3D Render Accuracy: Gaussian Splatting Analysis in Dallas

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“Are Gaussian Renders one-to-one accurate with the real world?”

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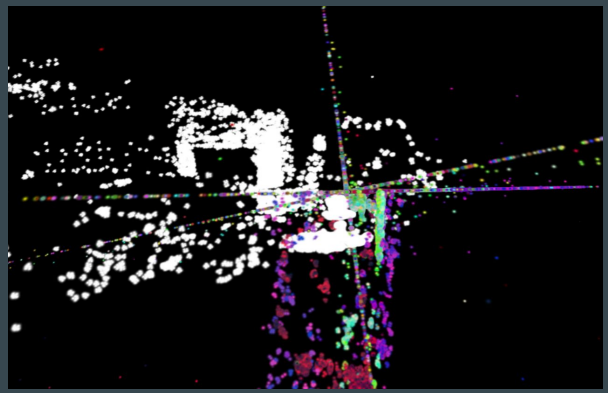
Quick Recap of What Gaussian Splatting Is:

- Gaussian Splatting is an advanced Method for reconstructing 3D environments from 2D image
- This process uses point-based representations of the environment, using gaussian functions
- This method is known for its photorealistic quality, and potential for real time rendering
- Used in VR, gaming, Digital Twins, Architecture and Real Estate



Taos Project Summary (How Gaussian Renders are used)

- Location: Taos, New Mexico
- Captured aerial images of classroom Environments, as well as interior imagery
- Tools: DSLR cameras, drones, COLMAP, Gaussian Splatting software
- Final product: photorealistic 3D renders of landscapes, structures, and interiors
- Main achievement: successful reconstruction, visual impressiveness

The Big Question: “ARE THEY ONE-TO-ONE?”

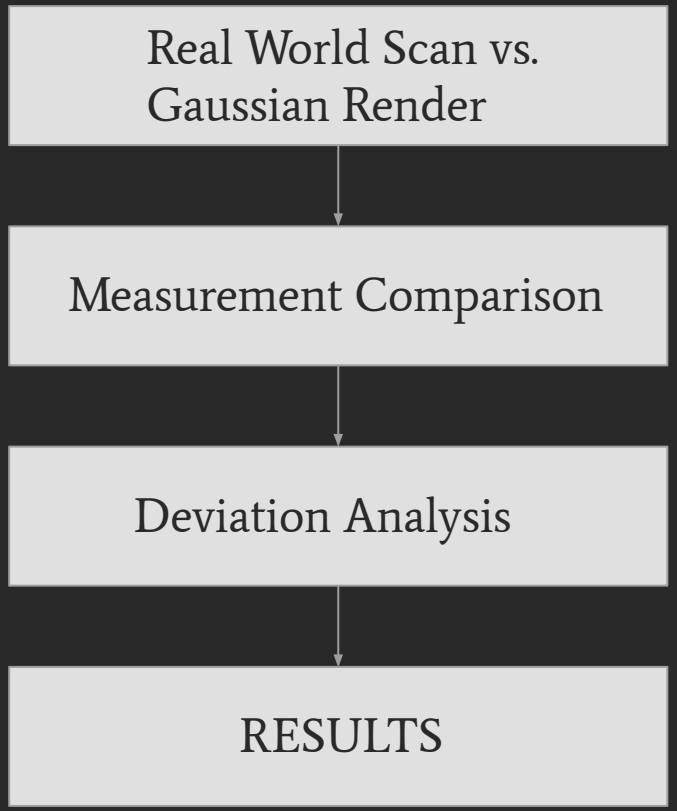
Our Hypothesis:

- Gaussian Renders are not one-to-one representations of real life environments
- Gaussian Renders need further Improvement and optimization to be reliably accurate.
- If Gaussian Renders where accurately 1:1 they could be used as simulations for sensitive instruments or software.

Our Approach to Testing One-to-One Accuracy

Goal: Quantitatively determine if Gaussian Splatting renders match real-world geometry

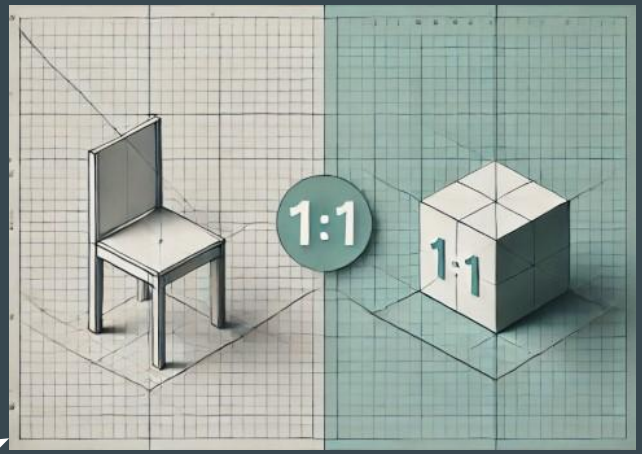
- Step 1: Collect real-world measurements
- Step 2: Extract measurements from the Gaussian render
- Step 3: Compare distances, angles, scales
- Step 4: Analyze deviations or lack thereof



What does ONE-TO-ONE Accuracy really mean?

Definition for our study:

- Object positions & sizes in render match real-world geometry
- Spatial relationships preserved (scale, angles, depth)
- Negligible distortion, shift, and/or compression



Our Tolerance range:

- ±1% deviation in distance = 1:1
- Anything > 0.01% = failure of 1:1 mapping

Our Real World Model Data:

Right Triangle A

AB=2ft AC=2ft BC=2.8282ft

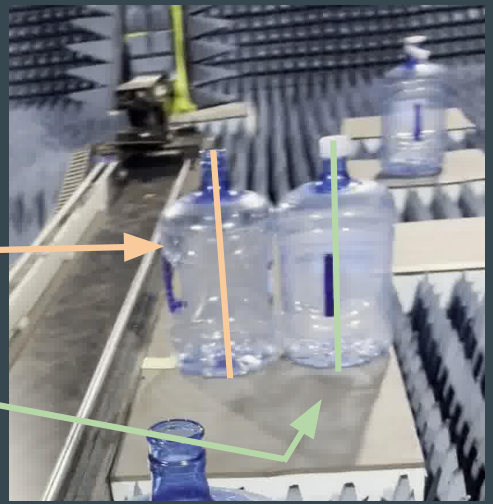
Right Triangle B

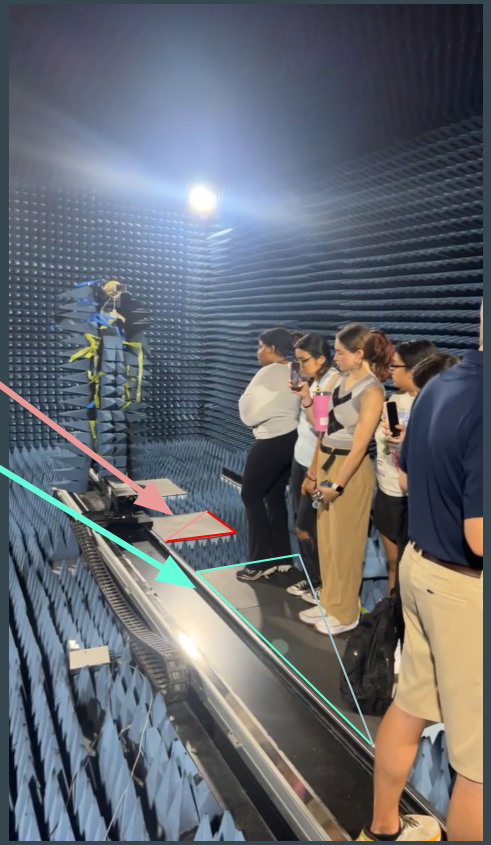
AB=2ft AC=4ft BC=4.4721ft

Water Jugs:

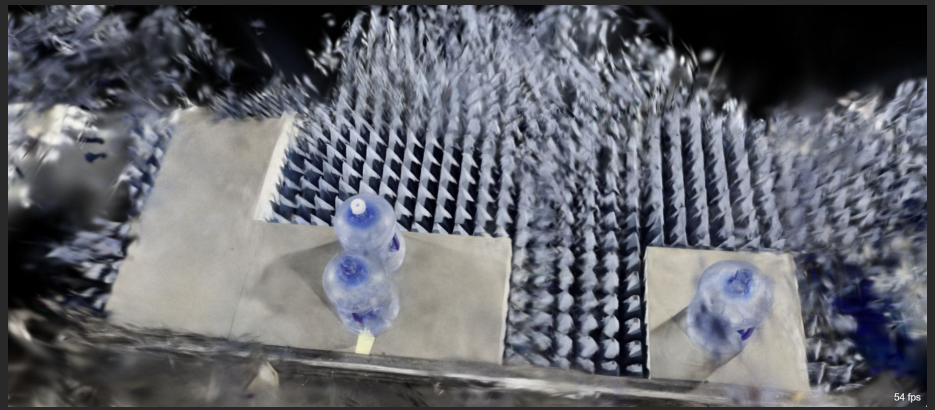
Height (I) = 1.583ft

Height (O) = 1.583ft



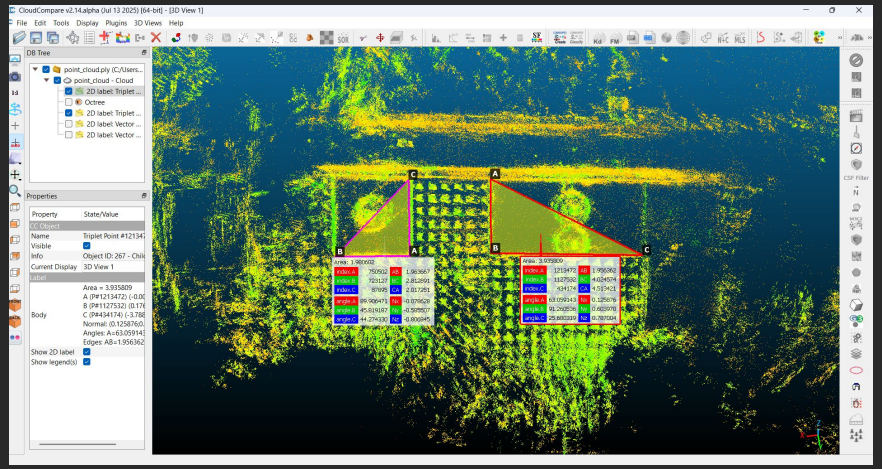


30K Analysis - Water Jugs in the Anechoic Chamber



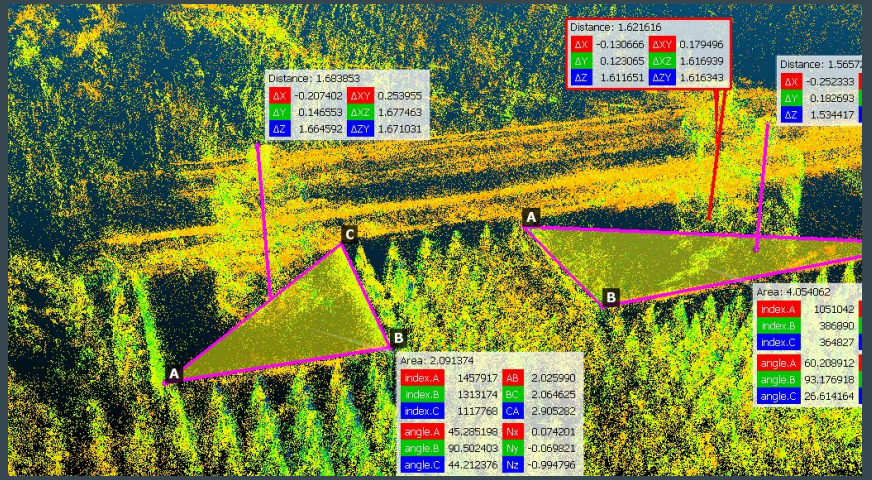
Scale factor=
Real XY/ModelXY = A/B ≒ SF
Take Geometric Mean of
Total SF's

GeoMean of SF = 1.010415
Relative Error of Area= Real Value-True Value/True Value ≒ REA
RelAreaError
TriA = -0.01
TriB = -0.02



60K Analysis - Water Jugs in the Anechoic Chamber

GeoMean of SF 0.984944
Relative Error of Area= Real Value-True Value/True Value ≃ REA
RelAreaError
TriA= 0.05
TriB=0.01



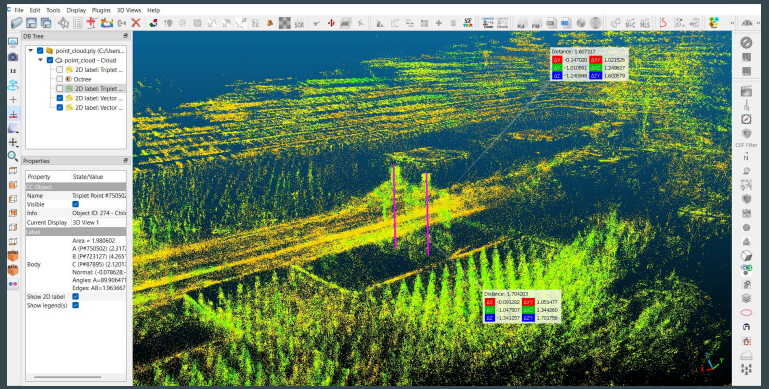
Scale factor=
Real XY/ModelXY = A/B ≃ SF
Take Geometric Mean of Total SF's

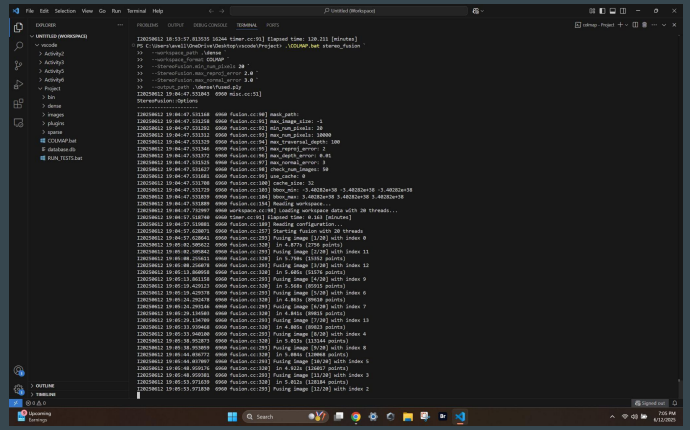
Repeated Testing Across Multiple Iterations

We analyzed 2 distinct yet correlated architectural features: Floor Panels & Water Bottle Jugs

Our Results: 100% showed measurable error (>1%)

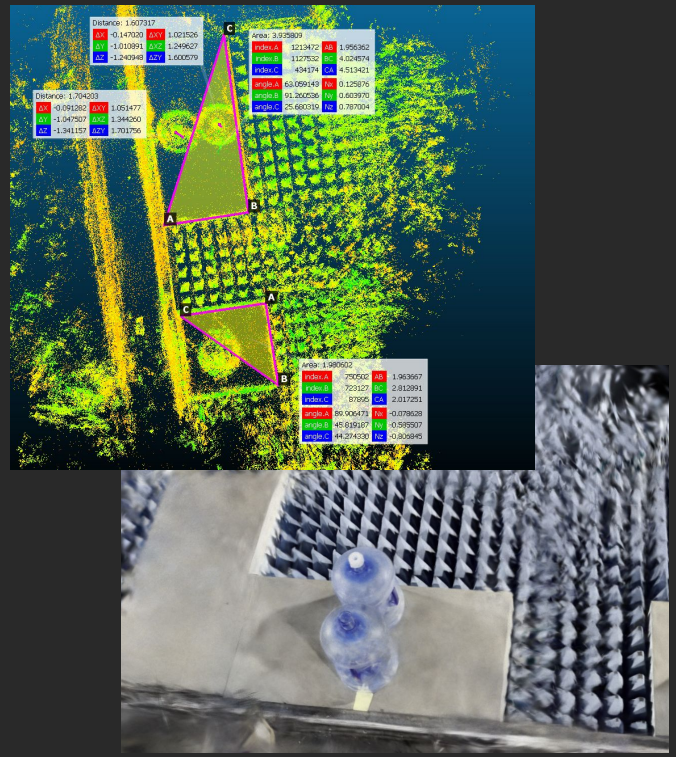
(30K) Relative Error of Area: TA = -0.01%
TB = -0.02%
(60K) Relative Error of Area: TA = 0.05%
TB = 0.01%





Why do these Errors occur when Gaussian Splatting?

- Gaussian Splatting optimizes for visual fidelity, not spatial accuracy
- No hard geometric constraints during rendering
- Accumulated camera pose drift
- Perspective distortion from uncalibrated cameras



Our Mathematical Framework & Interpretation

- ***Scale Factor:*** *Used to Detect Consistent distortion*

  In spatial scaling

- ***Geometric Mean of SF's:*** *Consolidates multiple*

  Scale comparisons into one accurate metric

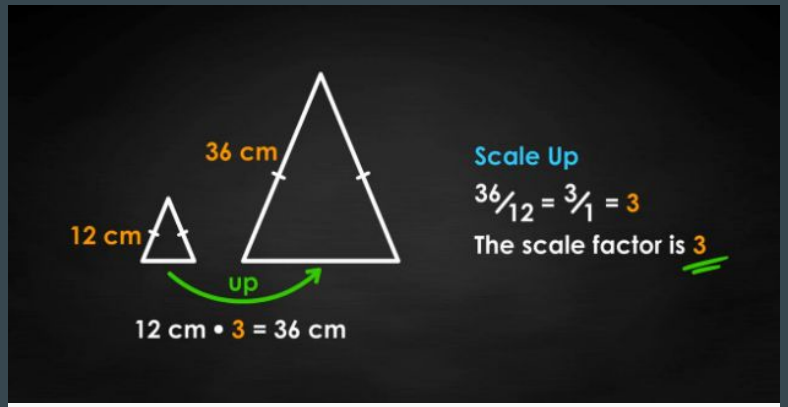
- ***Relative Error of Area (REA):*** *Measures distortion*

  In the surface area across triangles & Features

Final Interpretation:

- *Visual Quality ≠ spatial precision*
- *Small Errors Compound in spatial modeling*
- *Even Small %errors matter for precise modeling*

  (robotics, simulations etc...)



$$\bar{X}_{geom} = \sqrt[n]{\prod_{i=1}^{n} x_i} = \sqrt[n]{x_1 . x_1 ..... x_n}$$

$$\text{Relative error} = \frac{|\text{Observed Value} - \text{True Value}|}{\text{True Value}}$$

Our Conclusion: 3D Gaussian Render Accuracy

Hypothesis confirmed:
Gaussian Splatting renders are not 1:1 accurate

- Visually realistic but geometrically approximate
- Spatial distortions are consistent and measurable
- Mathematical proof achieved through error modeling

Thank You All: Q/A & Discussion

- Thank you for your time & attention

- We appreciate the opportunity to share our work with you
- This project represents a strong step forward in our understanding of mathematics
- We welcome any feedback, questions, or suggestions

- Let's open the floor for Q&A