PanoGS

Foundation-Depth-Guided High-Resolution Gaussian Splatting from Sparse Panoramic Images for Interactive Web3D Exploration

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Why sparse 360° panoramas

MOTIVATION

A few 360° panoramas can cover an entire indoor space.

Heritage, real estate, inspection and digital twins — fast capture and interactive exploration matter most.

But turning sparse panoramas into a navigable 3D scene is still hard.



Why sparse 360° reconstruction is hard

01

Limited overlap

Wide baselines, few shared pixels, textureless regions and occlusions.

02

ERP distortion

Equirectangular projection stretches geometry, complicating pose, depth and rendering.

03

Uncertain depth

Depth from few wide-baseline views is ambiguous and often low-resolution.

04

Perspective assumptions

Standard 3DGS expects dense pinhole images and reliable SfM.

Result: direct reconstruction is unreliable — and low-resolution depth blurs edges and drops thin structures.

Contributions

1 **Foundation-depth-guided sparse panoramic pipeline**

A few 360° RGB images in, high-resolution 3DGS scenes ready for the browser out.

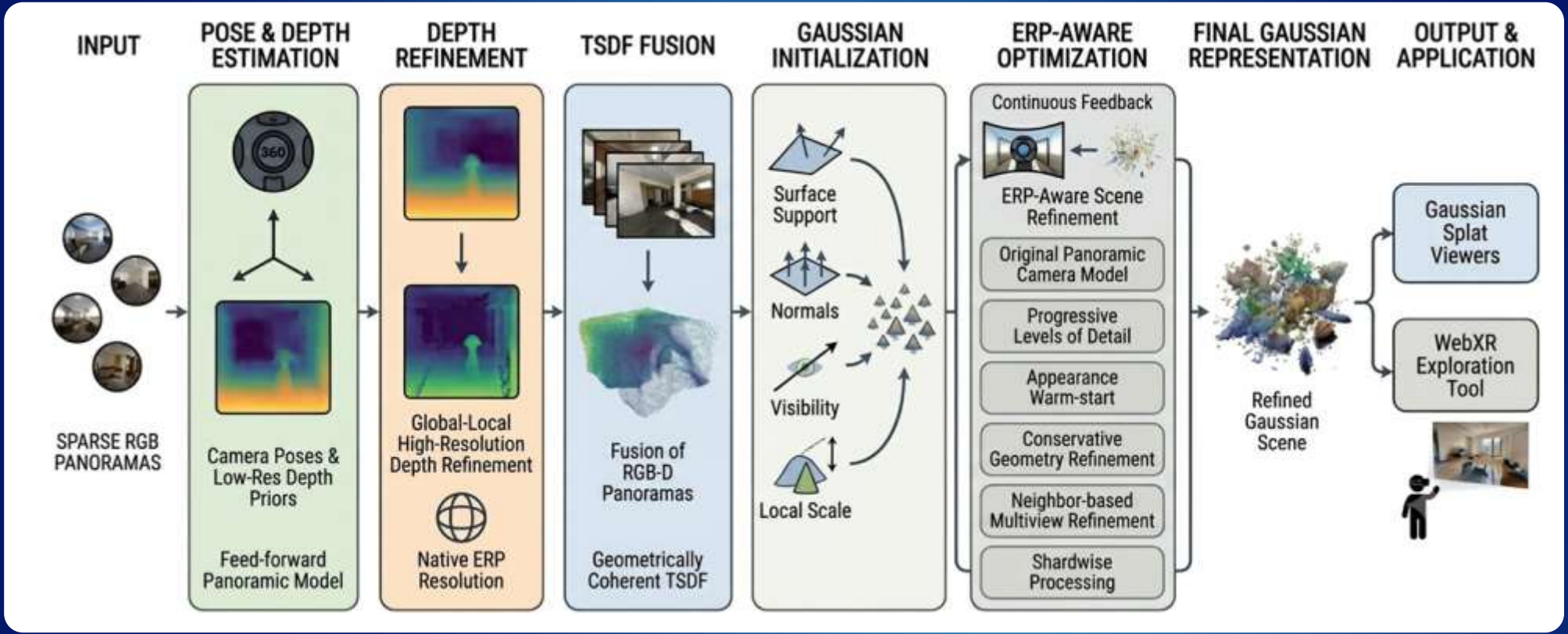
2 **Native-resolution depth-to-Gaussian initialization**

High-res ERP RGB-D panoramas and TSDF fusion give each Gaussian its surface, orientation and size.

3 **ERP-aware Gaussian optimization workflow**

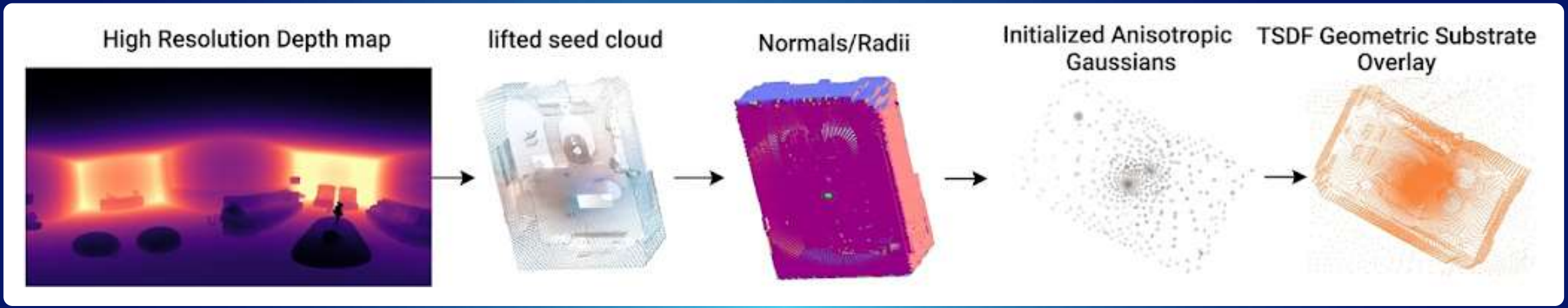
Progressive LODs, appearance warm-start, conservative geometry, neighbor-based refinement, shardwise processing.

PanoGS at a glance



Key design choice: keep the full 360° camera model end to end — no early split into perspective views.

Geometry-to-Gaussian initialization



Position & color

Taken directly from the lifted seed's position and pixel color.

Orientation

Each Gaussian is turned to face along the estimated surface normal.

Flattened shape

Wide along the surface, thin across it — surface-aligned discs, not round blobs.

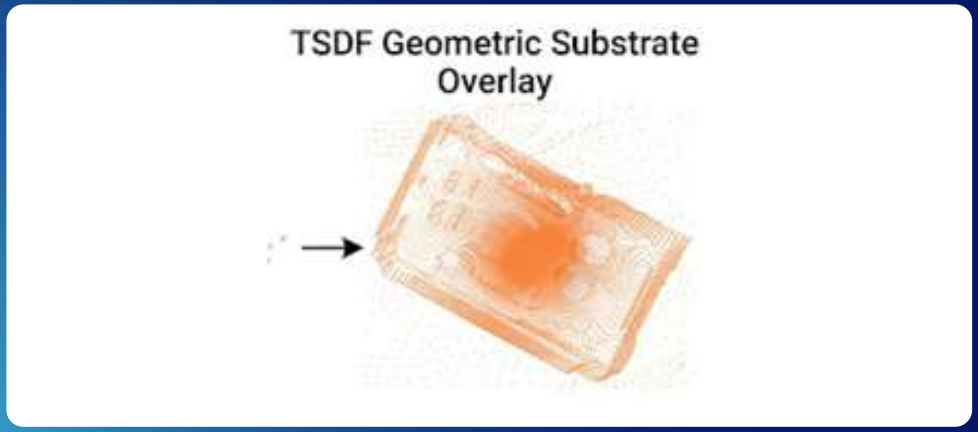
A TSDF geometric substrate

Registered RGB-D panoramas are fused into a TSDF — **not the output**, but one shared surface to check the Gaussians against.

Lifting each view separately creates duplicates near depth edges, small objects and weakly observed regions.

Diagnose expose misregistration, ghosting and duplicates

Regularize penalize Gaussians that drift off the fused surface



Surface consistency

Keeps Gaussians on the surface — less ghosting around small objects and contact regions.

Progressive optimization

THREE LEVELS OF DETAIL, SAMPLED PROPORTIONALLY ACROSS SHARDS

≤ 1M	Preview LOD
≤ 5M	Warm-start LOD
All	Full-native LOD

REFINEMENT SCHEDULE

1 Appearance warm-start
Geometry fixed; color and opacity updated.

2 Conservative geometry
Small, delayed, bounded moves only.

3 Neighbor multiview
Each view supervised only by nearby panoramas.

4 Shardwise
Chunks refined independently to fit GPU memory.

From workspace to browser

Export any LOD to a packed .splat — position, scale, RGBA and orientation per Gaussian.

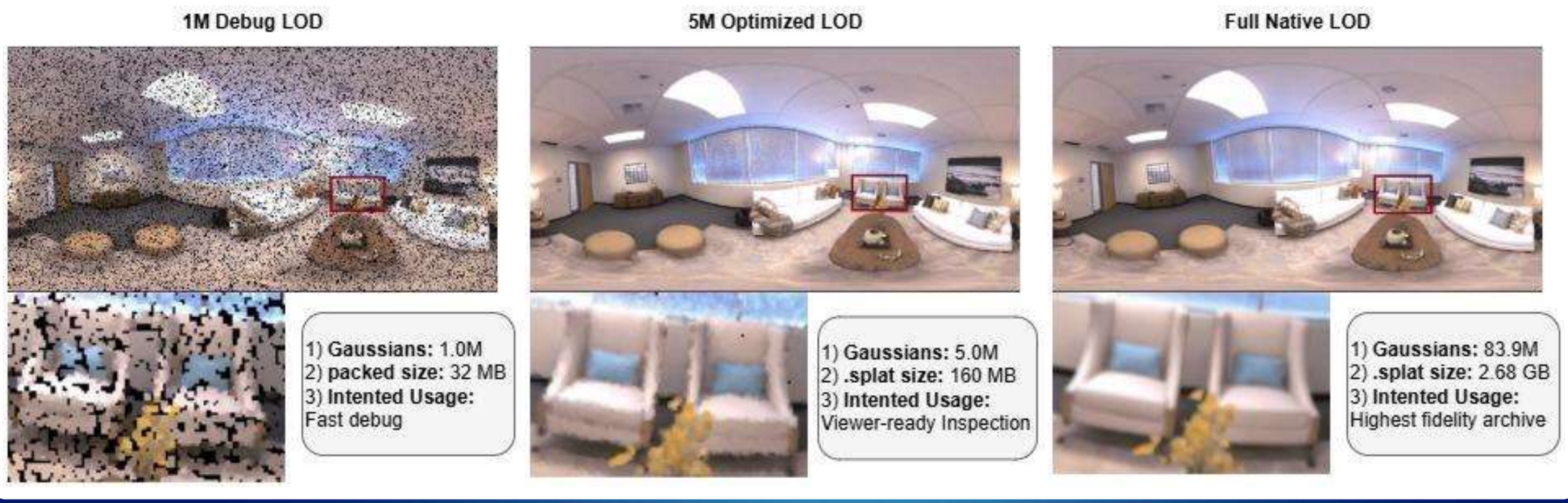
Render with plain WebGL — each Gaussian drawn as a small screen-aligned quad.

Sort in a web worker, with progressive loading — navigable before everything arrives.

Viewer: open-source antimatter15/splat (Kwok 2023). No plugins, commodity hardware.



One scene, three levels of detail



1M fast preview & sanity checks

5M viewer-ready — the practical sweet spot

Full native highest-fidelity archive

Datasets: Replica360 (8 scenes, 4096 × 2048) · HM3D test (1024 × 512)

Exploring in the browser






Works well

Walls, floors, sofas, beds and tables are coherent; the 5M LOD is usually enough.

Still hard

Ghosting around small objects, duplicates at depth edges, unstable plants, vases, chair legs.

Takeaway

PanoGS is a modular bridge from sparse 360° capture to deployable Web3D Gaussian assets.

Explicit control over resolution, levels of detail, export size and viewer behavior.

Next: TSDF-based pruning and opacity weighting · a full anisotropic panoramic rasterizer · outdoor scenes



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Thank You!

Questions?

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