BallGAN: 3D-aware Image Synthesis with a Spherical Background

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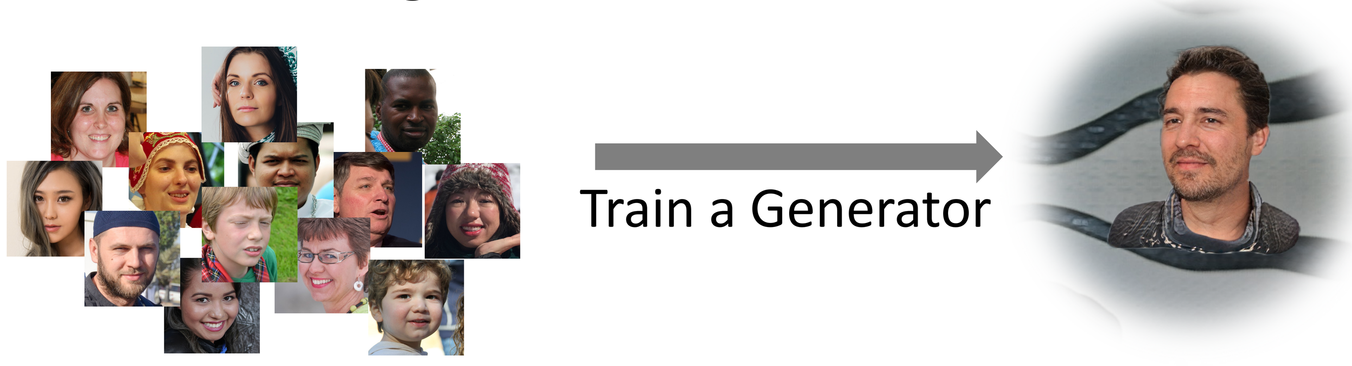
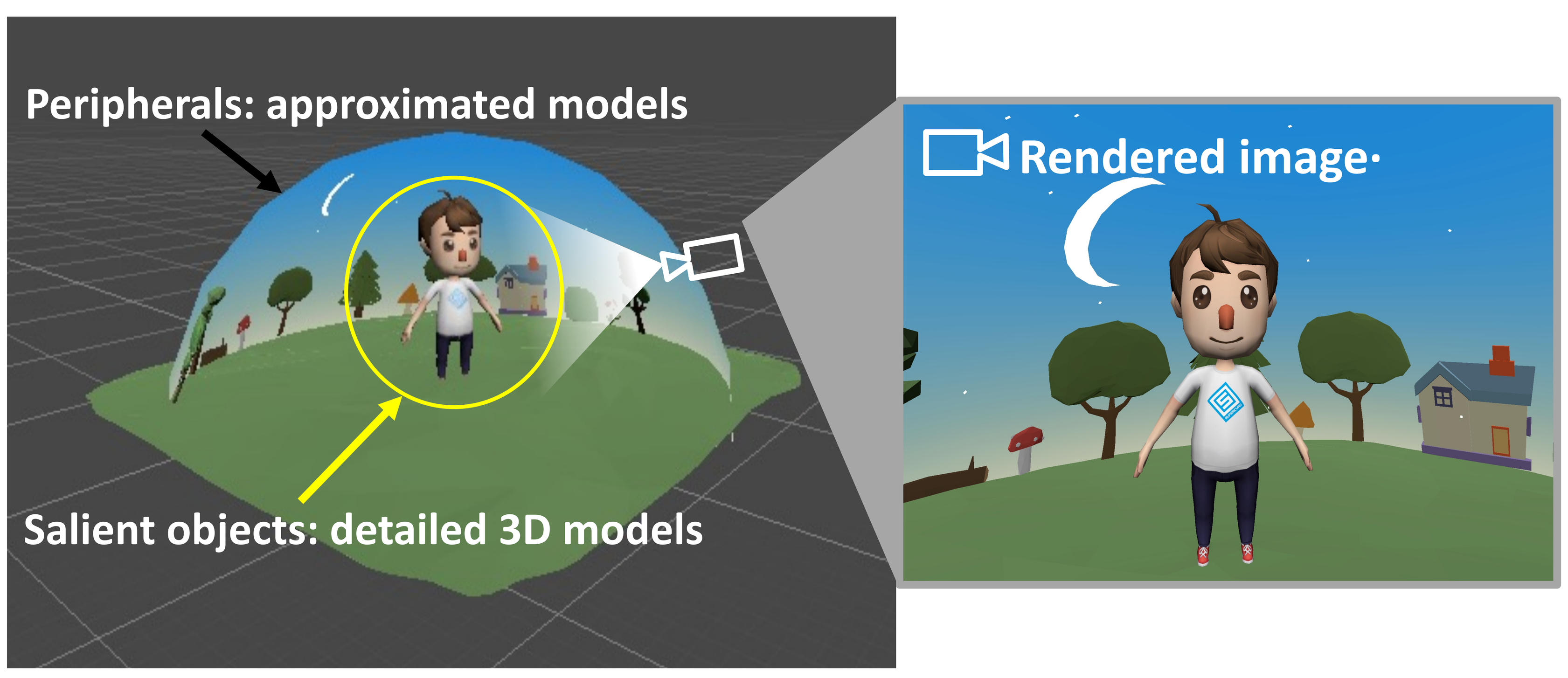
3D-aware GANs

- Goal : to generate 3D scenes
- Dataset: 2D images

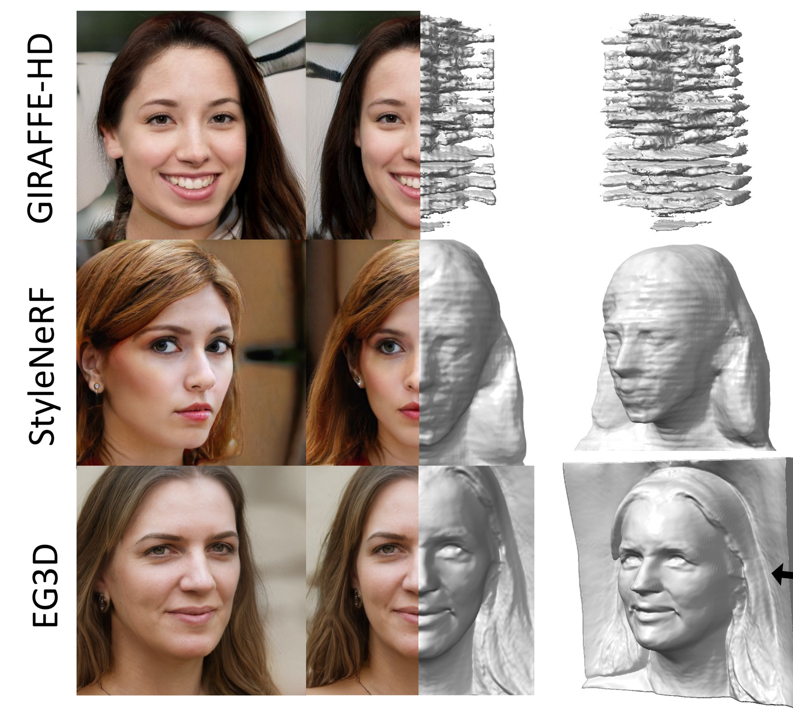


Motivation

- Who cares the backgrounds?
- Smart trick from the graphics community:



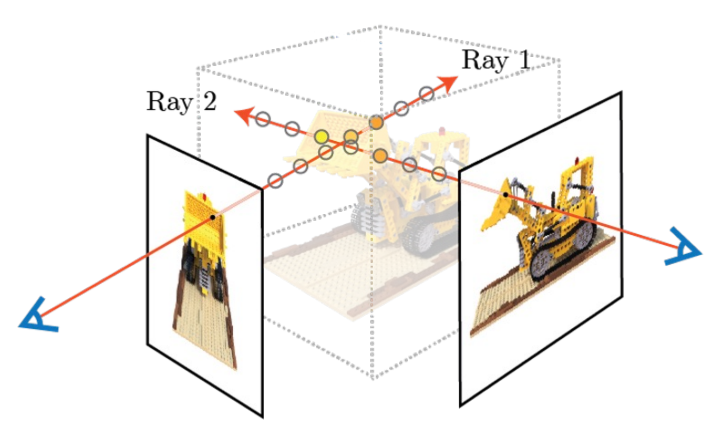
Problem of previous methods



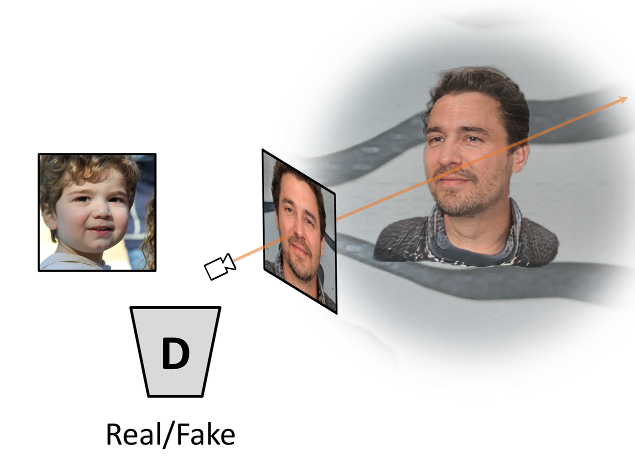
- Broken foreground geometry
- Lacks detail in geometry
- Face sticking to the wall

- We do not have 3D supervision in 3D-aware GANs.

NeRFs *:*
multi-view images
= 3D supervision

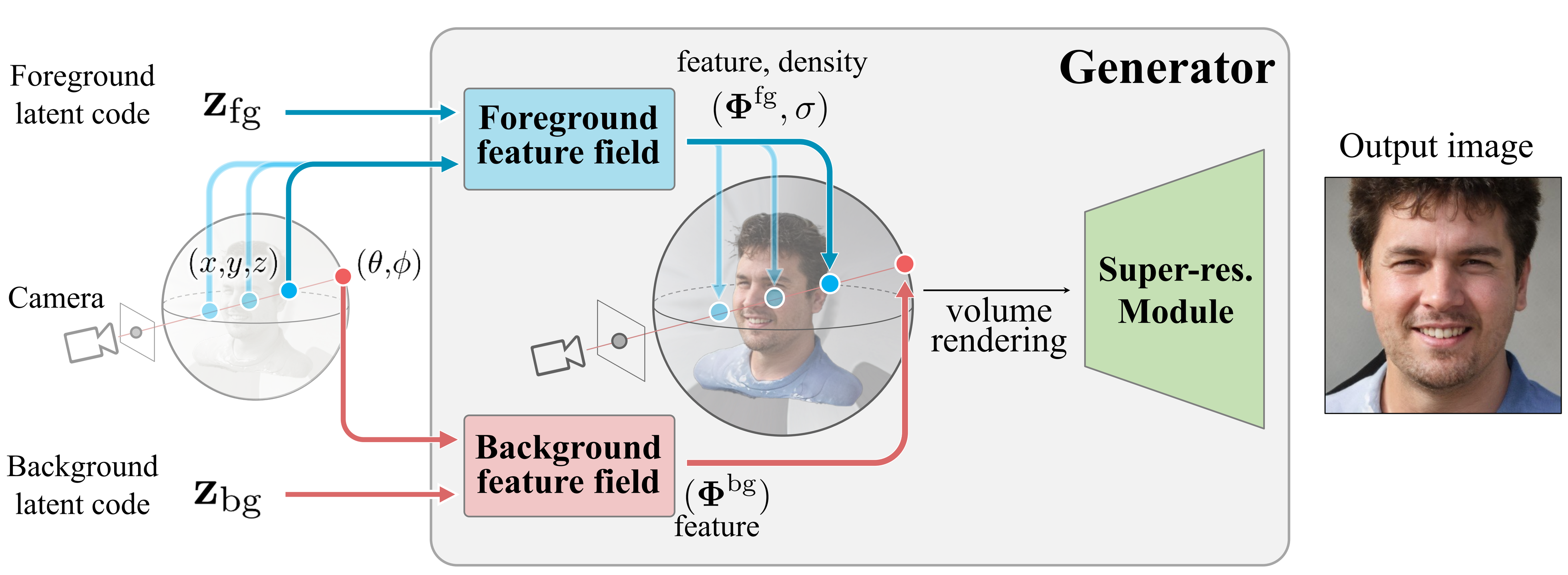


3D-aware GANs *:*
Rendered 2D images should be realistic
= no 3D supervision



Method

- Let's split a scene into a foreground and a simple background!
  - **>** Foreground model : A typical 3D scene representation (tri-plane[1], NeRF[2])
  - **> Background model** : A spherical surface with a fixed radius.



Note: The background model does not produce density.

- Modified volume rendering:
  The occupancy of the background is 1.

$$\phi(\mathbf{r}) = \sum_{i=1}^{N_{\text{fg}}} T_i(1-\exp(-\sigma_i\delta_i))\mathbf{\Phi}_i^{\text{fg}} + T^{\text{bg}}\mathbf{\Phi}^{\text{bg}}$$

- Loss for FG-BG separation:

$$\mathcal{L}_{\text{bg}} = \sum \min(T^{\text{bg}}, 1-T^{\text{bg}})$$

- Foreground density reg $\mathcal{L}_{\text{fg}}$ [3]:

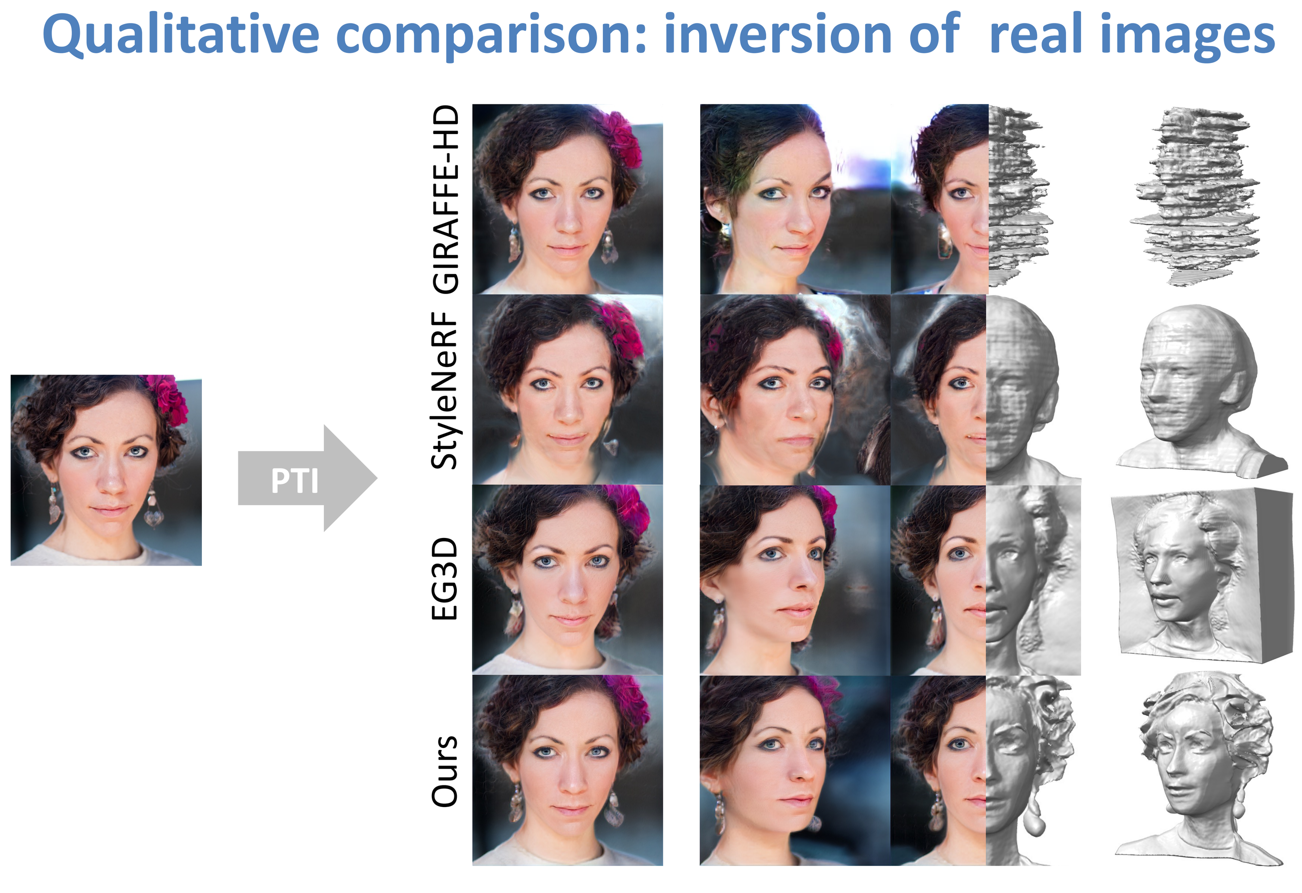
$$\mathcal{L}_{\text{fg}} = \sum_{r}\left(\sum_{i,j}\mathbf{w}_i^r\mathbf{w}_j^r|t_i^r - t_j^r| + \frac{1}{3}\sum_i \mathbf{w}_i^{r2}\delta_i^r\right)$$

[1] Chan et al, Efficient Geometry-aware 3D Generative Adversarial Networks
[2] Gu et al, StyleNeRF: A Style-based 3D-Aware Generator for High-resolution Image Synthesis
[3] Barron et al, Mip-NeRF 360: Unbounded Anti-Aliased Neural Radiance Fields

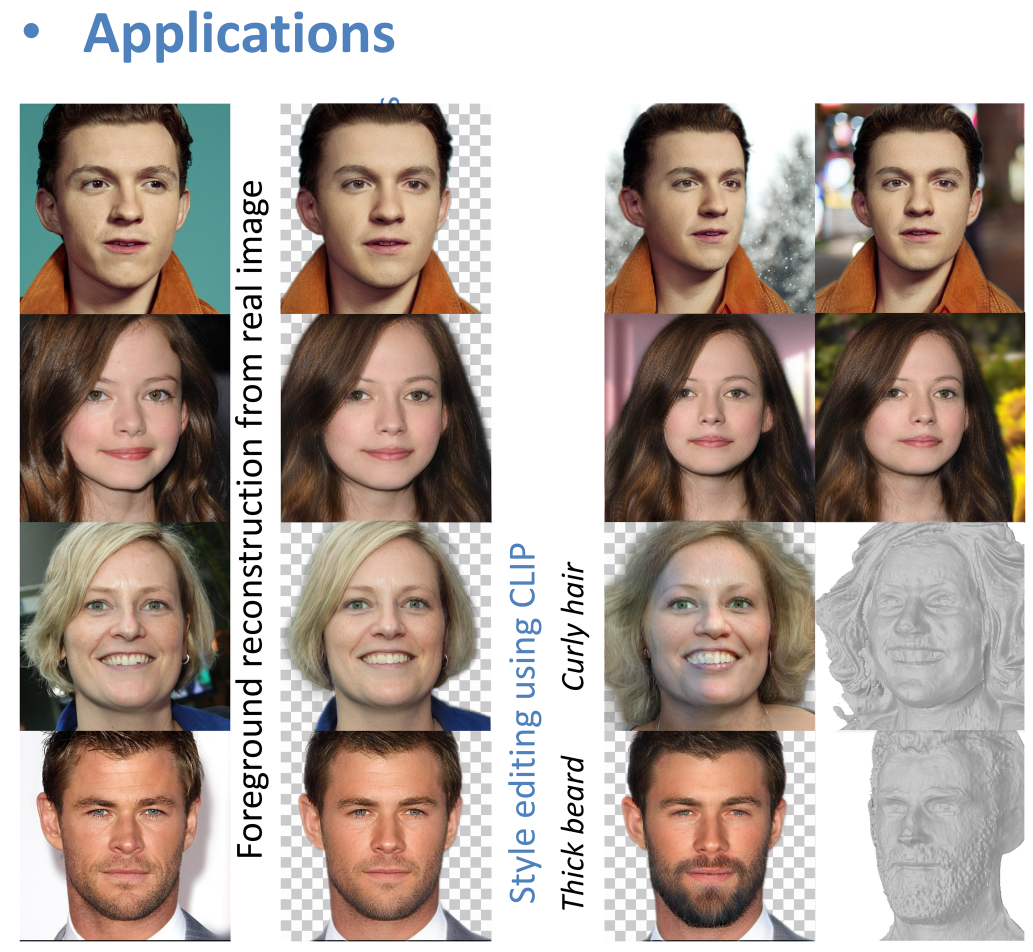
Results

- **Results on FFHQ/ AFHQv2-Cats**

- **Qualitative comparison: inversion of real images**



- **Applications**



- **Training stability**