Speedy-Splat: Fast 3D Gaussian Splatting with Sparse Pixels and Sparse Primitives

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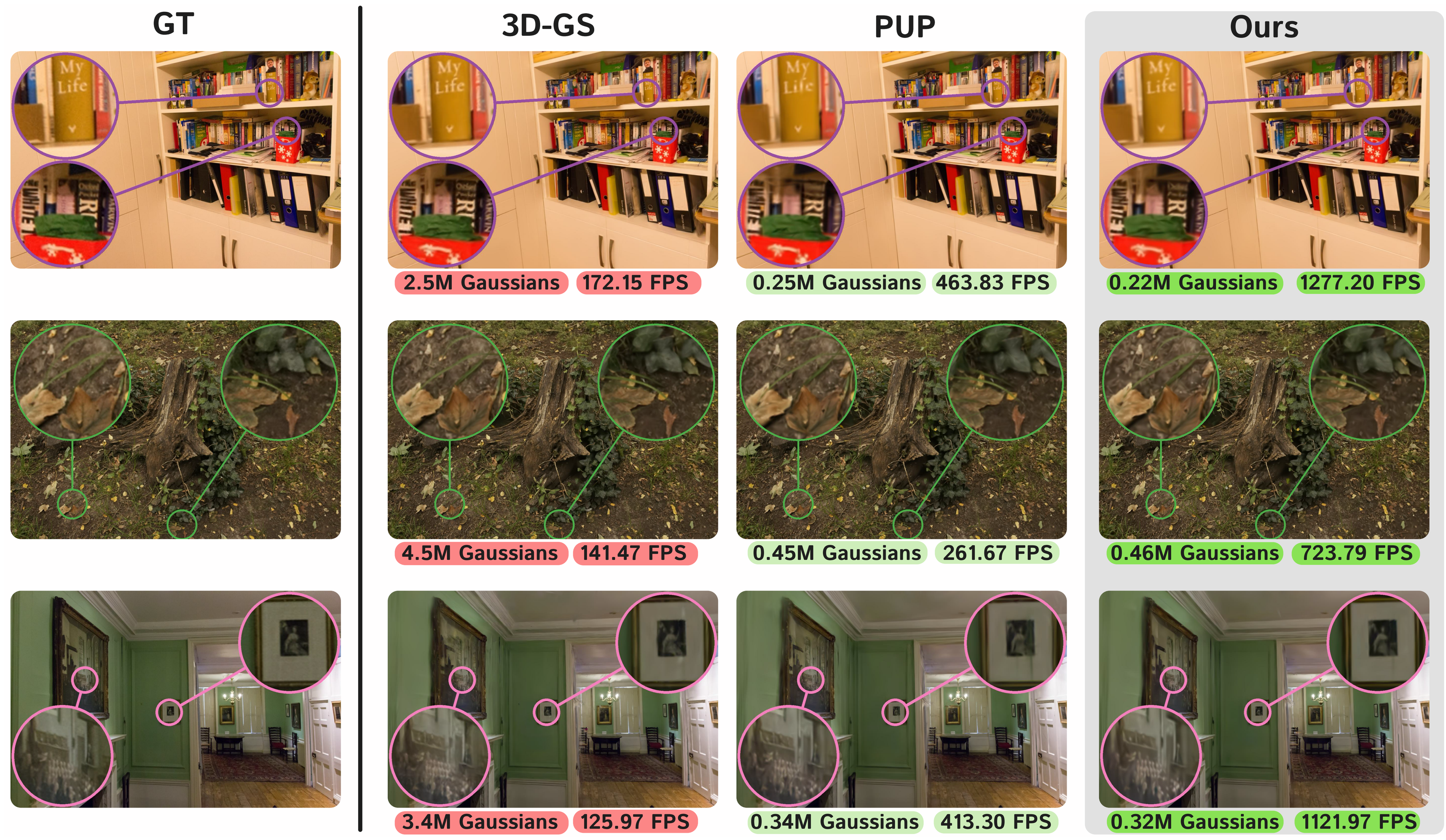
speedysplat.github.io

Motivation

How can we accelerate the rendering speed of 3D Gaussian Splatting (3D-GS) by over 6×?

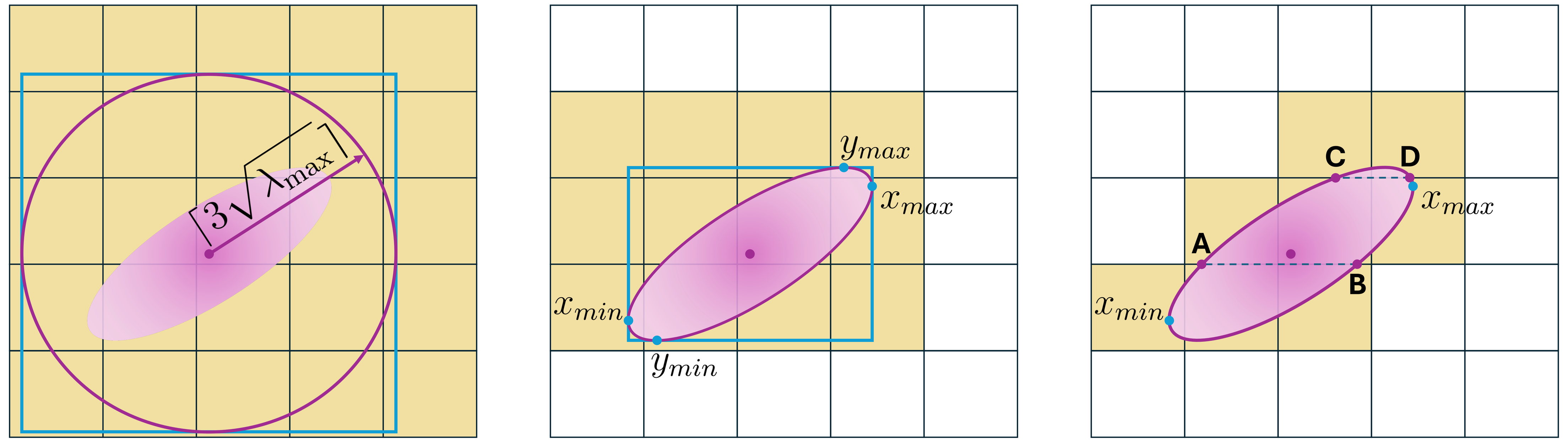
Rendering speed is primarily determined by two factors:

1. The **number of Gaussians allocated to each pixel**, and
2. The **total number of Gaussians** in the scene.



Method

Localization



(a) 3D Gaussian Splatting (b) SnugBox (c) AccuTile

Our localization algorithms reduce the number of Gaussians per pixel.

(a) 3D Gaussian Splatting overestimates Gaussian-to-tile intersections.
(b) Our **SnugBox** algorithm finds the axis-aligned tight bounding box of the Gaussian and corresponding rectangular tile extent in constant time.
(c) Our **AccuTile** algorithm extends SnugBox to quickly compute exact Gaussian-to-tile intersections.

SnugBox and AccuTile are **lossless –** they do not change the rendered image.

Pruning

Our pruning method reduces the total number of Gaussians by ~90%.

We compute a pruning score $\tilde{U}_i$ for each Gaussian $\mathcal{G}_i$ as a second order approximation of the L_2 reconstruction error:

$$\tilde{U}_i = \sum_{\phi \in \mathcal{P}_{gt}} \left(\nabla_{g_i} I_{\mathcal{G}}(\phi)\right)^2 \approx \sum_{\phi \in \mathcal{P}_{gt}} \nabla_{\mathcal{G}_i} I_{\mathcal{G}}(\phi) \nabla_{\mathcal{G}_i} I_{\mathcal{G}}(\phi)^T \approx \nabla^2_{\mathcal{G}_i} L_2,$$

where $\mathcal{P}_{gt}$ is the set of all training poses, $I_{\mathcal{G}}(\phi)$ is the rendered view for pose ϕ, and g_i is the value of the projected Gaussian in $I_{\mathcal{G}}(\phi)$.

We use this score to prune the scene during training via two modalities:

1. **Soft Pruning,** performed during the densification stage, and
2. **Hard Pruning,** performed after the densification stage.

Results

When compared to original 3D-GS, **Speedy-Splat** achieves
6.5× FPS, 10× compression, and 45% faster training.

Our **lossless** methods **boost FPS by 2×** for free.

Method	FPS↑	Comp.↑	Train↑	PSNR↑	SSIM↑	LPIPS↓
3D-GS	*1.00×*	*1.00×*	*1.00×*	27.55	0.814	0.222
EAGLES	1.51×	3.68×	1.37×	26.94	0.800	0.250
ELMGS	2.69×	5.00×	-	27.00	0.779	0.286
PUP	2.55×	8.65×	-	26.83	0.792	0.268
Mini-Splat	3.20×	6.84×	1.26×	27.34	0.822	0.217
Ours (Lossless)	1.99×	0.99×	1.10×	27.57	0.814	0.221
Ours (Full)	6.51×	10.6×	1.45×	26.94	0.782	0.296

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