KAIST [1] ETH zürich [2]

SurFhead

Affine Rig Blending for Geometrically Accurate 2D Gaussian Surfel Head Avatars

ICLR 2025

Jaeseong Lee[1*] Taewoong Kang[1*] Marcel C. Bühler[2] Min-Jung Kim[1]
Sungwon Hwang[1] Junha Hyung[1] Hyojin Jang[1] Jaegul Choo[1]

* Indicates equal contribution

summertight.github.io/SurFhead

ICLR
International Conference On Learning Representations

Teaser

Geometrical Head Avatars

High Fidelity Normals & Depths

Geometrical Head Avatars

1 Relighting

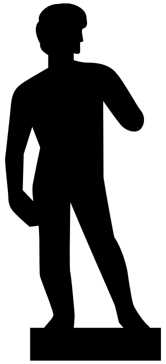
High Fidelity Normals & Depths

Geometrical Head Avatars

High Fidelity Normals & Depths

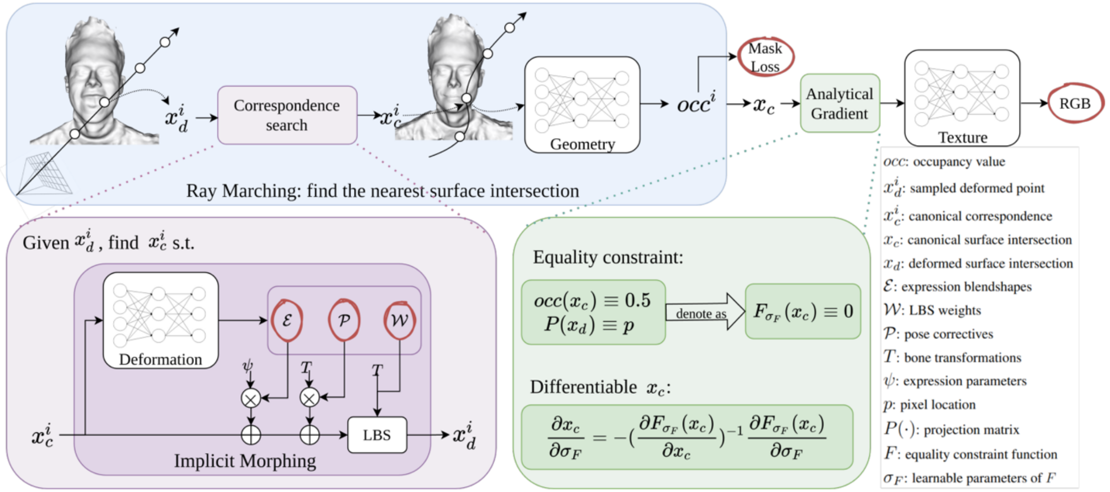
1 Relighting

2 Meshing

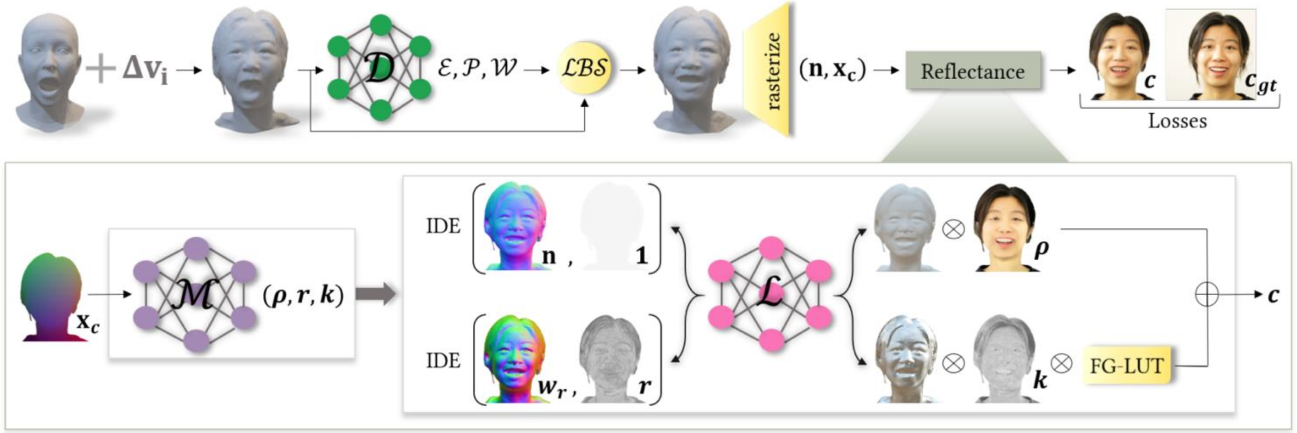


Geometrical Head Avatars – Previous art

IMAvatar (Zheng et al., CVPR 2022)



FLARE (Bharadwaj et al., TOG 2023)



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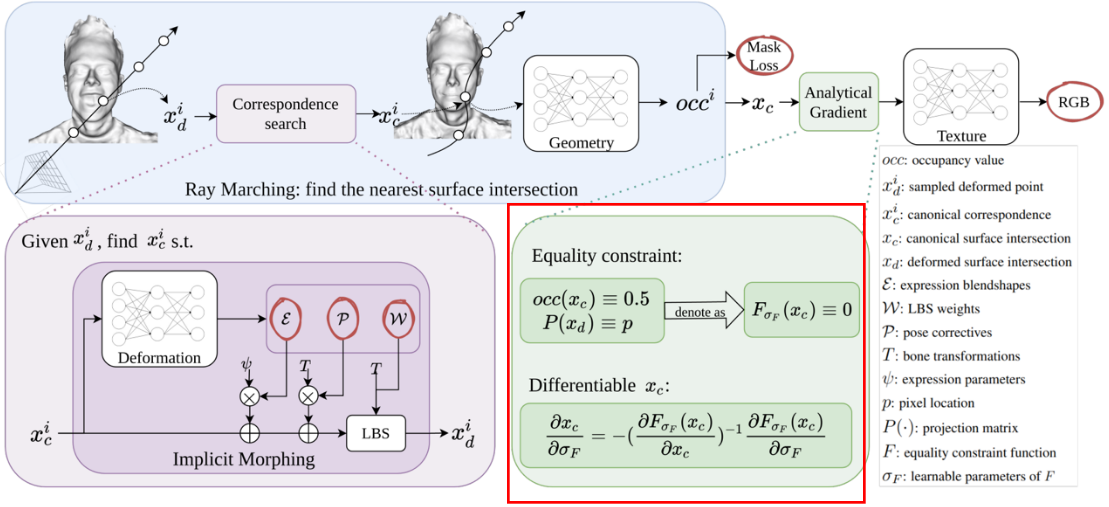

Exhaustive Numerical Surface Search

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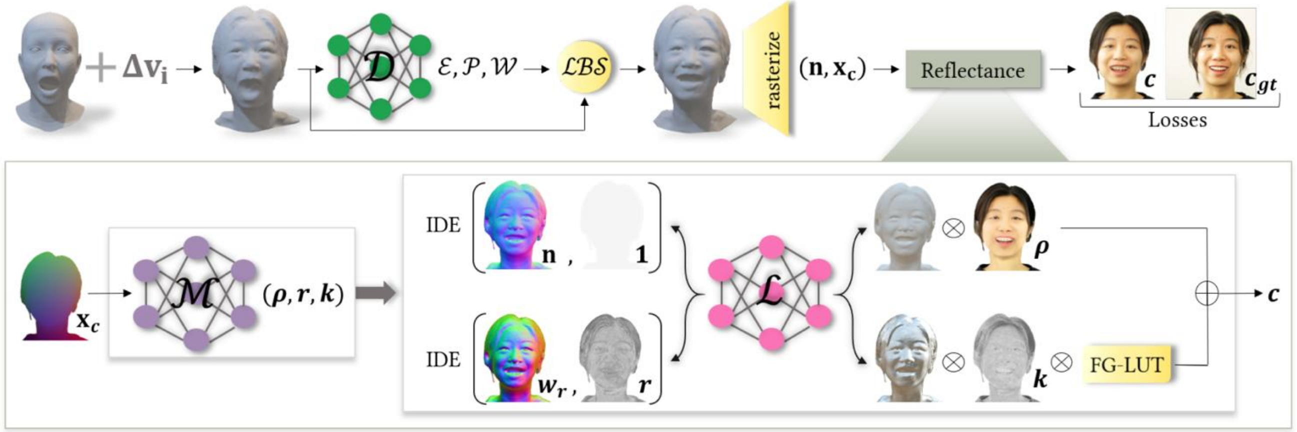

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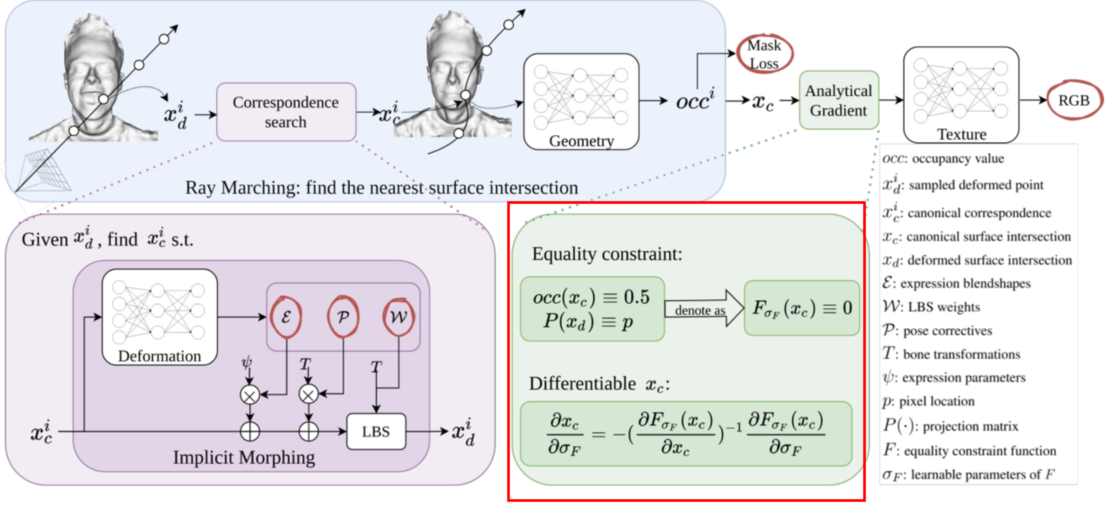

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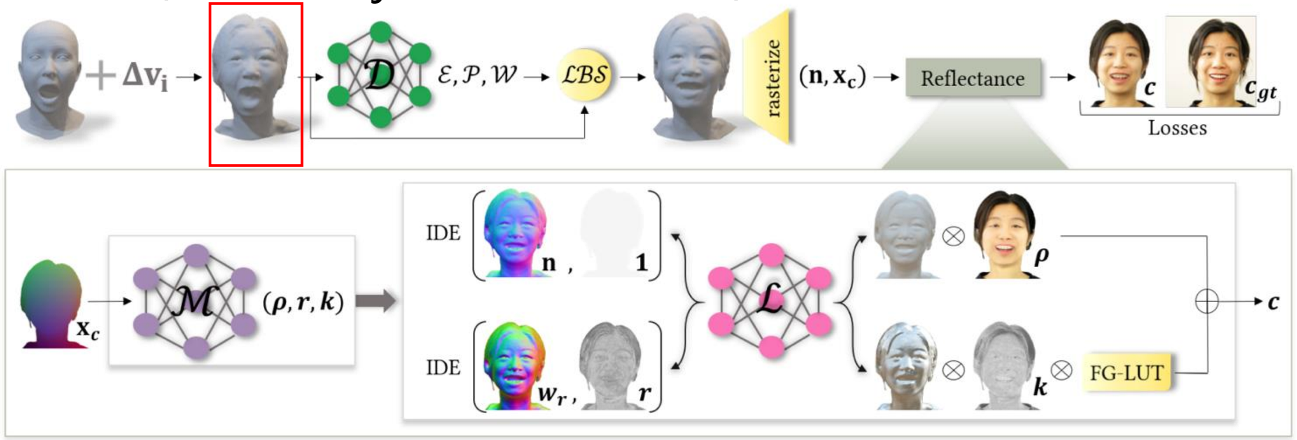


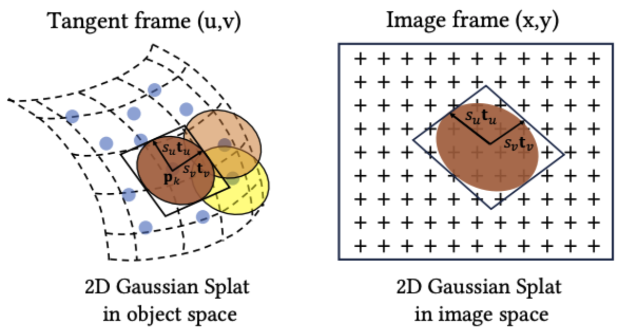
Unstable Training-time Remeshing

How to design ‘geometrical’ & ‘dynamic’ **Gaussian** head avatars?

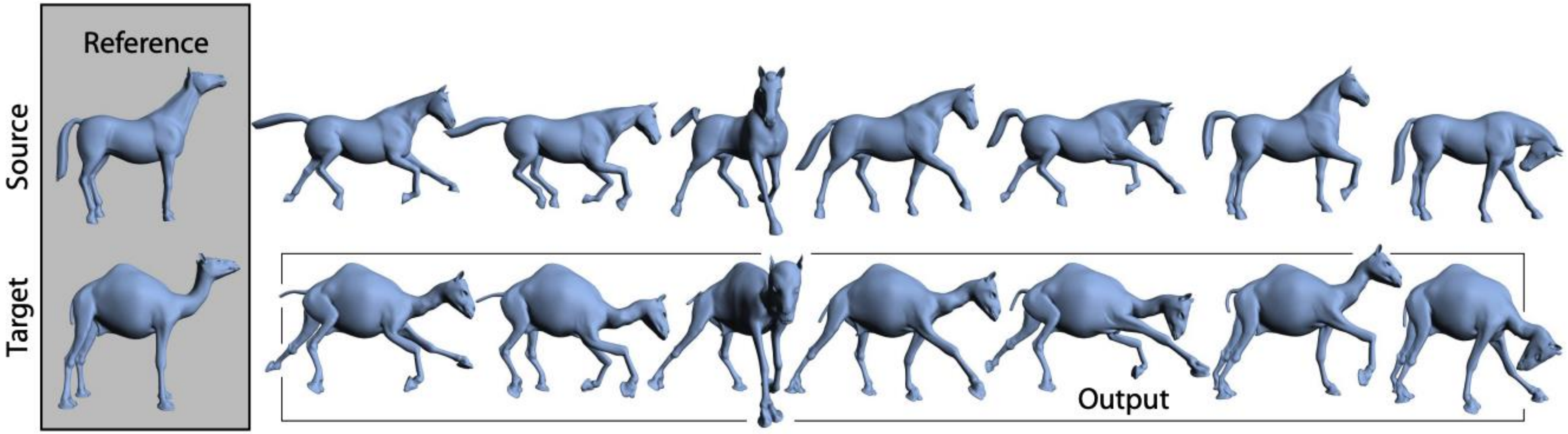
3DGS (Kerbl et al., SIGGRAPH 2023)

How to design ‘geometrical’ & ‘**dynamic**’ Gaussian head avatars?

To achieve accurate normal and depth**, we utilize 2D surfels**
Also accurate rigging states, inspired by DTF**, rigging Gaussians with Jacobian gradients.**



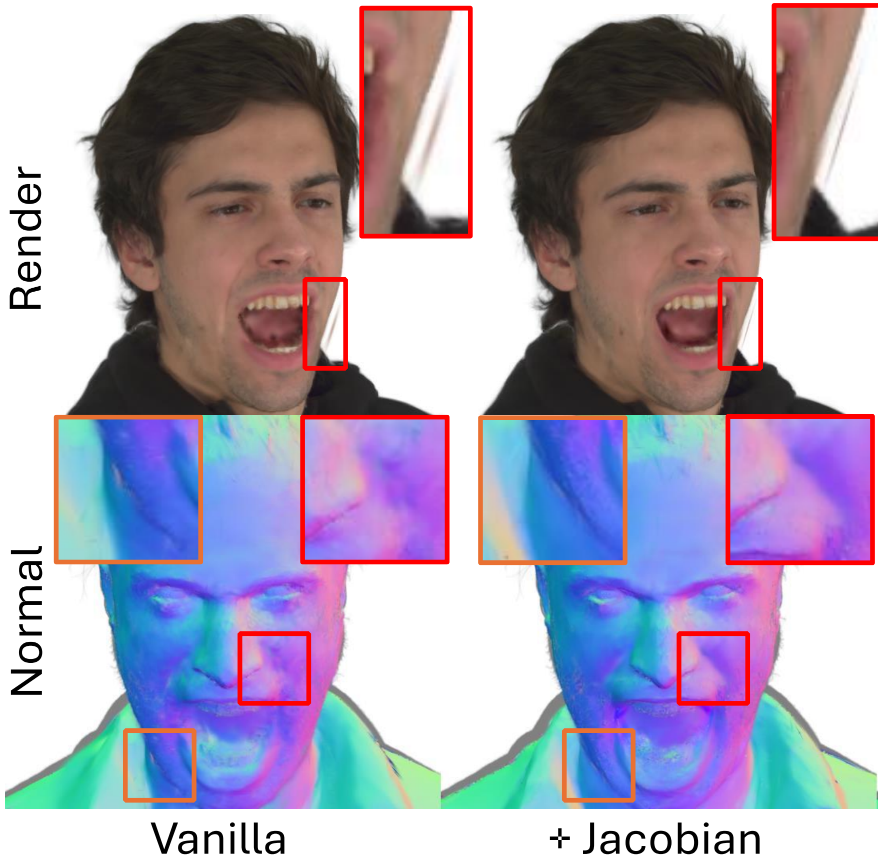
2DGS (SIGGRAPH 2024, Huang et al.)



DTF (SIGGRAPH 2000, Sumner and Popovic)

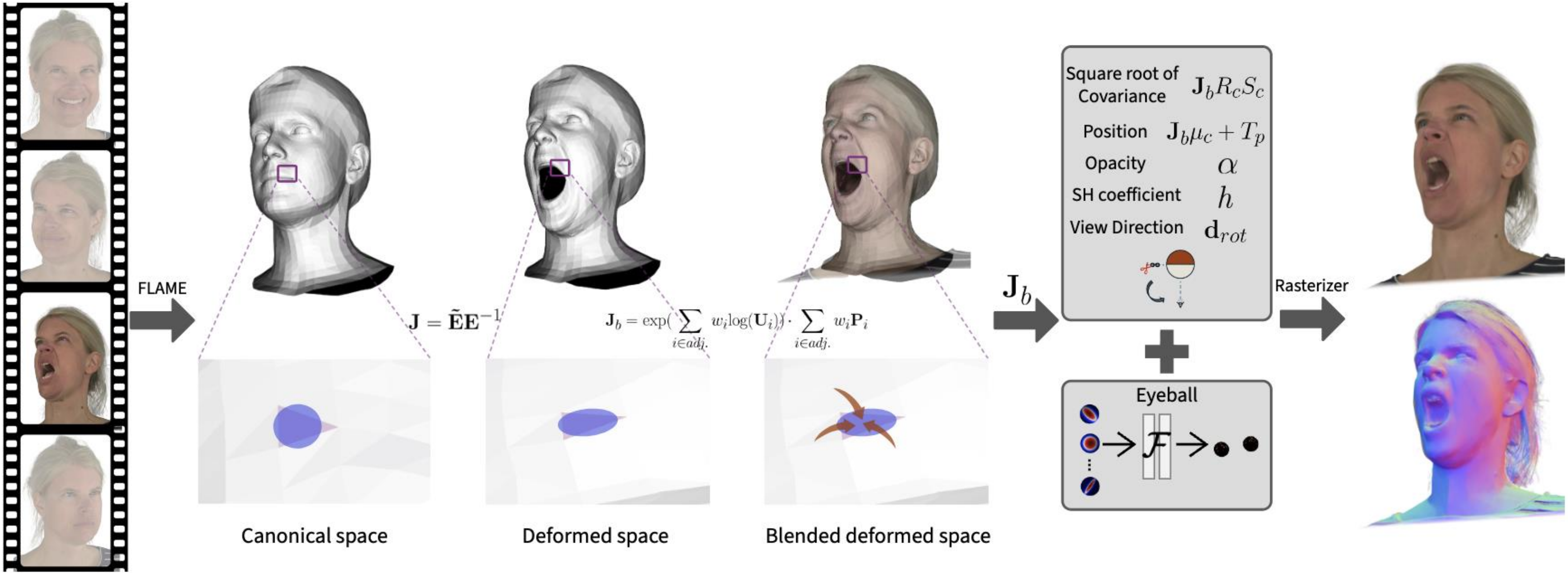
However,

Only using 2DGS and Jacobian Gradients lead to **floating artefacts** and **ambiguous normal.**



To handle these,

We propose Jacobian Blend Skinning (JBS).



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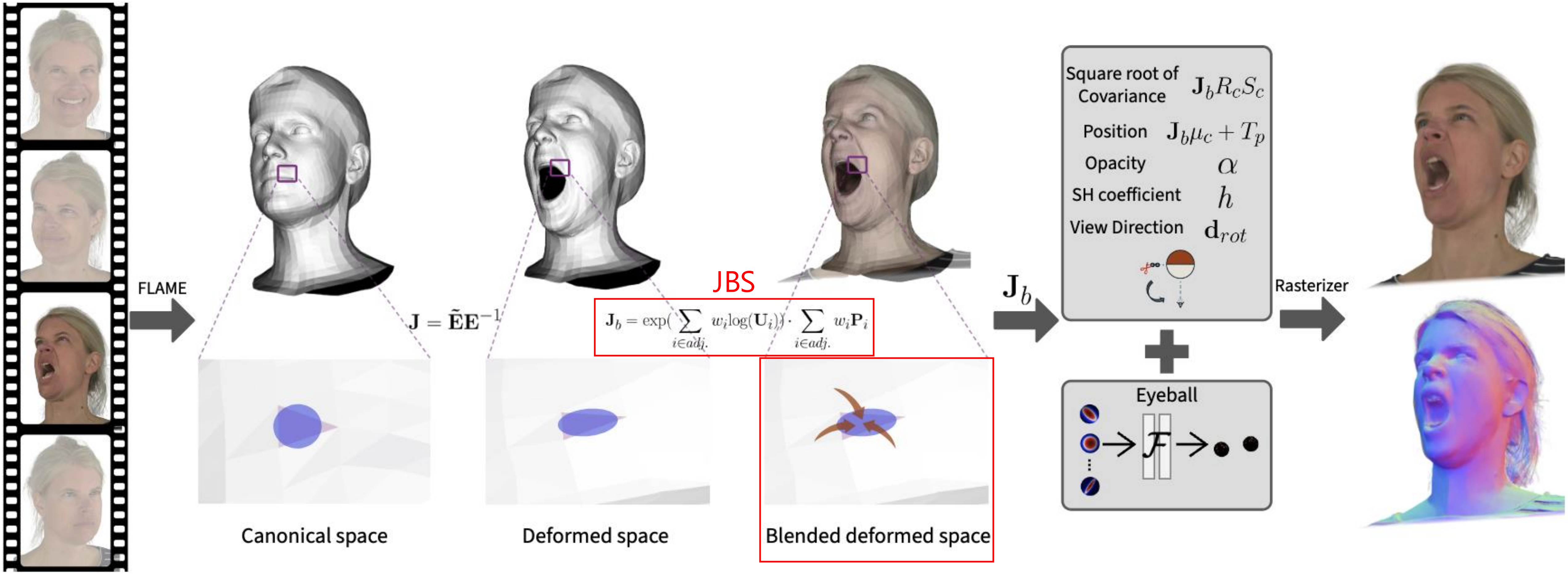
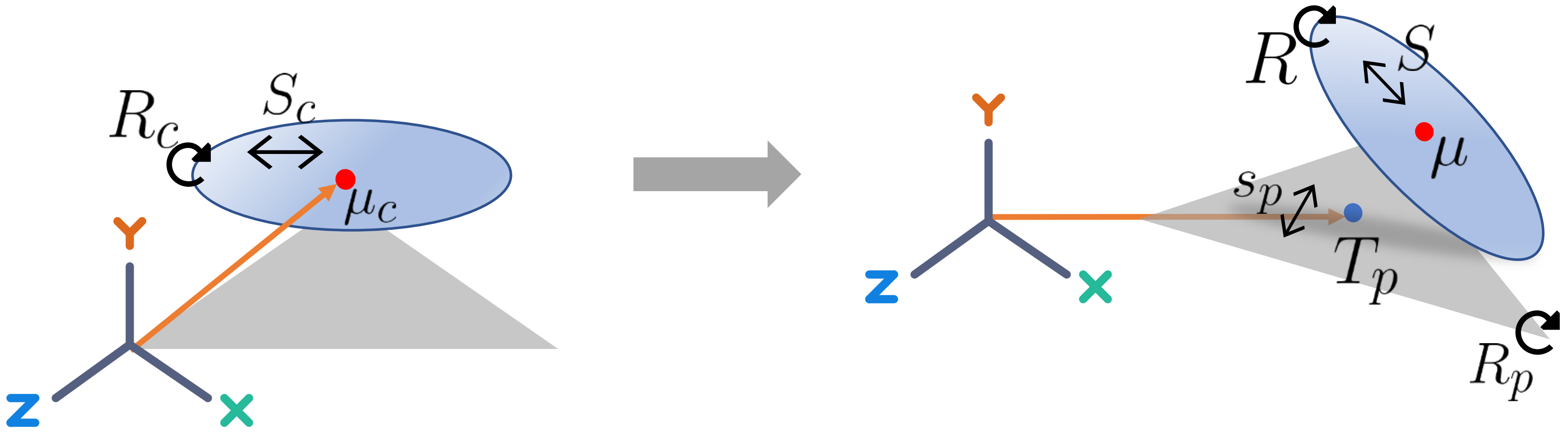


Mesh Binding Inheritance

We follow 3DMFM binding inheritance strategy of GaussianAvatars (CVPR 2024, Qian et al.)

$$R = R_p R_c, \mu = s_p R_p \mu_c + T_p, S = s_p S_c$$



Canonical
Local Space

Deformed
Metric Space

Similarity to Jacobian Transforms

Following DTF, we replace the GaussianAvatars' similarity transforms to Jacobian transforms.

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$$\Leftrightarrow$$

$$\Sigma^{1/2} = s_p R_p R_c S_c$$

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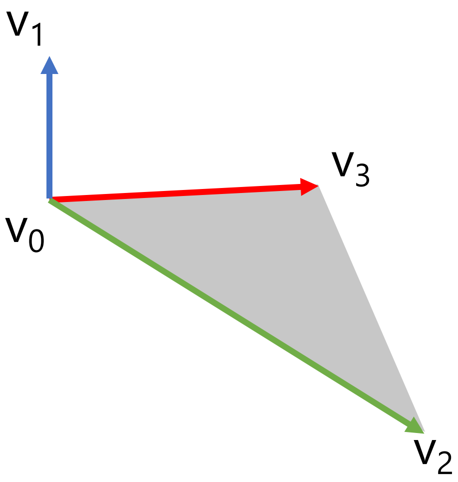
$$\Sigma^{1/2} = \boxed{s_p R_p} R_c S_c$$

$$\Sigma^{1/2} = \boxed{J} R_c S_c$$

Jacobian Deformation Transfer

Jacobian can represent stretch and shear transforms unlike similarity transforms.



$E = [v_1 - v_0, v_2 - v_0, v_3 - v_0]$

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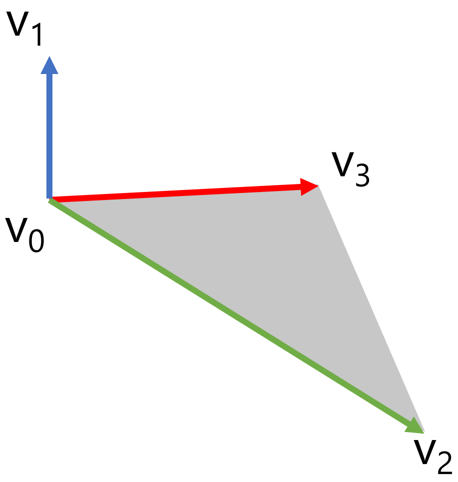

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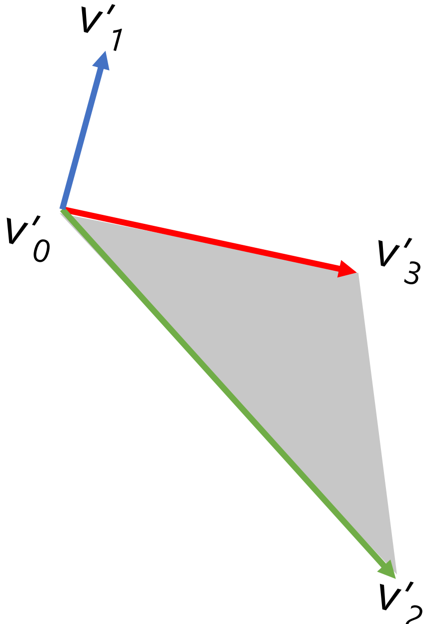

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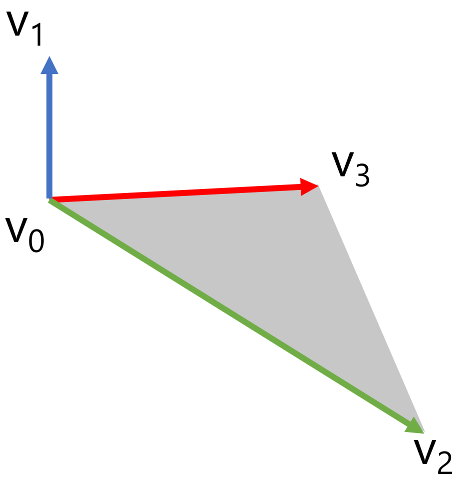

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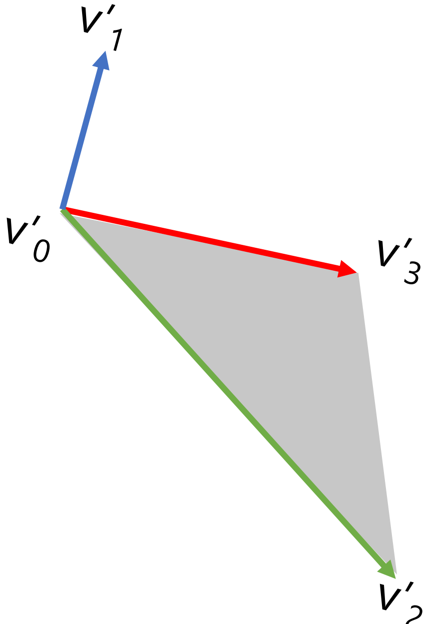

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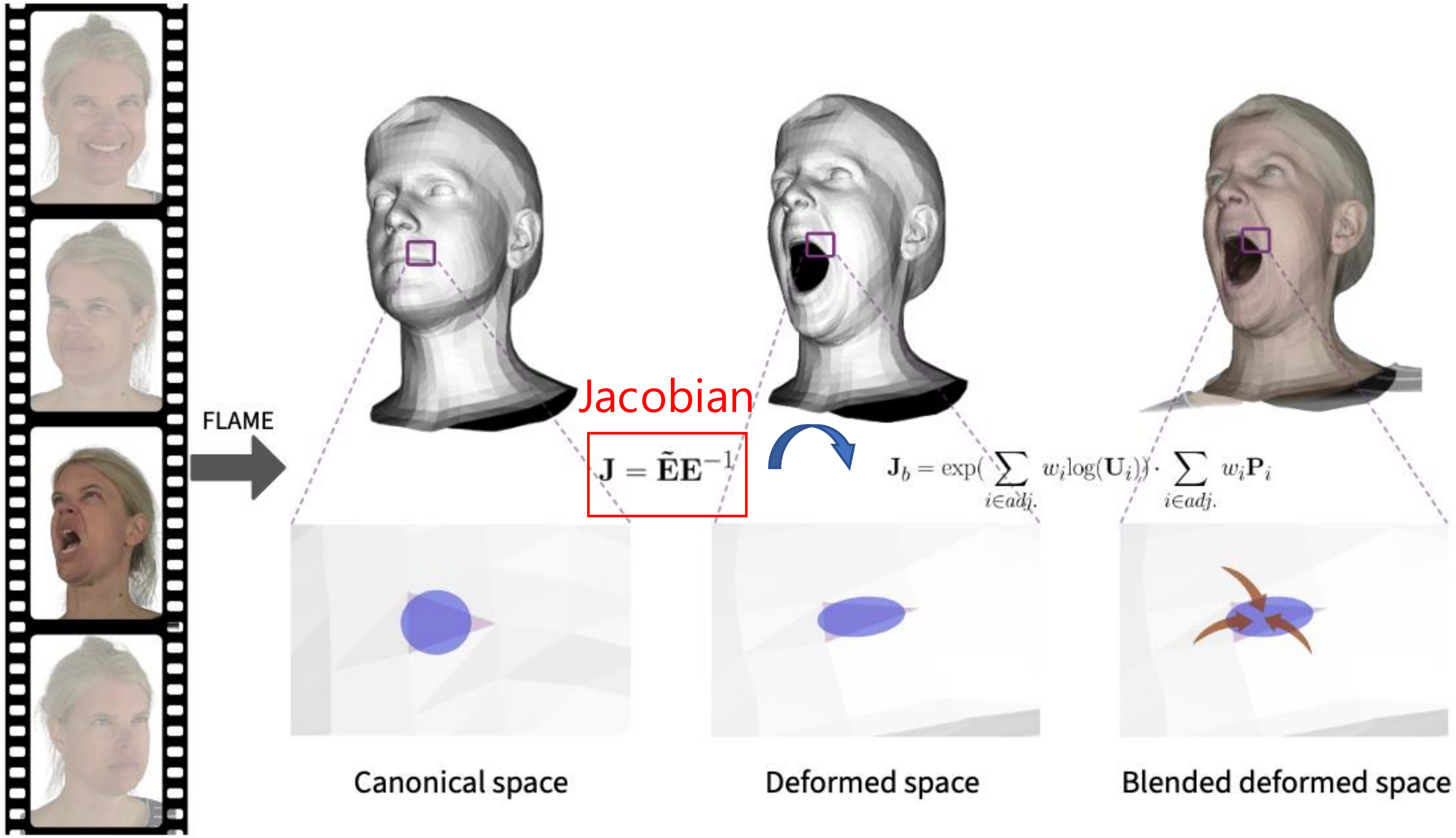
Deformed
Metric Space

$$J = E'E^{-1}$$

DTF (SIGGRAPH 2000, Sumner and Popovic.)

Jacobian to JBS

We replace again it with our JBS, blending Jacobians with adjacent transforms.



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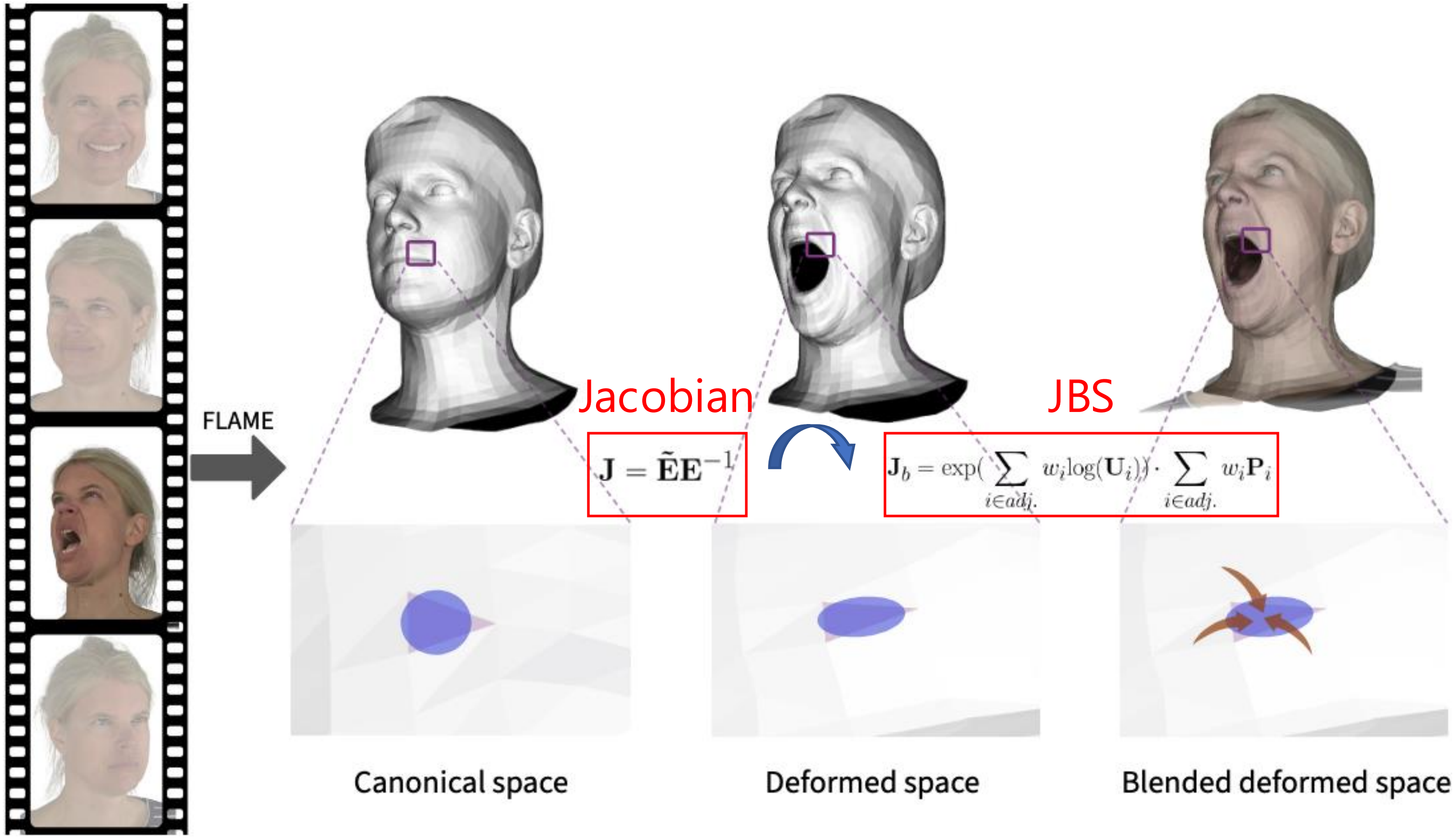

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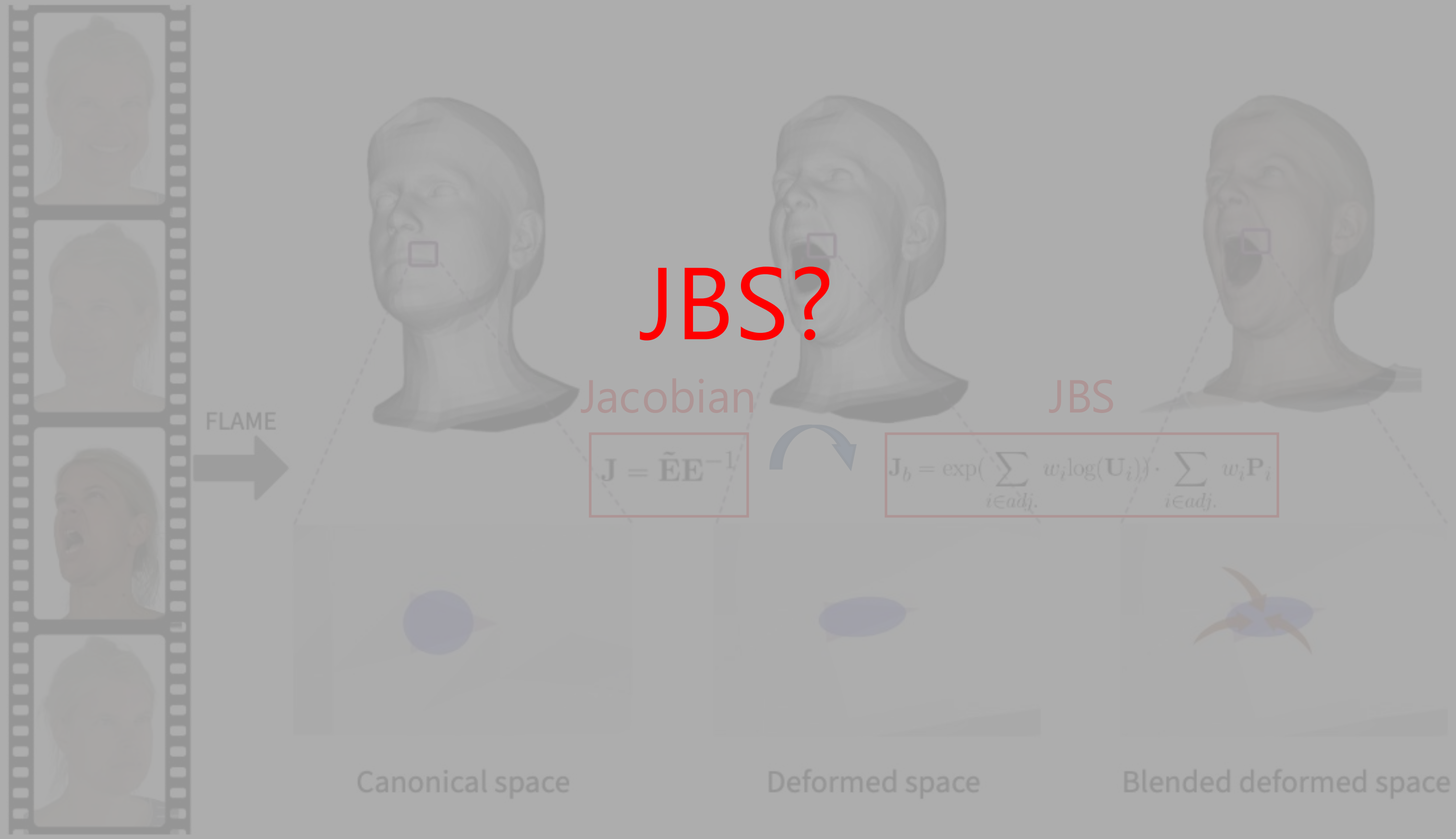

Let’s delve into JBS step-by-step

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$$\mathbf{J}_b := \mathrm{JBS}(\mathbf{J}, w) = \underbrace{\exp(\sum_{i \in adj.} w_i \log(\mathbf{U}_i))}_{\mathbf{U}_b} \cdot \underbrace{\sum_{i \in adj.} w_i \mathbf{P}_i}_{\mathbf{P}_b}$$

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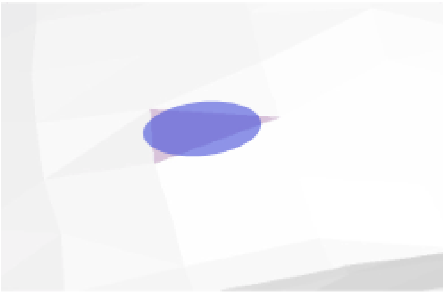
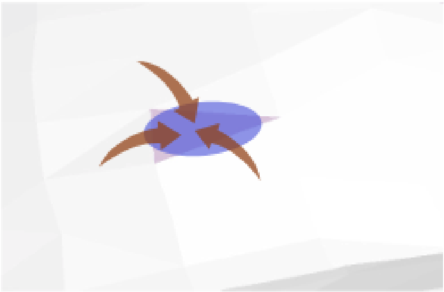


Deformed space



Blended deformed space

Let's delve into JBS step-by-step

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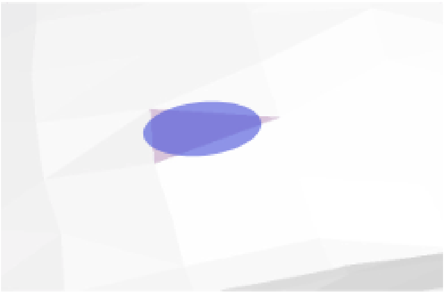
In matrix-logarithm space

$$\mathbf{J}_b := \mathrm{JBS}(\mathbf{J}, w) = \underbrace{\exp\left(\boxed{\sum_{i \in adj.} w_i \log(\mathbf{U}_i)}\right)}_{\mathbf{U}_b} \cdot \underbrace{\sum_{i \in adj.} w_i \mathbf{P}_i}_{\mathbf{P}_b}$$



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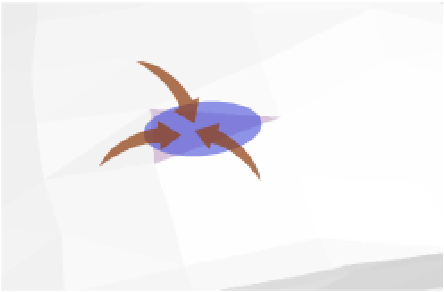

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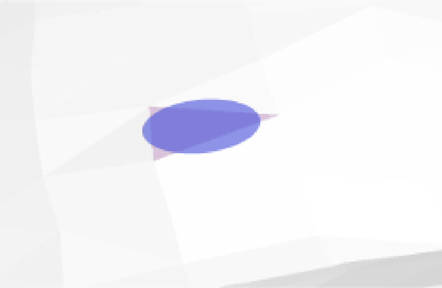

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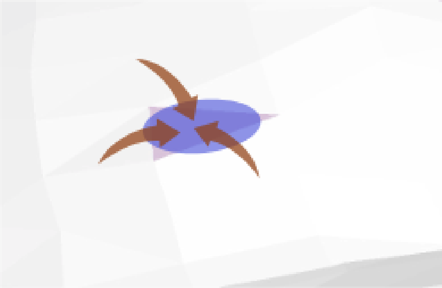

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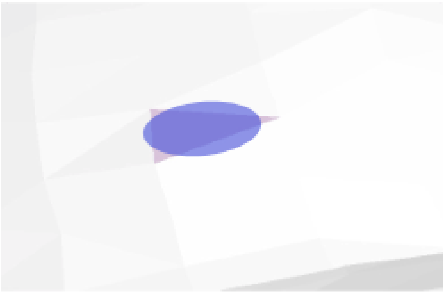

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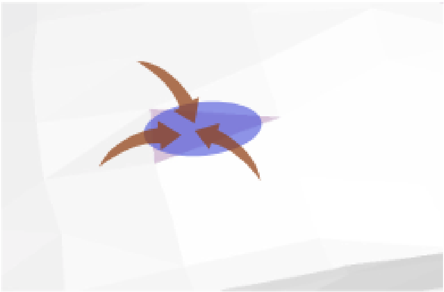

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Let’s delve into JBS step-by-step

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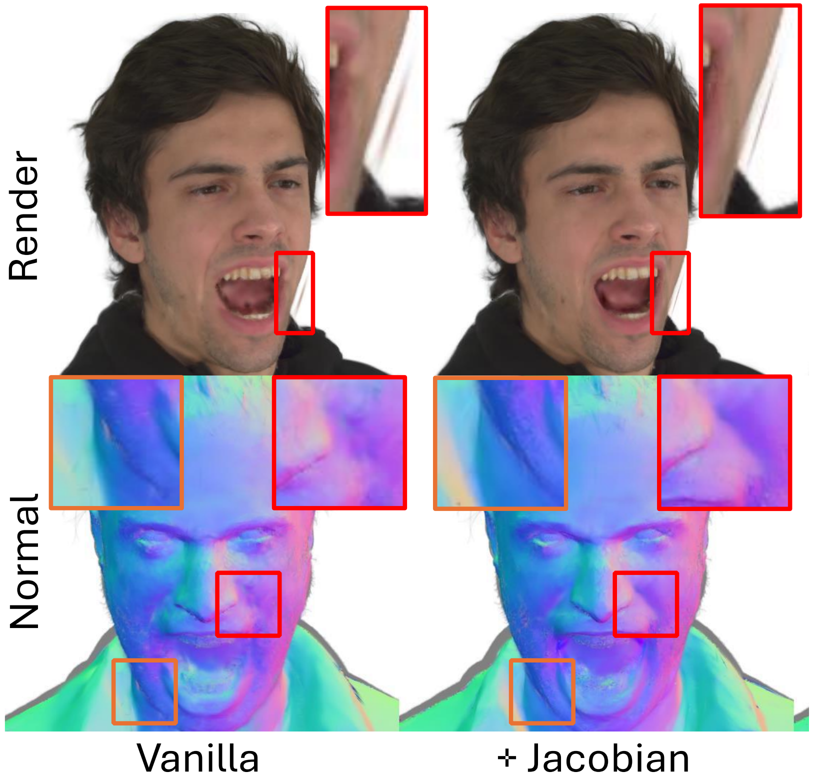
$$\Downarrow$$

$$\Sigma^{1/2} = \boxed{J_b} R_c S_c \qquad \mu = \boxed{J_b} \mu_c + T_p$$

Finally



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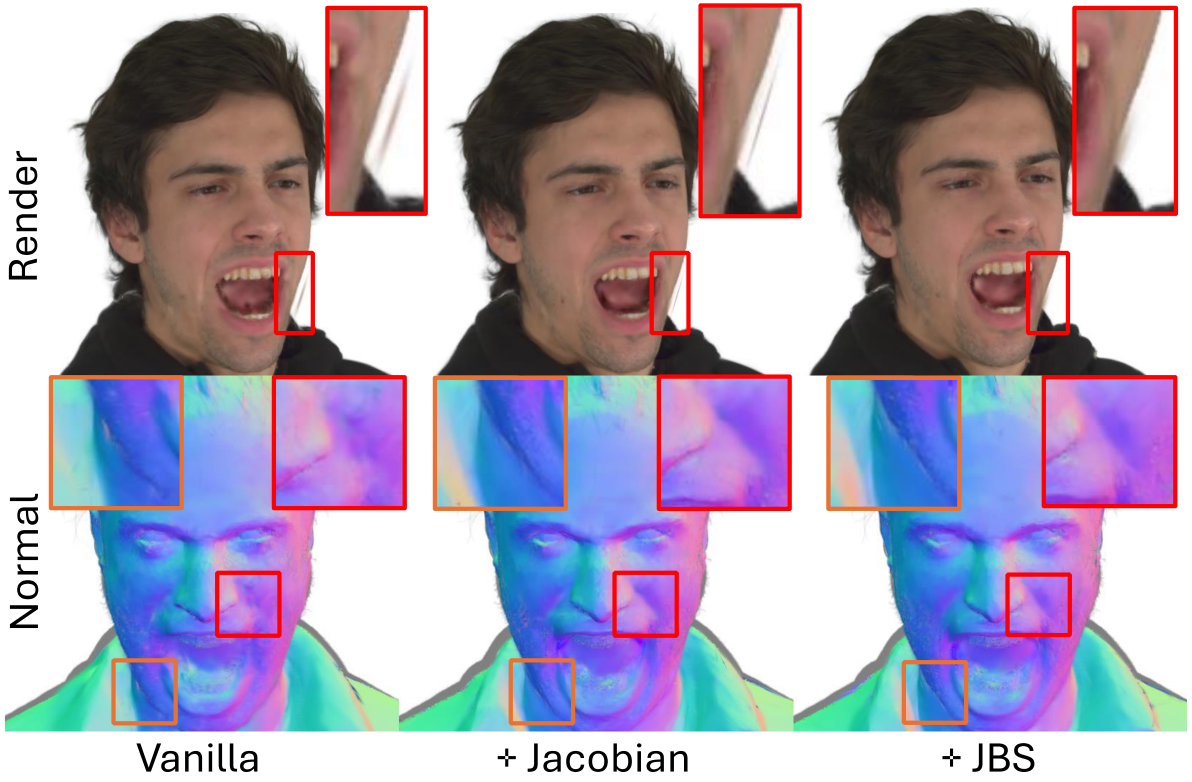

Resolving hollow-illusion

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Stop Gradient

Rotation R
Position μ

$+$

$$\mathcal{L}_{\text{eye}} = \sum_{i \in E} (1 - \alpha_i)^2$$

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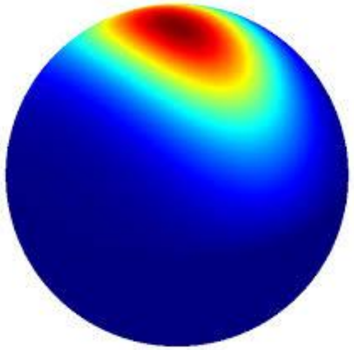
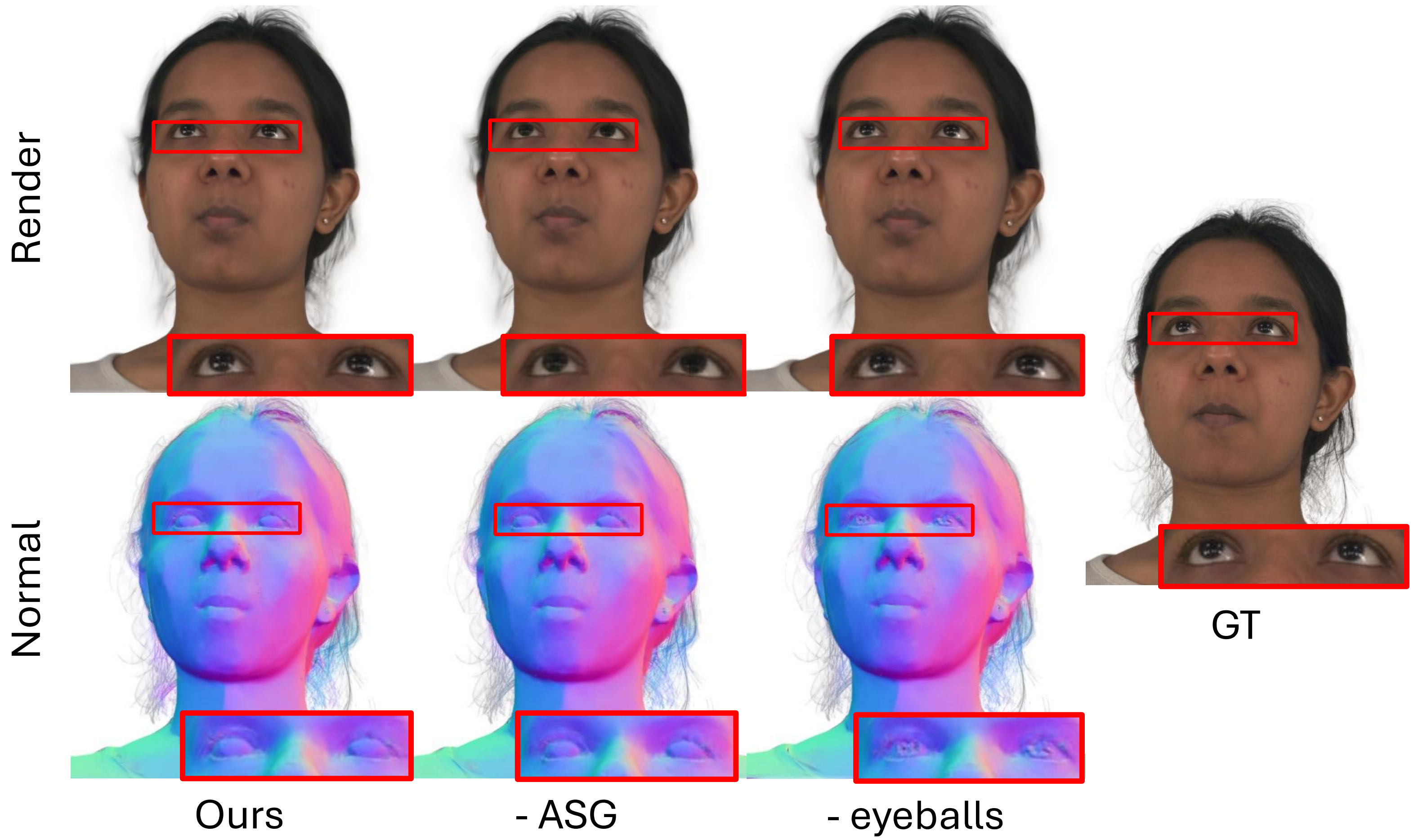
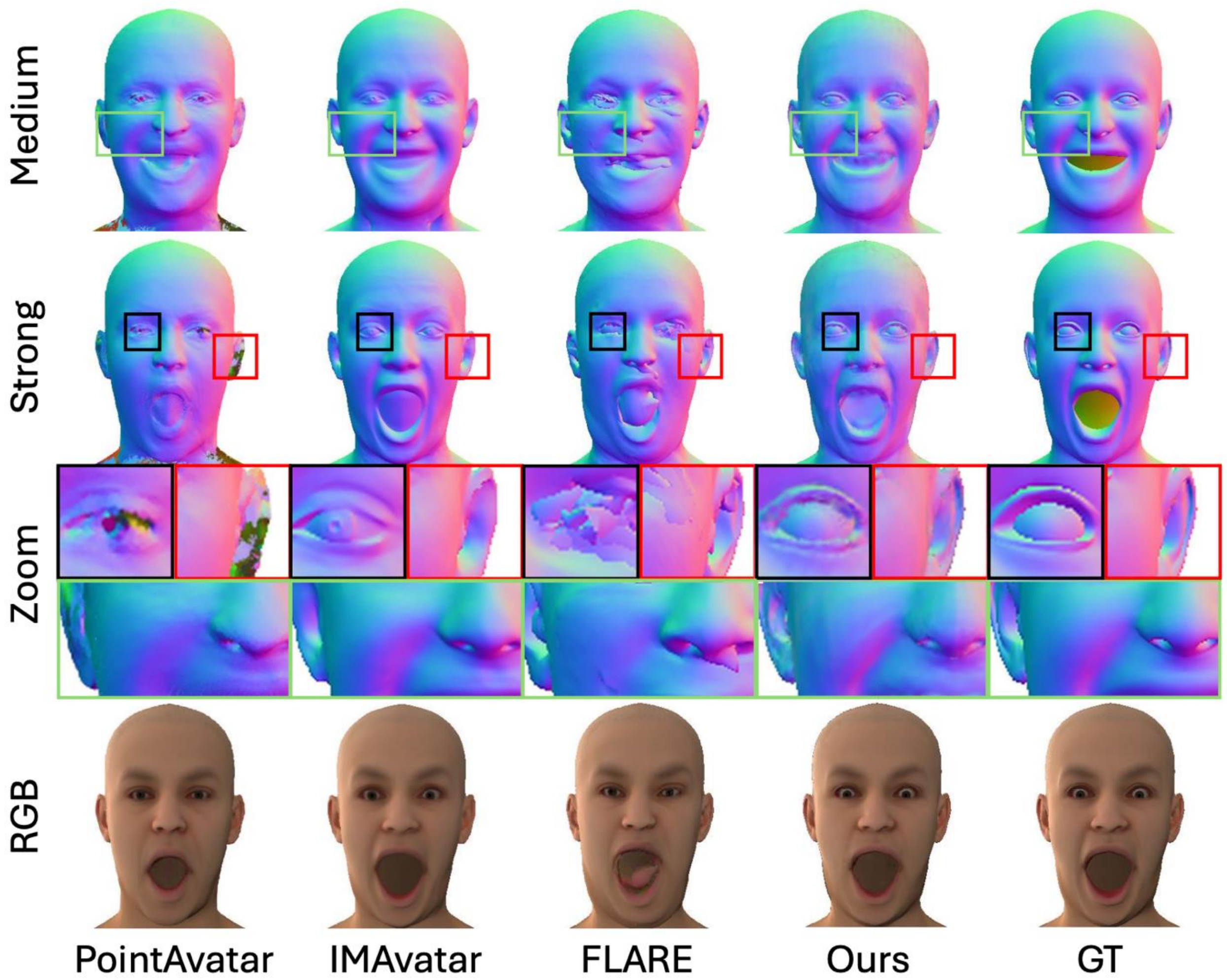


ASG (TOG 2013, Xu et al.)

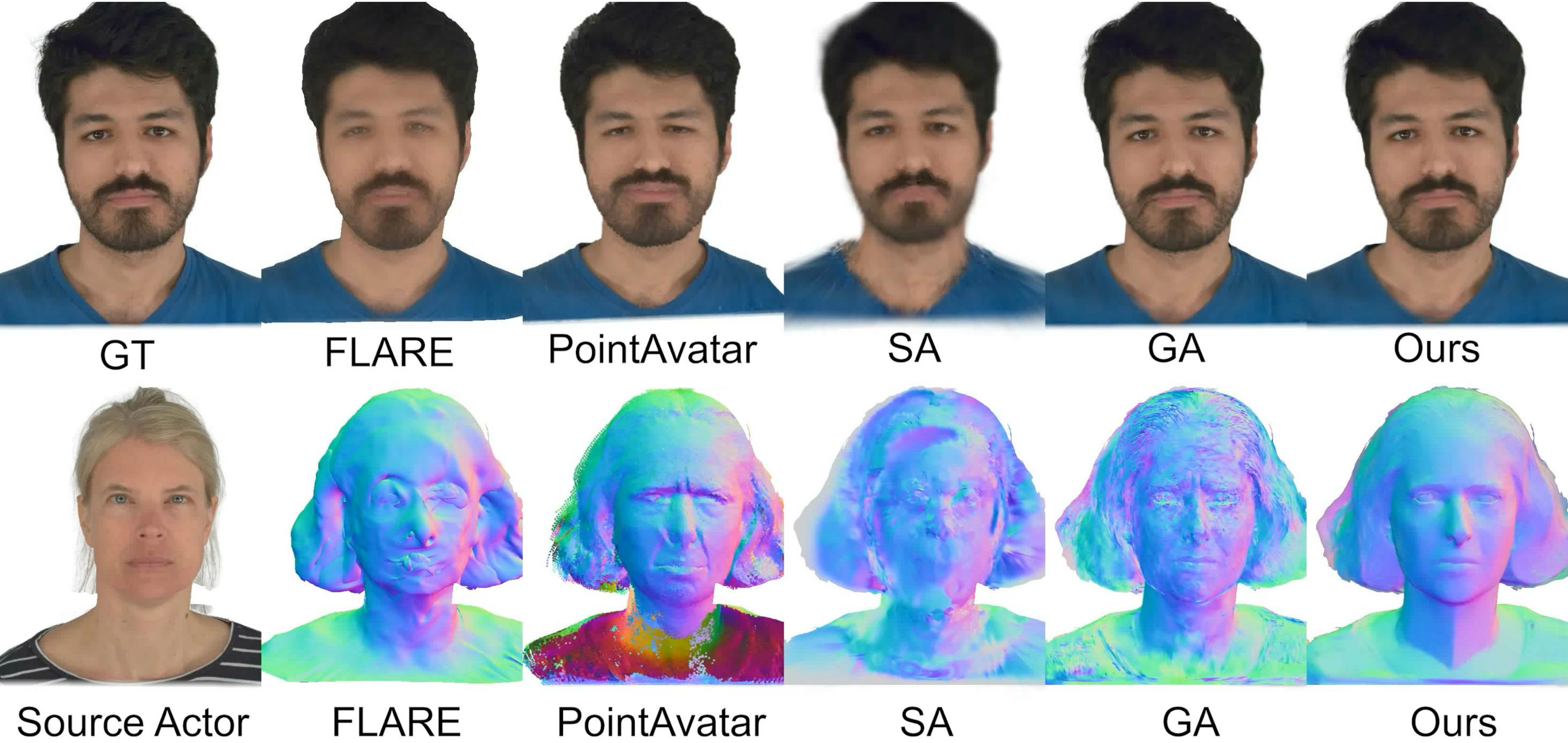
Resolving hollow-illusion



Comparison on FaceTalk (CVPR 2023, Zheng et al.)



Comparison on NeRSemble (SIGGRAPH 2023, Kirschstein et al.)



Application #1 **Relighting**
using GaussianShader (CVPR 2024, Jiang et al.)

Application #2 **Meshing**
using Truncated Signed Distance Function (TSDF)

Thank you for watching!

For more details visit summertight.github.io/SurFhead