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3D Gaussian Splatting for UAV-Based 3D Reconstruction: An Emerging Technology for Drone Surveying

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Technology Snapshot.

Technology	3D Gaussian Splatting (3DGS)
Technology Domain	3D Reconstruction / Computer Vision
Application Area	UAV Mapping and Drone Surveying
Technology Status	Emerging / Active Research
Key Advantage	Rapid, photorealistic 3D scene representation and rendering
Current Challenge	Survey-grade geometric accuracy and georeferencing
Future Potential	Geospatial digital twins and interactive measurable 3D environments

Keywords: 3D Gaussian Splatting, UAV, Drone Surveying, 3D Reconstruction, Photogrammetry, Digital Twin

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1. From Photogrammetry to Gaussian Scene Representation

Drone-based three-dimensional mapping is currently dominated by Structure-from-Motion (SfM) photogrammetry and Multi-View Stereo (MVS). In a conventional workflow, a sequence of overlapping UAV images is processed to estimate camera geometry, identify corresponding features and generate dense point clouds, meshes, orthophotos and digital surface models. These products are well established in topographic mapping, construction monitoring, mining, heritage documentation and environmental surveying.

A rapidly developing alternative is 3D Gaussian Splatting (3DGS). Introduced by Kerbl et al. in 2023 for real-time radiance-field rendering, 3DGS represents a scene using a collection of three-dimensional Gaussian primitives rather than relying primarily on a conventional polygon mesh or an implicit neural representation. Each Gaussian contains spatial and appearance-related parameters that are optimized against the input images. The original method demonstrated high-quality novel-view synthesis with real-time rendering, stimulating substantial research into its application to larger and more complex environments. [1]

For UAV researchers, however, photorealistic visualization represents only one part of the challenge. A more fundamental question is emerging: *Can a visually realistic 3D Gaussian representation also serve as a geometrically reliable and georeferenced surveying product?*

2. What Makes 3DGS Different?

A conventional photogrammetric workflow can be summarized as follows:

UAV Images → Camera Calibration/SfM → Sparse Points → Dense Matching/MVS → Point Cloud → Mesh/DSM/Orthomosaic

A 3DGS workflow follows a different sequence:

UAV Images → Camera Poses/Sparse Geometry → 3D Gaussian Initialization → Gaussian Optimization → 3D Scene Representation → Real-Time Rendering

Rather than describing a scene solely through discrete surface points or polygonal triangles, 3DGS represents it using large numbers of anisotropic Gaussian primitives. Their position, orientation, scale, opacity and appearance parameters are optimized so that rendered views reproduce the original observations.

This representation offers a significant advantage: complex scenes can be rendered with high visual quality at interactive or real-time frame rates. The original 3DGS study reported real-time rendering at 1080p while maintaining high-quality novel-view synthesis. [1]

For drone applications, this capability could enable users to explore detailed UAV-derived environments interactively without repeatedly generating or rendering computationally intensive photogrammetric meshes.

3. The Surveying Challenge: Appearance Is Not Geometry

A critical distinction must be made between visual realism and geometric reliability. A model may appear highly realistic without necessarily achieving survey-grade geometric accuracy. Traditional photogrammetry benefits from a mature framework involving camera geometry, ground control, bundle adjustment, coordinate reference systems and independent accuracy assessment. Surveyors can compare model coordinates with check points and quantify horizontal and vertical errors.

By contrast, 3DGS was originally developed primarily for novel-view synthesis and rendering, rather than for surveying. Its direct application to UAV mapping therefore raises important questions concerning absolute scale, surface definition, coordinate accuracy and the extraction of conventional geospatial products.

A photogrammetric point cloud provides explicit XYZ coordinates from which distances, elevations, areas and surfaces can be derived. Gaussian representations, however, are optimized partly according to their contribution to image formation. Consequently, excellent image reproduction does not automatically demonstrate equivalent metric reliability. The distinction between photometric quality and geometric accuracy is therefore one of the most important issues in adapting 3DGS for geospatial surveying.

4. UAV LiDAR and 3DGS: A Significant Research Direction

One promising approach combines 3DGS with an independent source of high-quality geometric information.

Recent UAV research has investigated the integration of dense LiDAR point clouds and aerial imagery with geometry-aware 3D Gaussian Splatting. Rather than relying solely on sparse SfM geometry for initialization, accurately registered UAV LiDAR can provide substantially denser and more reliable geometric information.

Qin et al. [2], for example, proposed a geometry-aware 3DGS method using dense UAV LiDAR point clouds and imagery. This research suggests the following future architecture:

UAV LiDAR → Accurate 3D Geometry

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UAV Imagery → Detailed Appearance Information

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Geometry-Constrained 3DGS

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Accurate, Photorealistic and Efficiently Renderable 3D Environment

Their approach incorporated geometric information related to depth, surface normals, curvature and local spatial consistency. The method specifically addressed limitations in geometric precision and structural consistency that can arise in large UAV-derived scenes.

Such integration may be more significant for surveying than simply replacing conventional photogrammetry with 3DGS. It offers the possibility of combining the metric reliability of LiDAR with the visual richness and rendering efficiency of Gaussian representations.

5. Could 3DGS Replace SfM–MVS?

At present, replacement may be the wrong question. SfM remains highly relevant because even the original 3DGS implementation begins with sparse points and camera information obtained through camera calibration and SfM-type processing. [1] Accordingly, 3DGS is better understood as part of an evolving reconstruction ecosystem rather than as a completely independent substitute for photogrammetry as described in Table. The most realistic technological direction is therefore likely to be a hybrid workflow.

Photogrammetry, GNSS/RTK/PPK and LiDAR can provide geometric constraints and geospatial reference, while Gaussian Splatting can provide a highly efficient and visually rich representation of the reconstructed environment.

6. Potential Implications for Drone Surveying

If the challenges associated with metric accuracy, coordinate referencing and surface extraction are adequately addressed, 3DGS could support several future UAV applications.

Requirement	SfM–MVS Photogrammetry	3D Gaussian Splatting
Camera pose estimation	Mature	Commonly depends on initial camera estimates
Dense surface reconstruction	Established	Active research area
Photorealistic visualization	Good	Major strength
Real-time scene rendering	More demanding for complex models	Major strength
Orthomosaic and DSM production	Established	Not its original purpose
Survey measurements	Established workflow	Requires careful geometric validation
Georeferencing	Mature	Developing research problem
LiDAR integration	Established	Rapidly developing

Construction sites could be reconstructed periodically and explored as high-detail, interactive 3D environments. Quarry and mine surveys could combine LiDAR-derived geometry with UAV imagery to produce metrically constrained yet photorealistic representations. Heritage sites, urban corridors and infrastructure assets could similarly benefit from rapid visualization of complex three-dimensional environments.

Another important possibility is the development of the geospatial digital twin. Conventional drone surveys commonly produce snapshots in the form of orthomosaics, point clouds or terrain models representing a specific date. Efficient Gaussian representations may eventually support more interactive visualization of repeatedly acquired three-dimensional observations, particularly when combined with accurate positioning and temporal information.

However, this transition requires the research community to move beyond visual demonstrations.

Evaluation should increasingly address the following questions:

1. How accurate is the reconstructed geometry?
2. Can the model preserve absolute scale and coordinate reference?
3. How reliably can dimensions, elevations and volumes be extracted?
4. How should GCP, RTK/PPK and LiDAR constraints be incorporated?
5. Can uncertainty be quantified in a manner comparable with conventional photogrammetric surveying?

These questions are essential if 3DGS is to progress from a computer-graphics technology into an accepted component of geospatial measurement and surveying practice.

7. Technology Outlook

3D Gaussian Splatting represents a significant change in the way three-dimensional scenes can be represented and visualized. Its rendering speed and photorealistic output make it highly attractive for UAV-derived environments.

Recent research integrating dense UAV LiDAR with Gaussian representations demonstrates that researchers are already addressing one of the technology's principal limitations: the need for stronger geometric consistency in large-scale aerial reconstruction. [2]

Nevertheless, photorealism should not be confused with surveying accuracy. For geospatial applications, the critical development pathway will involve integrating Gaussian representations with rigorous photogrammetric geometry, GNSS control, LiDAR observations, coordinate reference systems and independent accuracy validation.

The immediate future of 3DGS in drone surveying is therefore unlikely to be simply "3DGS instead of photogrammetry."
A more technically compelling direction is:

Photogrammetry + GNSS/LiDAR + 3DGS → Geometrically controlled, georeferenced and photorealistic 3D environments

Successful integration could move drone surveying beyond the production of static maps and point clouds toward interactive, measurable and continuously updateable three-dimensional representations of the real world.

References

[1] B. Kerbl, G. Kopanas, T. Leimkühler and G. Drettakis, "3D Gaussian Splatting for Real-Time Radiance Field Rendering," ACM Transactions on Graphics, Volume. 42, Issue. 4, Article 139, 2023. DOI: 10.1145/3592433.

[2] K. Qin, J. Li, S. Zlatanova, H. Wu, Yin Gao, Yuchen Li, Sizhe Shen, Xiangjun Qu, Zhiyuan Yang, Zhenxin Zhang, Banghui Yang, Shaoyi Wang, "Novel UAV-based 3D reconstruction using dense LiDAR point cloud and imagery: A geometry-aware 3D Gaussian Splatting approach," International Journal of Applied Earth Observation and Geoinformation, Volume. 140, Article 104590, 2025. DOI: 10.1016/j.jag.2025.104590.