Additional Material: NoiseGS: Boosting 3D Gaussian Splatting with Positional Noise for Large-Scale Scene Rendering

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1. Introduction

In this additional material, we present additional ablation study results for large-scale scene reconstruction using the *Block_All* scene from the *MatrixCity* dataset and the *Building* scene from the *Mill19* dataset, as well as relatively smaller scenes from the *Tanks and Temples* dataset, which include the outdoor *Courthouse* scene and the indoor *Meetingroom* scene.

2. Effectiveness of our proposed methods

Scenes	*Block_All*				*Building*			
	PSNR ↑	SSIM ↑	LPIPS ↓	training	PSNR ↑	SSIM ↑	LPIPS ↓	training
Grendel-GS [ZWL*24]	27.59	0.861	0.266	2h 48m	22.20	0.770	0.314	57m
+Positional Noise	27.72	0.866	0.257	2h 44m	22.61	0.782	0.296	57m
+ℓ_p-penalization	27.73	0.867	0.251	2h 53m	22.76	0.788	0.287	1h 1m

Table A1: *Ablation study results on Block_All and Building.*

Table A1 shows that in complex large-scale scenes, applying our positional noise and ℓ_p-penalization leads to improved rendering quality. Notably, the effect of adding positional noise is particularly significant, it enhances all three rendering quality metrics compared to the baseline, without incurring additional training time. This suggests that our method successfully helps suboptimal Gaussians, which are often trapped in complex view configurations, escape through the application of positional noise and scale constraints, thereby facilitating more effective optimization.

Moreover, to assess the effectiveness of our method in relatively smaller scene, we conducted an ablation study on two scenes from the Tanks and Temples dataset [KPZK17]. It should be noted that applying positional noise and scale ℓ_p-penalization to smaller scenes may require particular caution due to differing scene characteristics. This is because smaller scenes tend to converge more easily to optimal positions, reducing the necessity of positional noise. Additionally, the likelihood of large Gaussians emerging is lower compared to large-scale scenes. As a result, if the influence of the scale regularization loss is not carefully tuned, it may adversely affect rendering quality during fine-tuning due to overly strong constraints. Taking this into account, we set the learning rate for positional noise to 1×10^{-4}, which is smaller than the original value, in the ablation study in relatively small-scale scenes. The weight of ℓ_p-penalization was kept at 0.01.

Scenes	*Courthouse (outdoor)*				*Meetingroom (indoor)*			
	PSNR ↑	SSIM ↑	LPIPS ↓	training	PSNR ↑	SSIM ↑	LPIPS ↓	training
3DGS [KKLD23]	22.13	0.785	0.354	10m 59s	25.25	0.866	0.315	13m 8s
+Positional Noise	22.19	0.791	0.347	10m 17s	25.42	0.869	0.313	11m 30s
+ℓ_p-penalization	22.29	0.791	0.345	9m 28s	25.48	0.870	0.311	11m 21s

Table A2: *Ablation study results on Courthouse and Meetingroom.*

As shown in Tab. A2, integrating our proposed method with the baseline progressively improves rendering performance. Notably, unlike in large-scale scenes, applying scale penalization in smaller scenes slightly reduced training time. Although the performance gains were modest compared to large-scale scenes, our approach demonstrates efficiency advantages, such as fewer Gaussians required, thereby decreasing fine-tuning time.

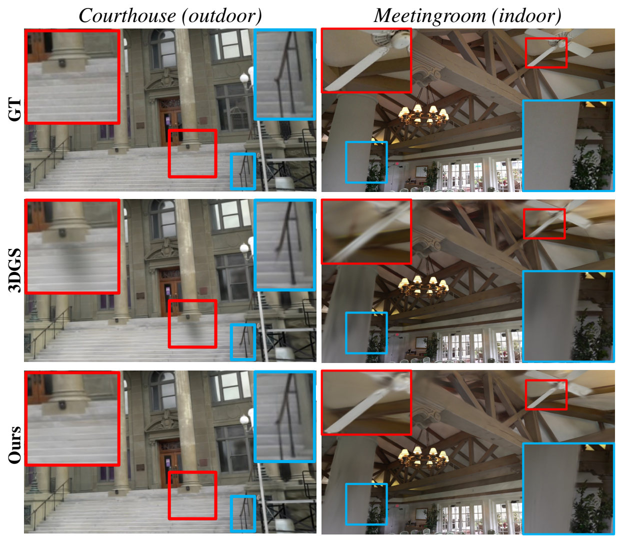

Figure A1: *Comparison of rendering results across methods: GT (Ground Truth), 3DGS, and our method, on two scenes.*

Figure A1 shows qualitative results for relatively small-scale outdoor and indoor scenes. In both scenes, our method reduces issues caused by floaters compared to 3DGS, resulting in noticeable improvements such as reduced blurriness, fewer object discontinuities, and clearer rendering. These results confirm the potential of noise injection and scale penalization even in relatively smaller scenes.

3. Limitations and Conclusion

In this additional material, we provide further experimental results demonstrating that our proposed approach consistently performs well across scenes ranging from large-scale reconstructions to relatively smaller outdoor and indoor environments. However, we acknowledge a limitation of our method in that the influence of positional noise and the ℓ_p-penalization for scale regularization must be specifically adjusted depending on the size of the scene. To achieve robust performance across even smaller, object-level scenes, a more finely tuned noise design will be necessary. We consider addressing this challenge as an important direction for future work.

References

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