Application of Photogrammetry to Gaussian Splatting for mesh and texture reconstruction

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1 Gaussian Splatting

- A recent breakthrough tool for generating novel-views of a scene from several photographs[2].
- It creates a point cloud of 3D gaussians that it then rescales, rotates and recolors using gradient descent to fit the original photographs.
- Downside, is that almost all available tools for 3D are designed for working with polygons and textures, and not Gaussians.
- These Gaussians need to be somehow transformed into a polygonal mesh and textures for use in modern workflows.

There are no methods so far to extract both the mesh and texture[3]

SuGaR can extract a mesh, but no texture data[1]. Texture-GS extracts a modifiable texture, but that texture only applies to Gaussians[5].

2 Photogrammetry

- A well-developed method for extracting a 3D model from photos of an object.
- Requires high-degree of overlap between images for best results [4].
- This research proposes the use of PG for extracting a 3D model from GS.

Research Question

"Is PG a viable method for extracting the polygonal 3D mesh and texture from a GS scene?"

3 Controlled Experiment

- Several 3D models were placed into a blender scene, and renders were taken of them from different angles.
- Renders used to train three GS scenes, one with 120 renders (120-GS), one with 60 renders (60-GS), and one with 30 (30-GS).
- 182 renders of the trained GS scenes were used in Photogrammetry to generate a model.
- 182 renders of the original model were also used in Photogrammetry (No-GS), for comparing the new method against .
- Quantitative measures were taken for quantitative analysis
- Visual inspection of lit and normal renders of final models was used for qualitative analysis.

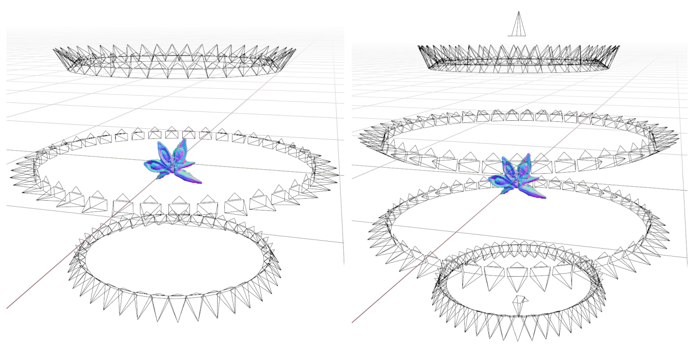

Figure: Visualization of camera angles used for GS training images (left) and PG model generation input images (right).

4 Quantitative Results

Measure	No-GS	120-GS	60-GS	30-GS
ATL	3.766	3.630	3.538	3.102
MRE	0.319	0.366	0.386	0.411
%-RC	0.991	0.990	0.989	0.989
PSNR-L	40.136	39.841	39.747	39.452
PSNR-N	41.191	40.352	40.126	39.418

Table: The mean of each measure of each category across the 27 models included in the final results. Generally, the results worsen across all measures when comparing from No-GS, to 30-GS, to 60-GS, to 120-GS.

Measure	120-GS	60-GS	30-GS
ATL	0.333	0.105	**2.351e-6**
MRE	**0.015**	**4.194e-3**	**3.831e-5**
%-RC	0.077	**0.032**	**2.588e-3**
PSNR-L	0.522	0.406	0.161
PSNR-N	0.185	**0.048**	**4.551e-3**

Table: For each category, for each measure, p-value for difference to 'No-GS' model measures. Significant differences ($p < 0.05$) are marked with bold. In all such cases, No-GS has the better average quality for that measure.

Measure	120 vs. 60	120 vs. 30	60 vs. 30
ATL	0.491	**4.965e-5**	**5.710e-4**
MRE	0.228	**8.993e-3**	0.096
%-RC	0.654	0.081	0.161
PSNR-L	0.775	0.324	0.467
PSNR-N	0.494	0.069	0.172

Table: P-values for difference tests between Gaussian Splatting based models. Significant differences ($p < 0.05$) are marked with bold.

5 Visual Results

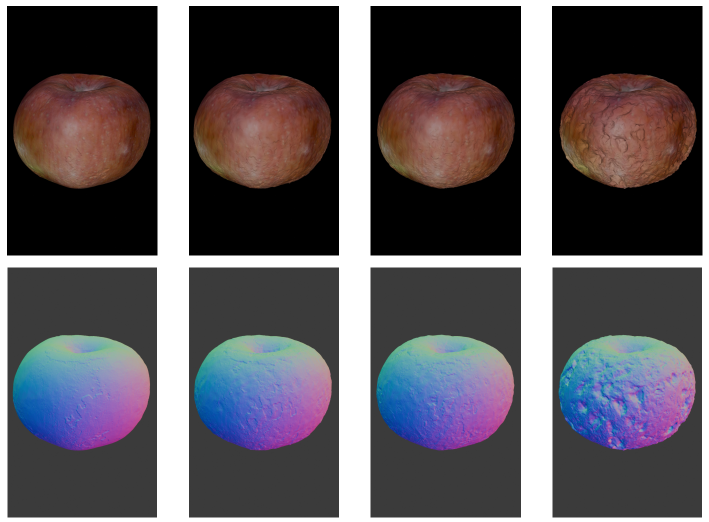

Figure: Visual comparison of geometry and lit textured views of '120-GS', '60-GS', '30-GS', and 'No-GS' models respectively for the apple-1 input model.

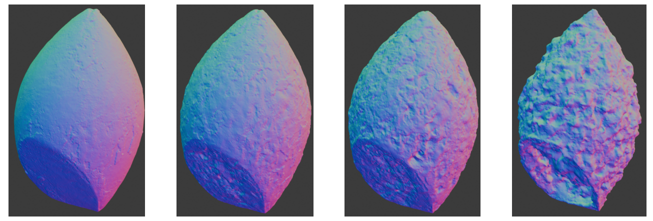

Figure: Visual comparison of geometry of 'No-GS', '120-GS', '60-GS' and '30-GS' models respectively for the beauty-blender-1 input model.

6 Conclusions

- It is possible to generate a 3D model from Gaussian Splatting using Photogrammetry.
- Using GS causes a significant drop in at least one quality measure.
- Many models accurately recreated the original model with 120 and 60 GS training images, however GS with only 30 images introduces geometric errors.
- Visual errors much more prominent on models with featureless surfaces.
- In cases of minimal geometric deterioration, an accurate 3D model is able to be successfully created from Gaussian Splatting by using Photogrammetry.
- When GS based models produce accurate results, the amount of initial images can be reduced by 3 times before visual errors emerge.

References

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