NEURAL INFORMATION PROCESSING SYSTEMS

AdpSplit:
Error-Driven Adaptive Splitting for Faster Geometry Discovery in 3D Gaussian Splatting

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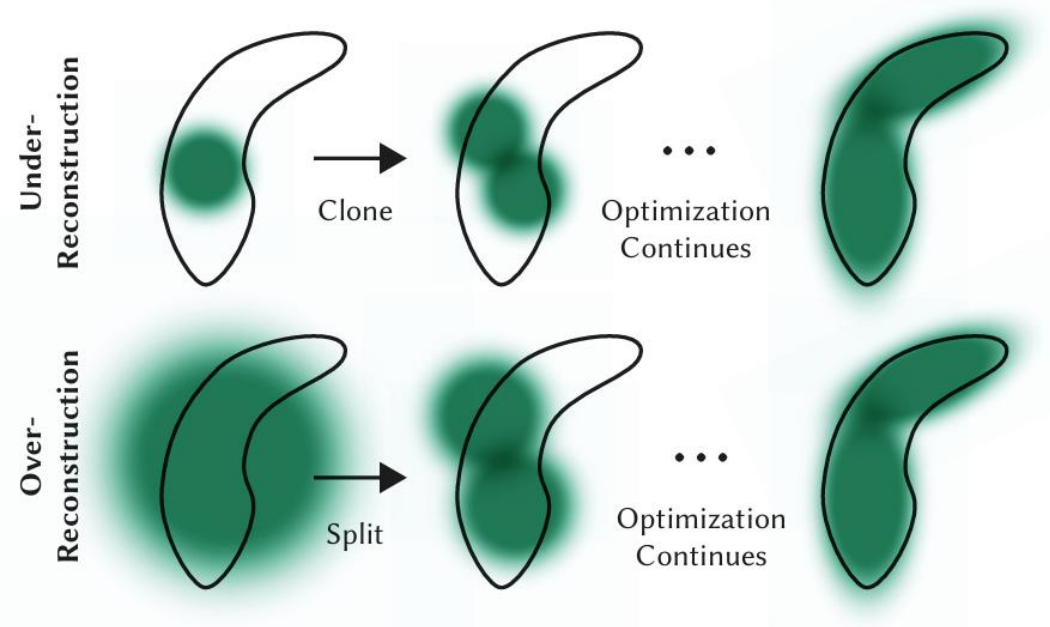
Introduction

- Novel View Synthesis (NVS) is a core computer vision task that aims to generate photorealistic images from novel viewpoints.
- 3D Gaussian Splatting [1] expands its initially sparse set of Gaussian primitives through adaptive density control (ADC) to capture missing geometry and fine details.

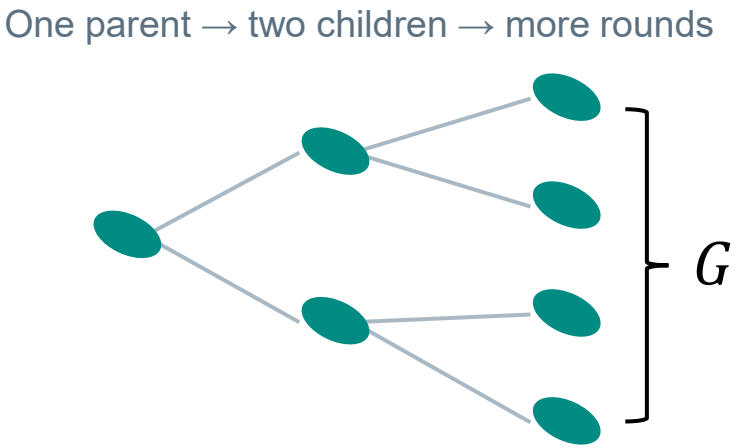


Splitting and Cloning

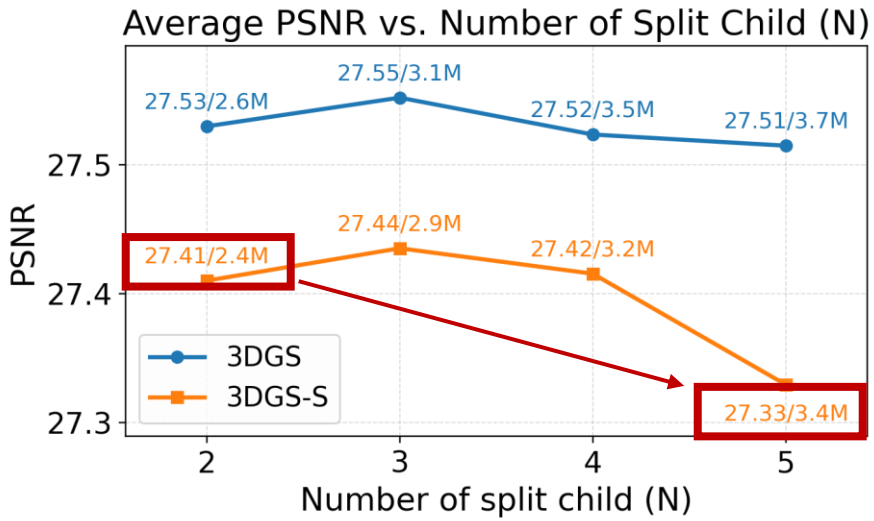
[1] Bernhard Kerbl et. al., “3D Gaussian Splatting for Real-Time Radiance Field Rendering”, ACM SIGGRAPH 2023.

Motivation

- ADC split operator produces a fixed number of children for each split candidate at randomly sampled locations.
- Question: how many children, and how to initialize them?



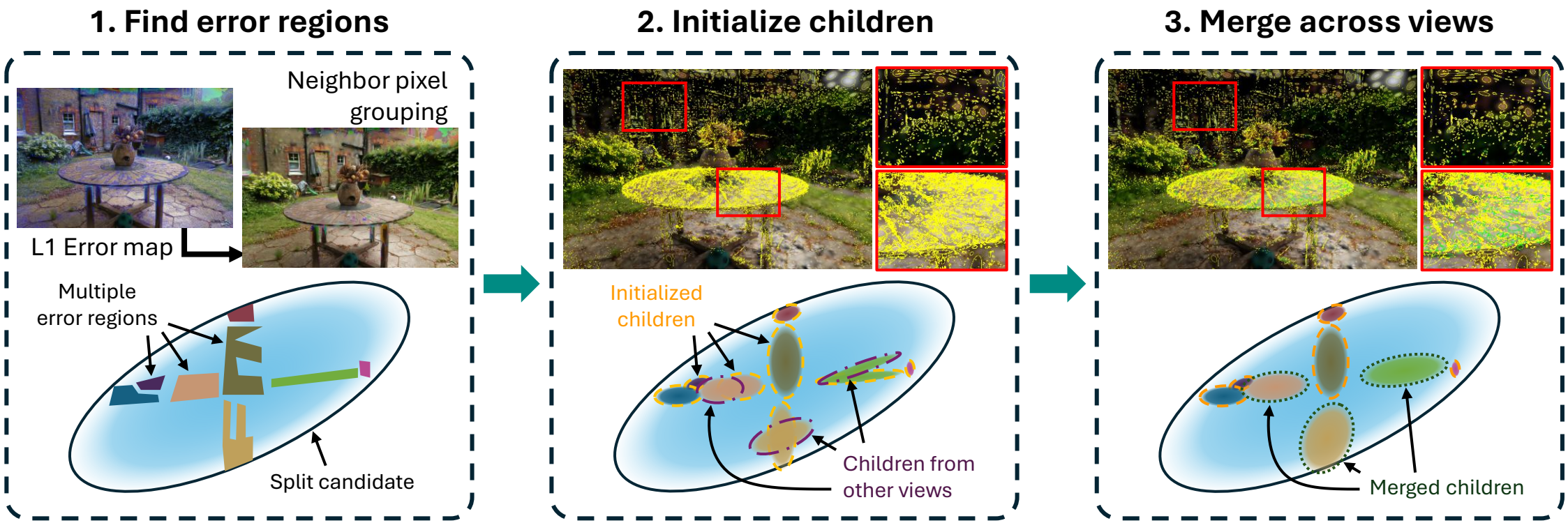
Fixed-cardinality splitting requires
at least $log_2 G$ repeated densification rounds.



Simply increasing the cardinality is not enough

Method

- Adaptive child count + informed initialization
  → useful structure in fewer rounds



Group high-error pixels attributed to the parent.

Region → position, shape, color.
Parent → depth prior.

Combine nearby proposals with similar colors.

Experiment

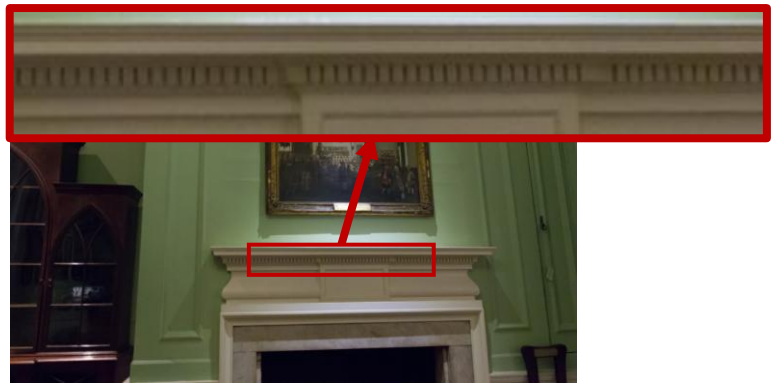
- Baselines:
  - 3DGS, MiniSplatting, DashGaussian, SpeedySplat, FastGS
- Setup
  - NVIDIA RTX 5000 Ada GPU.
  - Shortened densification 9k out of total iteration 24k.
  - All other hyperparameters are kept consistent with 3DGS (e.g., lr).
- Datasets
  - MipNeRF360, Tanks and Temples, and Deep Blending.
- Metrics
  - PSNR, SSIM, LPIPS, training time, number of primitives.

Results

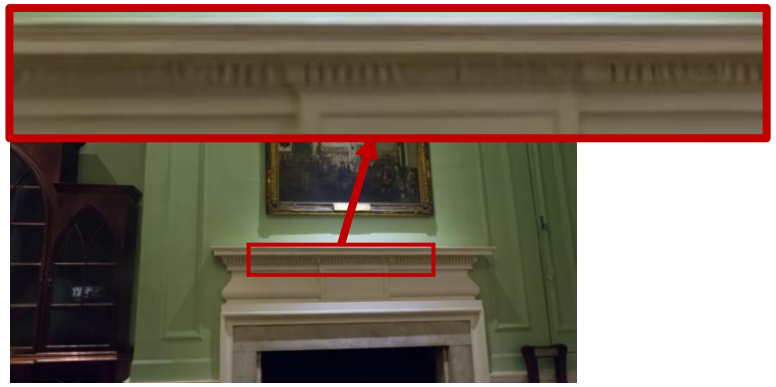
Method	MipNeRF360						Deep-Blending						Tanks&Temples					
	PSNR	SSIM	LPIPS	Time	Δt	#G.	PSNR	SSIM	LPIPS	Time	Δt	#G.	PSNR	SSIM	LPIPS	Time	Δt	#G.
3DGS	27.53	**0.813**	**0.221**	1807	–	2.65	29.68	**0.907**	**0.239**	1676	–	2.48	23.72	**0.852**	**0.169**	967	–	1.58
3DGS-S	27.41	0.808	0.228	**1318**	**-27.1**	**2.41**	**29.87**	0.906	0.243	**1152**	**-31.3**	**2.21**	23.69	0.850	0.174	**707**	**-26.9**	**1.47**
3DGS-AdpSplit	**27.54**	0.810	0.225	1391	-23.0	2.55	29.80	**0.907**	0.240	1197	-28.6	2.25	**23.83**	0.850	0.172	748	-22.6	1.51
MiniSplatting	**27.32**	**0.822**	**0.217**	1172	–	0.49	29.97	0.910	**0.241**	1050	–	0.55	**23.40**	**0.846**	**0.181**	723	–	0.30
MiniSplatting-S	27.27	0.821	0.219	**898**	**-23.4**	**0.48**	**30.07**	**0.911**	0.242	**816**	**-22.3**	**0.53**	**23.40**	0.843	0.186	**527**	**-27.1**	**0.28**
MiniSplatting-AdpSplit	**27.32**	0.820	0.220	920	-21.5	**0.48**	29.97	0.910	0.242	828	-21.1	**0.53**	23.27	0.838	0.192	562	-22.3	**0.28**
DashGaussian	**27.71**	**0.820**	**0.213**	594	–	2.43	**29.79**	**0.905**	**0.246**	358	–	1.95	24.00	**0.853**	**0.178**	349	–	1.21
DashGaussian-S	27.63	0.819	0.214	**499**	**-16.0**	2.40	29.72	0.904	0.248	**314**	**-12.3**	**1.82**	23.94	0.850	0.181	**292**	**-16.3**	1.17
DashGaussian-AdpSplit	27.70	**0.820**	**0.213**	522	-12.1	**2.36**	29.71	0.904	0.248	325	-9.2	1.85	**24.12**	0.851	0.179	304	-12.9	**1.15**
SpeedySplat	26.86	0.781	0.295	1090	–	**0.30**	29.63	0.903	0.268	841	–	**0.25**	**23.51**	0.820	0.240	500	–	**0.18**
SpeedySplat-S	27.03	0.787	0.283	**868**	**-20.4**	0.34	**29.64**	**0.904**	**0.266**	**649**	**-22.8**	0.27	23.46	0.823	0.234	**395**	**-20.9**	0.20
SpeedySplat-AdpSplit	**27.10**	**0.790**	**0.279**	912	-16.3	0.35	29.62	0.903	**0.266**	677	-19.5	0.27	23.49	**0.824**	**0.233**	422	-15.5	0.20
FastGS	27.54	**0.798**	0.261	171	–	0.40	29.90	**0.905**	**0.267**	105	–	0.22	**24.26**	**0.842**	**0.208**	108	–	0.24
FastGS-S	27.37	0.790	0.272	**127**	**-25.7**	**0.31**	29.80	0.901	0.274	**78**	**-25.7**	**0.17**	23.99	0.837	0.214	**80**	**-25.9**	**0.21**
FastGS-AdpSplit	**27.55**	0.797	**0.260**	143	-16.4	0.40	**29.95**	0.904	0.269	83	-21.0	0.19	24.17	0.840	0.209	86	-20.4	0.23

Results

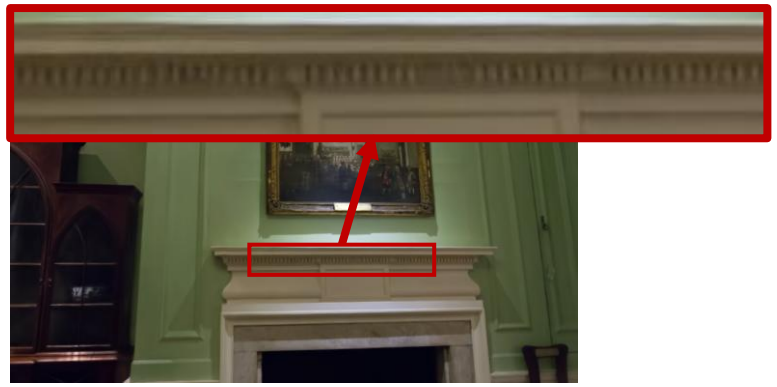
- The recovered quality appears in fine details.



Ground Truth



3DGS



+AdpSplit



Ground Truth



FastGS



+AdpSplit

Conclusion

- We identify a hidden bottleneck in 3DGS training is **fixed-cardinality random split** operator.
- We show that **an error-driven adaptive split strategy** enables faster geometry search with shortened densification rounds.
- AdpSplit **boosts existing 3DGS training accelerators** (by 9.2–22.3%), while keeping comparable rendering quality.



Thank you!

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Code: https://github.com/ASU-ESIC-FAN-Lab/AdpSplit





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