolution limit. It also maintained strong amplitude recovery and position accuracy across different layover scenarios.

The technical advance lies in how the framework handles channel migration. In standard methods, the same target must align across channels before reconstruction. At low altitude, however, the same target can shift between range cells, making this alignment unreliable. The new approach instead interpolates signals directly onto 3D grids and reconstructs the scene using an expanded sensing matrix that includes neighboring range units. This lets the algorithm retain phase information while avoiding the failures of conventional coregistration. The method also uses a 2-stage thresholding strategy to skip weak grids and suppress multipath, improving both efficiency and robustness. In simulated layover tests, 3DBP-CS showed position errors mostly below 0.1 and achieved clear super-resolution where other methods struggled. In building simulations, it recovered facades, corners, rooftops, and ground structures more faithfully. Quantitatively, it achieved a peak signal-to-noise ratio (PSNR) of 38.570, compared with 30.095 for 3DBP and 24.138 for the CS-based baseline; its normalized root mean square error (NRMSE) fell to 0.103, versus 0.256 and 0.374, while structural similarity index measure (SSIM) rose to 0.979.

The study shows that accurate 3D radar imaging at low altitude does not have to rely on fragile coregistration workflows. Instead, by shifting reconstruction from antenna alignment to target-oriented interpolation, the framework opens a more practical route for UAV-based urban sensing. The results suggest that high-quality 3D recovery can be achieved without specialized hardware acceleration, making the method especially promising for real engineering applications.

The team first developed a low-altitude array-InSAR signal model under a spherical wavefront assumption, then built a hybrid coordinate system using azimuth, range, and off-nadir angle. They applied 3D interpolation only to selected high-value grids, using global and local thresholds to reduce unnecessary calculations and suppress multipath. After that, they reconstructed elevation information with compressive sensing through an expanded sensing matrix. The method was tested in two simulation settings and with real Ku-band UAV SAR data collected at a flight height of 400 m over the Lingang Business Building area in Tianjin, China.

This work could strengthen UAV-based 3D radar imaging in urban mapping, target interpretation, infrastructure inspection, and other situations where complex vertical structures are difficult to resolve. Because it is tailored to sparse urban scenes and moderate layover conditions, the method may be especially useful for fast, flexible, low-altitude sensing missions. Looking ahead, the authors note that future optimization could further improve the framework through gridless reconstruction and low-rank modeling, which may expand its usefulness in larger, more complicated scenes and support wider deployment in remote sensing practice.

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Lucy Wang

BioDesign Research

[email us here](#)

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