DGH: Dynamic Gaussian Hair

Junying Wang[1,2], Yuanlu Xu[2], Edith Tretschk[2], Ziyan Wang[2], Anastasia Ianina[2], Aljaz Bozic[2], Ulrich Neumann[1], Tony Tung[2]

[1] University of Southern California [2] Meta Reality Lab Research

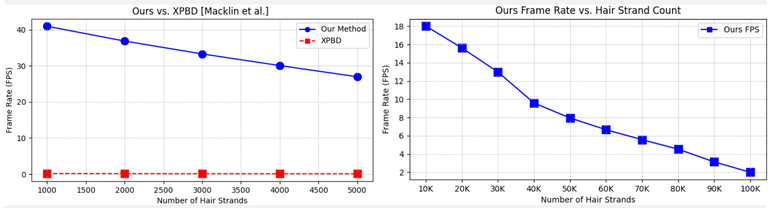
NEURAL INFORMATION PROCESSING SYSTEMS

Goal

Static hair Deformed hair Dynamic hair Novel view synthesis

Motivation

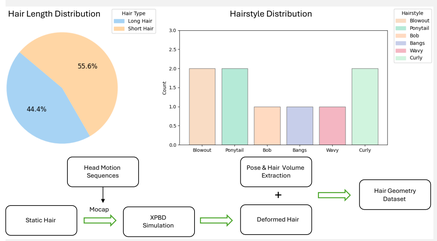
Can a photorealistic digital human truly feel alive if their hair never moves?



(1) **In the wild strand-level dynamic hair capturing is challenging.**
(2) **High complexity and poor generalization** due to intricate physical interactions across diverse hairstyles
(3) **Heavy computation** required for realistic simulation and rendering
(4) **Weak dynamic control** in NeRF/3DGS avatars, where hair motion is largely rigid with minimal non-rigid effects.

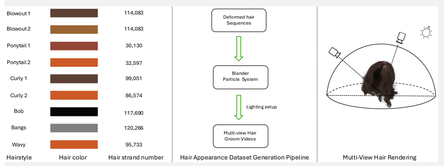
Dataset

How to create strand-level dynamic hair training data at scale?



Hair style and hair geometry simulation pipeline

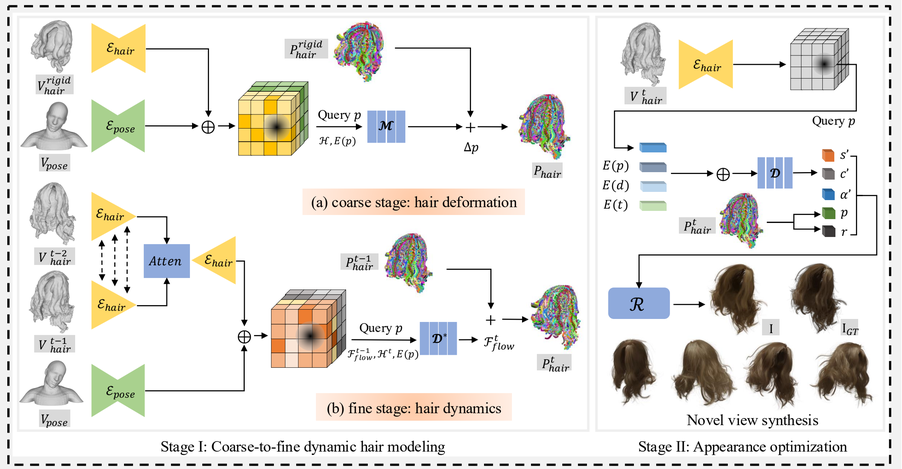
Hair geometry

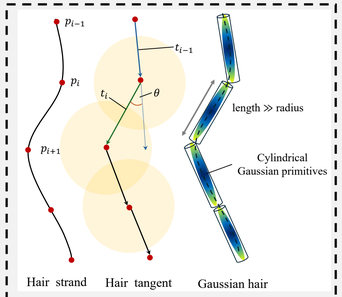


Hair appearance rendering pipeline

Hair appearance

Approach





Gaussian hair representation & Curvature blending

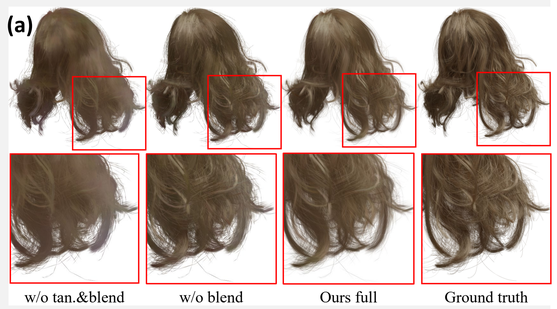
$$\mathbf{t}_i = \frac{\mathbf{p}_{i+1} - \mathbf{p}_i}{\|\mathbf{p}_{i+1} - \mathbf{p}_i\|}, \quad \kappa_i = \|\mathbf{t}_i - \mathbf{t}_{i-1}\|$$

$$\tilde{\kappa}_i = \frac{\kappa_i}{\kappa_{\max} + \epsilon}, \quad w_i = \tilde{\kappa}_i,$$

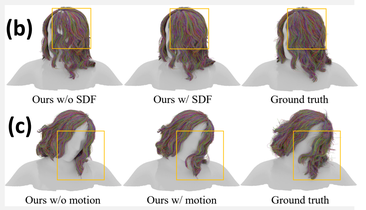
$$\mathrm{SH}_{\mathrm{blended},i} = \mathrm{SH}_i \cdot (1 - w_i) + \mathrm{SH}_{i-1} \cdot w_i$$

$$\alpha_{\mathrm{blended},i} = \alpha_i \cdot (1 - w_i) + \alpha_{i-1} \cdot w_i.$$

(1) Learning-based volumetric hair deformation
(2) Coarse-to-fine hair deformation dynamics
(3) Differentiable dynamic hair appearance optimization



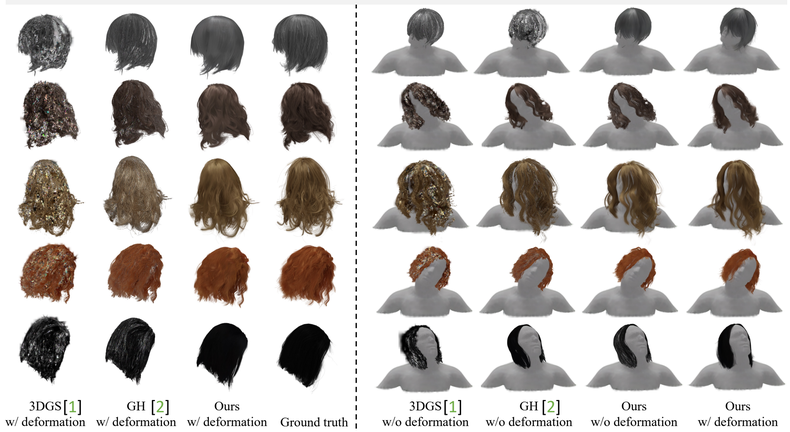
Ablations
(a) Hair curvature
(b) SDF Constraint
(c) Fine-Stage



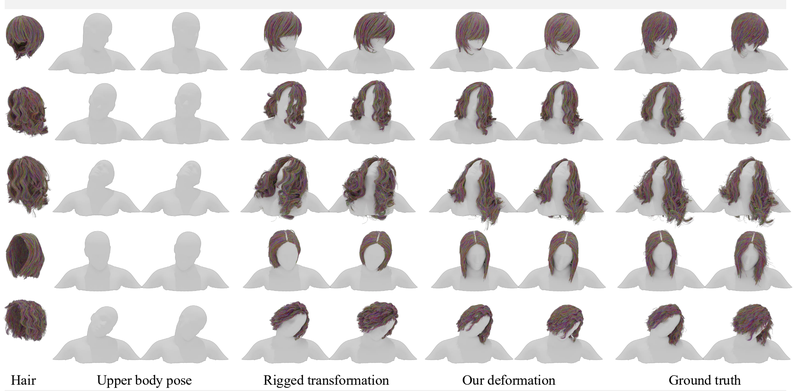
Evaluation

	Ours			Gaussian Haircut [2]			3D GS [1]		
Subject	**PSNR↑**	**SSIM↑**	**LPIPS↓**	**PSNR↑**	**SSIM↑**	**LPIPS↓**	**PSNR↑**	**SSIM↑**	**LPIPS↓**
Subject 1	28.026	0.906	0.101	23.248	0.873	0.101	20.747	0.852	0.132
Subject 2	24.817	0.820	0.169	20.921	0.791	0.180	19.972	0.772	0.215
Subject 3	24.987	0.744	0.227	20.960	0.742	0.236	19.972	0.687	0.287
Subject 4	27.534	0.955	0.071	24.181	0.906	0.078	20.246	0.894	0.101
Subject 5	29.681	0.933	0.069	26.053	0.924	0.058	23.605	0.906	0.083
Average	27.009	0.871	0.127	23.073	0.847	0.131	20.908	0.822	0.164

Results



Dynamic hair appearance comparison



Hair deformation comparison

Novel-view dynamic hair rendering driven by motion-capture data

Dynamic Gaussian hair integrated with multi-layer avatars

[1] *Kerbl, Bernhard, et al. "3D Gaussian splatting for real-time radiance field rendering." ACM Trans. Graph. 42.4 (2023): 139-1.*
[2] *Zakharov, Egor, et al. "Human hair reconstruction with strand-aligned 3d gaussians." ECCV 2024*