3D Mapping of Building Interiors [M.O.B.I.]

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🏠“Boy do I wish I could see the inside of that building right now!” 🏠

June 10, 2025

Our Motivation:

Q: What specific real-world problem are you tackling?

- Our project is centered around the current standard, of incomplete 3D rendered buildings. Most lack a fully rendered & texture mapped interior. As of now, most are not renders, but pictures stitched together in a 360 degree manner.

Q: Why is this challenge important right now?

- This 3D rendering is critical to many of the following industries & related individuals as it will substantially enhance their understanding, optimization, & future maintenance of their relevant properties.

Q: Who benefits from solving this problem (e.g., farmers, first responders, urban planners)?

- Interior Designers (Ex: What is the best layout for this property)
- Realtors
- Business Owners (Ex: Hospitality, Retail Design, & Maintenance)
- Virtual Reality Training with a 1:1 model (To accurately train PD/FD's in practical virtual settings)
- 3D Platform for Advanced Home Integrated Devices (Ex: Automated Floor Sweepers)
- Potentially: Contractors, Architects & City Inspectors dependant on the accuracy of the 3D mock-ups

What has already been done in this field?

Q: What tools, datasets, or systems are already used in this space ?

- 360 degree pictures of interiors
- 3D rendering software requiring manual inputs

Q: Are there gaps or limitations in current approaches ?

- Requires manual rendering
- Inefficient
- Cannot manipulate 3D render

Q: Mention any relevant papers, platforms, or methods.

- Virtual Staging Real Estate: 360 stitched images
- Construction Related Digital Twin
- Interior Digital Twin Research Paper
- Gaussian Splatting PDF

Our Contribution

Q: What's new or different about your approach ?

- It eliminates the need to manually render.
- Our approach would provide users with a full render of their chosen environment.
- Includes a texture map 1:1 with reality

Q: Are you combining tools in a novel way? Solving a niche problem?

- We are combining drone footage, and digital twin technology in order to create a fully traverable 3D
- Mock-up for the interior of select buildings.
- This ability solves the current problem in the industry, wherein traveable interior imagery is simply
- A combination of stitched images, with select places where you can traverse. Our Mockup will allow
- Users to fully traverse the mock-up, with its present textures, allowing for a more immersive and realistic
- View of the property at hand.

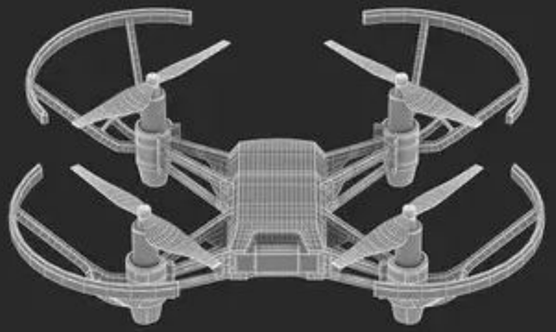
Q: Did you scope the project carefully to make it feasible?

- Yes, this has already been achieved by Will Bjorndahl a student of Dr. Camp with their lab in Dallas.

Our Agenda

Q: What tools or data will you use ?

- The tools that we will be using include the Tello Drones for interior Imaging.



Q: Will you test in simulation or the field ?

We will be testing in both the field & in simulation.

Q: What do the next 7 Days look like for your team ?

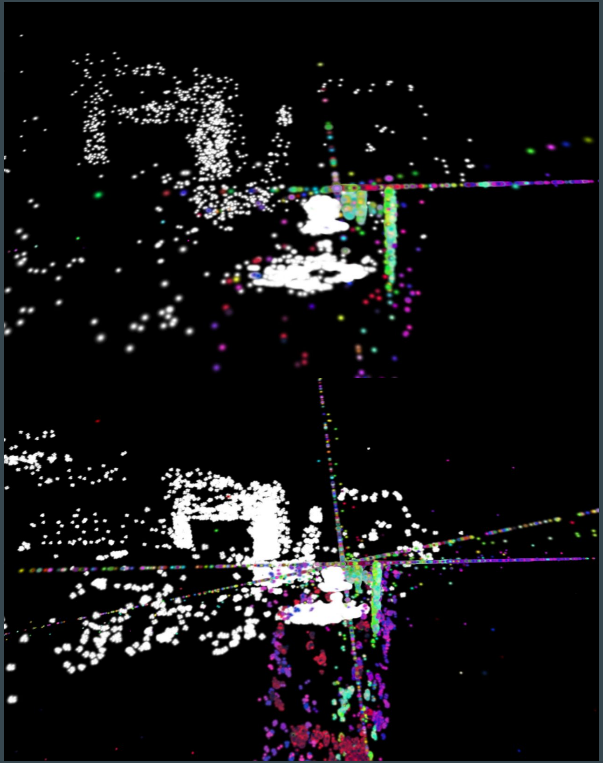
- Start creating a picture database of different buildings on the SMU Taos Campus starting with the gymnasium, dining hall, our current classroom, & the library using the Tellos.
- Implement this database into the software that we receive from Will
- Generate the Digital Twins of the different environments that we have collected imagery of.
- Fine tune our Mockups to meet our desired standards.

3D Point Cloud:

- The first point cloud rendering is the crucial foundation to achieving a Gaussian Splat render.
- This is an example of one of our attempts, showing the difference in graphs between sphere size 0.02 & 0.0008.
- We tested how well the different sphere sizes performed in gaussian splatting.

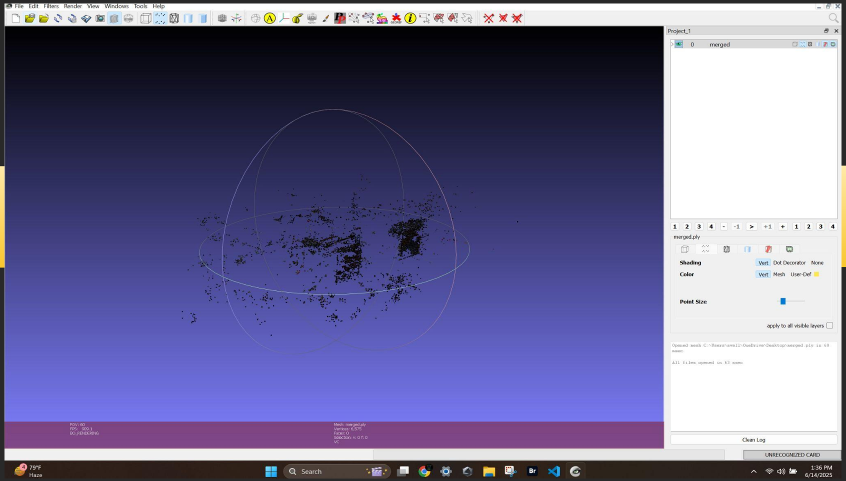
Sphere Size set at 0.0008->

Sphere Size set at 0.02->

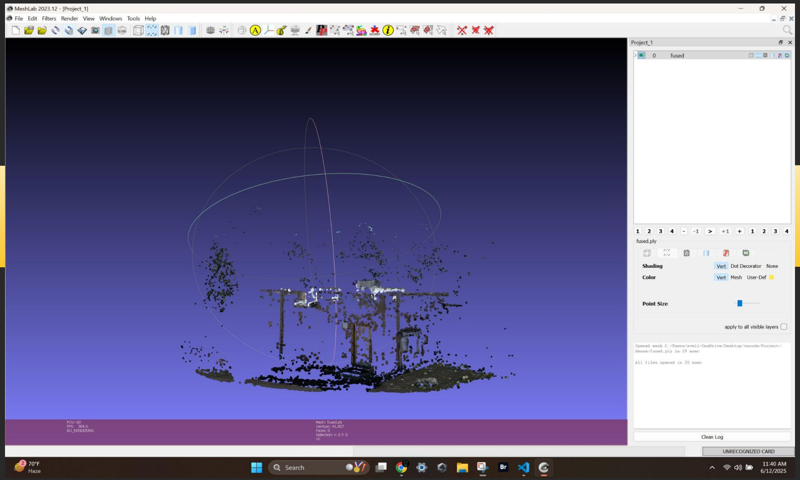


3D Render Attempts: 1 & 2

Attempt #1



Attempt #2

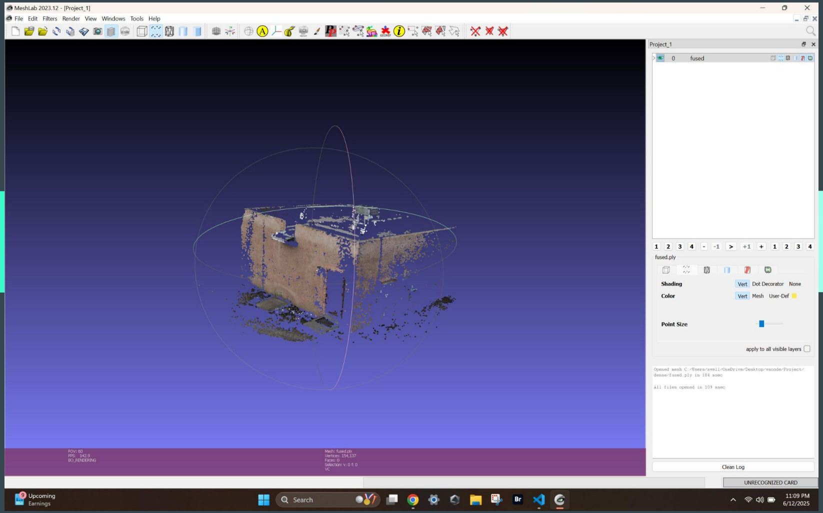


Attempt #1 : This attempt marked a major milestone in our project: compiling the renderer, loading images into COLMAP, and initializing splats for the first time. It was our first working render after overcoming PyTorch & CUDA build issues.

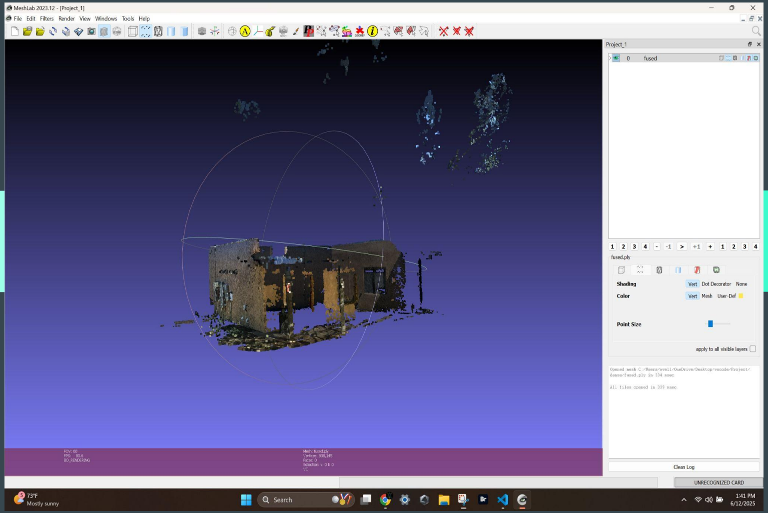
Attempt #2 : In this test, we experimented with a lower SH degree (lighting & diffusion) & altered pruning parameters (Different Points that the render folds to). While obtaining very little detail regarding the classroom’s real life visuals, it helped us understand how splat initialization, camera positions, and depth consistency affected the scene’s density.

3D Render Attempts: 3 & 4

Attempt #3



Attempt #4



Attempt #3 : In this attempt, we created a denser point cloud by adjusting our FOV settings. We then tested renderings using MeshLab, after using multiple sets of COLMAP calibration parameters. These renders exemplify the complexity of 3D geometry.

Attempt #4 : In our fourth attempt, we tried to segment outliers and foreground noise by setting a strong threshold for the confidence radii of splats. We then proceeded to tweak the train.py rendering pipeline & experimented with different camera settings, including: camera model, lighting, exposure and opacity.

Our Best 3D Render Output:

Finally, after debugging, configuring different environments and a whole lot of prayers. We achieved the meshed render, allowing us to begin the gaussian splatting process via radiance fields which would ultimately output our desired 3d render.

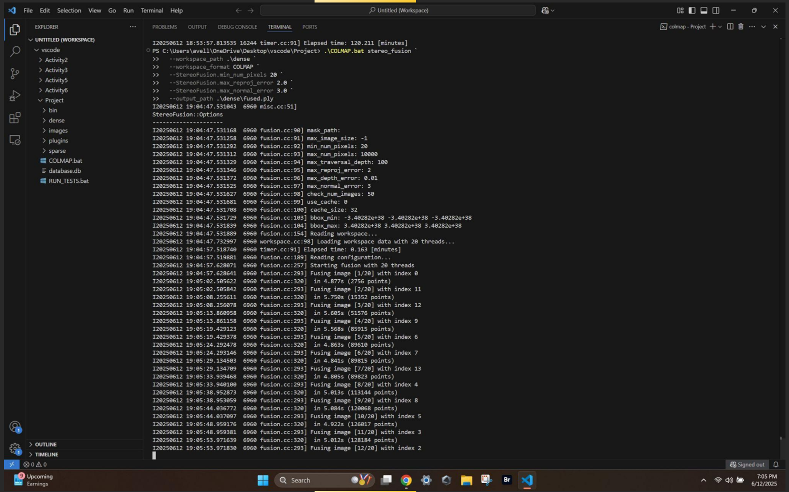
Analysis / Discussion

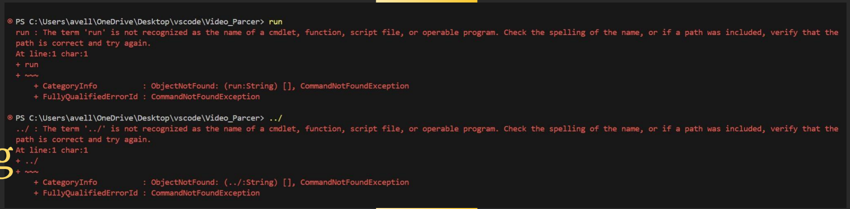
When we made our first 3D point cloud we were surprised at what ≈10,000 points looked like when graphed on a three dimensional plane. However, we had found that a high amount of points did not always mean a clear render, what mattered most was concentration of the points.

Our final result was close to our initial goal of making a 3D render of the SMU campus, however it showed us how crucial all of the steps in the process where and that fine tuning the programs was essential to making accurate digital twins.

Challenges & Limitations

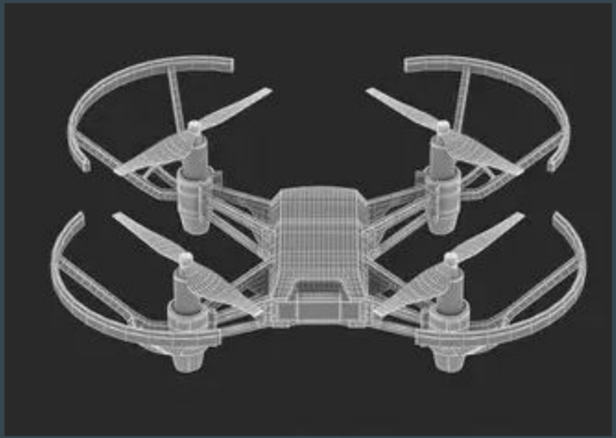
One of our major challenges was simply getting the software to run on the correct versions and dependencies within the ssh. After we tackled this task, we then moved onto running colmap, this posed issues such as formatting, and collecting functionable data that required us to take multiple videos and pictures in order to figure out what was needed for digital reconstruction. Finally, we reached our last challenge of rendering gaussian splatting for real time radiance fields. This was the most computationally demanding & mentally gruelling aspect of the projecte. These challenges ultimately altered our initial goal of creating a large-scale digital twin of SMU Taos to a more feasible plan of rendering various objects on campus, as well as our classroom.





Next steps: The Future of Gaussian Splatting

- Refine our Gaussian Splatting pipeline
- Achieve reliable, high-fidelity 3D reconstructions
- Using smartphones or basic DSLR cameras, individuals can create 3d Mockups of drone ready environments
- Using Digital Twins as training simulators
- 3D mockups of these environments can be input into blender, and various other simulation app's, allowing pilots to train certain routes, areas, and situations.
- These models can be embedded into the drone simulation industry similar to a plane flight simulator, enabling enhanced learning without the cost.



Summary & Conclusion:

- This project demonstrated that 3D-Rendering is accessible and enables the creation and manipulation of digital twins for any environment. With the use of software like Pycolmap, Open3D, & Gaussian Splatting, Digital Twins can be easily modeled for a wide variety of uses such as simulations, real estate, or modern art.
- Overall, this project was very rewarding, giving both Jonathan and I a more complete understanding of how to maneuver within Visual Studio Code, as well operating and organizing a drastic set of databases and directories.

Translation for the Challenges & Limitations Slide

This is Exactly what I wanted to do to my Laptop for probably a total of 12 hours this last week:

THANK YOU!!

Q & A ✅

References:

gaussian-splatting/LICENSE.md at main · graphdeco-inria/gaussian-splatting

repo-sam.inria.fr/fungraph/3d-gaussian-splatting/3d_gaussian_splatting_high.pdf