FACT-GS: Frequency-Aligned Complexity-Aware Texture Reparameterization for 2D Gaussian Splatting

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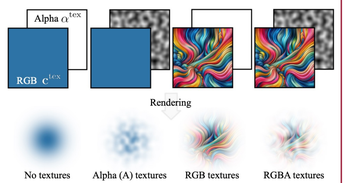
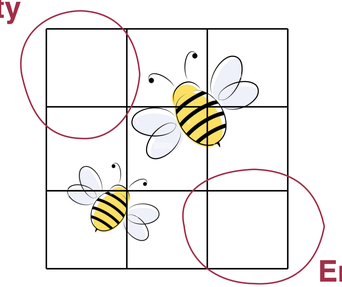
Motivation

Textured GS[1]:
Enable spatial color variation in each primitive by attaching per-Gaussian texture.

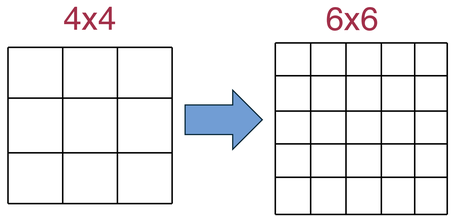


✗ Inefficient texture space utilization



Hard to response high-frequency content, waste capacity in plain area

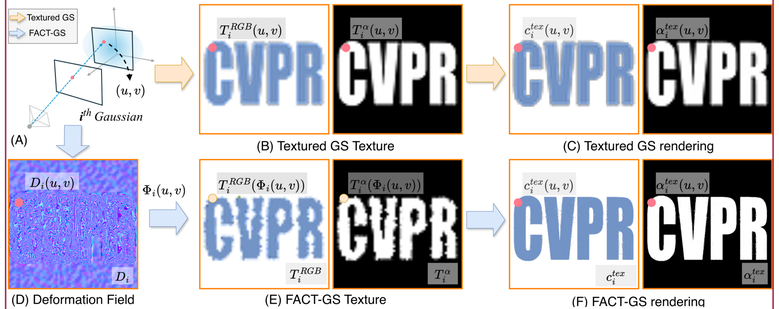
✗ Inefficient texture resolution scaling



Increasing resolution lead to quadratic memory overhead, but marginal performance gain

2.25x parameters

Method



Algorithm 1: Training of FACT-GS

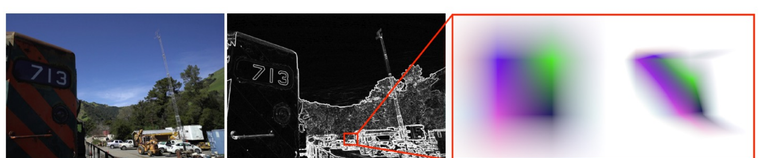
Input: Pretrained Gaussian parameters $\{p_i, s_\beta, s_\gamma, t_\beta, t_\gamma, o_i, \mathrm{SH}_i\}$, textures $\{\mathbf{T}_i\}$ and deformation field $\{\mathbf{D}_i\}$
Output: Rendered image $\hat{I}$ with aligned details

for *each Gaussian* $i = 1, \ldots, N$ **do**
  Compute (u, v) via tangent-plane mapping;
  Predict displacement $\mathbf{D}_i(u, v)$;
  Warp coordinates $(u', v') = (u, v) + \mathbf{D}_i(u, v)$;
  Sample $c_i^{\text{tex}}, \alpha_i^{\text{tex}}$ from $\mathbf{T}_i(u', v')$;
Blend all Gaussians to get $\hat{I}$;
Backpropagate loss to update all parameters.

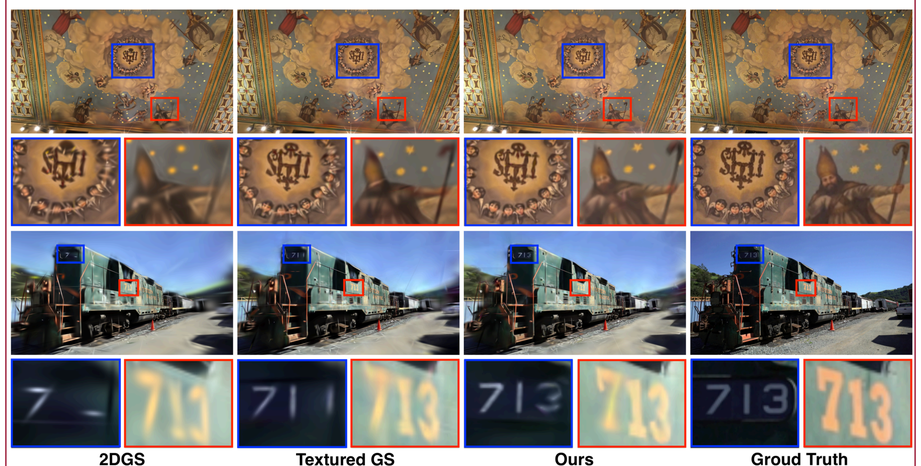
Optimization Objective:

$$\mathcal{L} = \eta\mathcal{L}_1 + (1-\eta)\mathcal{L}_{\text{SSIM}} + \mathcal{L}_\alpha$$

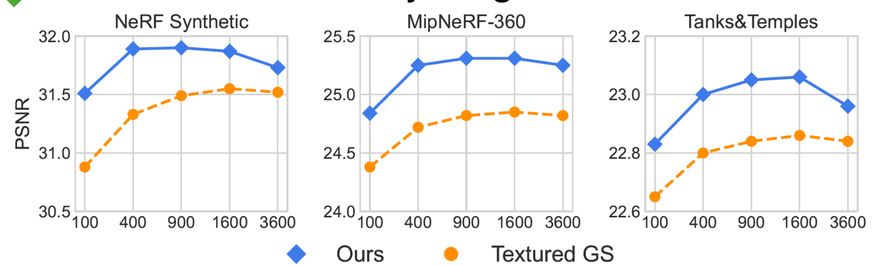
✓ **Better High-frequency Response**



Experiments



✓ **More Efficient Memory Usage**



Same performance with only $\frac{1}{16}$ texture parameters.

[1] Chao, Brian, et al. "Textured gaussians for enhanced 3d scene appearance modeling." *Proceedings of the Computer Vision and Pattern Recognition Conference*. 2025.

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