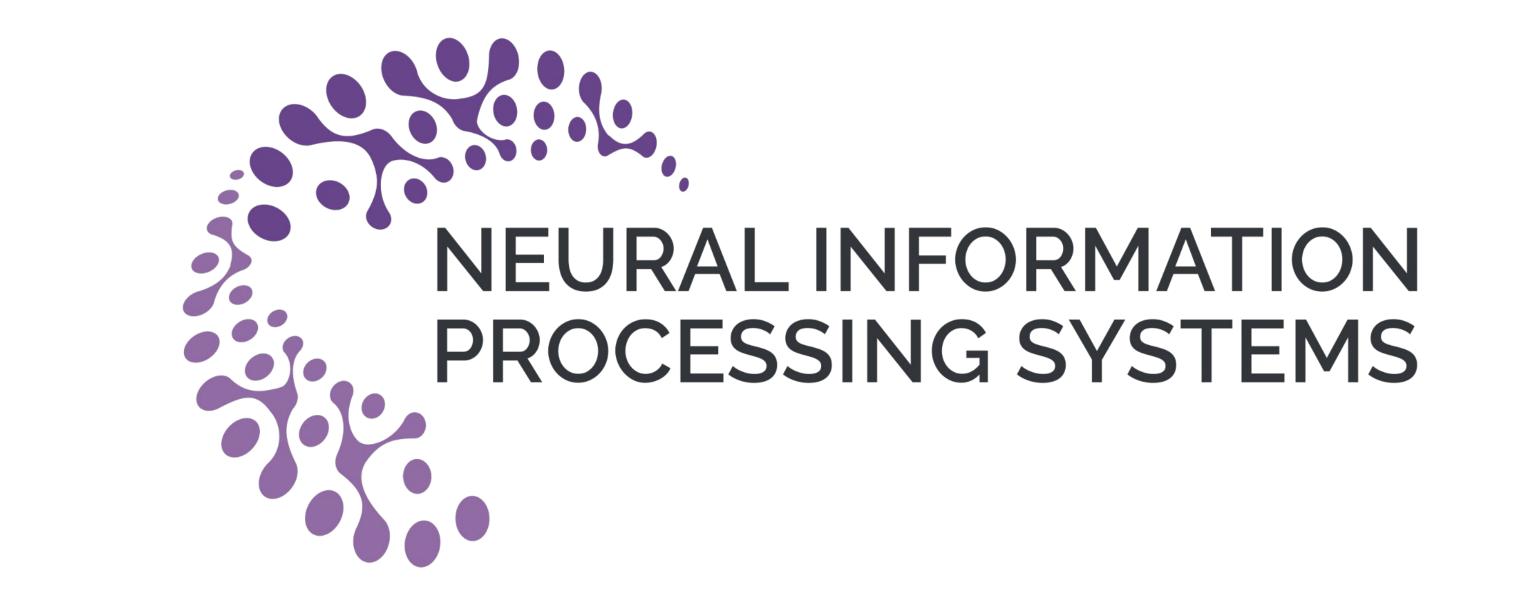# FLOWING 🏄: Implicit Neural Flows for Structure-Preserving Morphing

Arthur Bizzi, Matias Grynberg, Vitor Matias, Daniel Perazzo, João Paulo Lima,
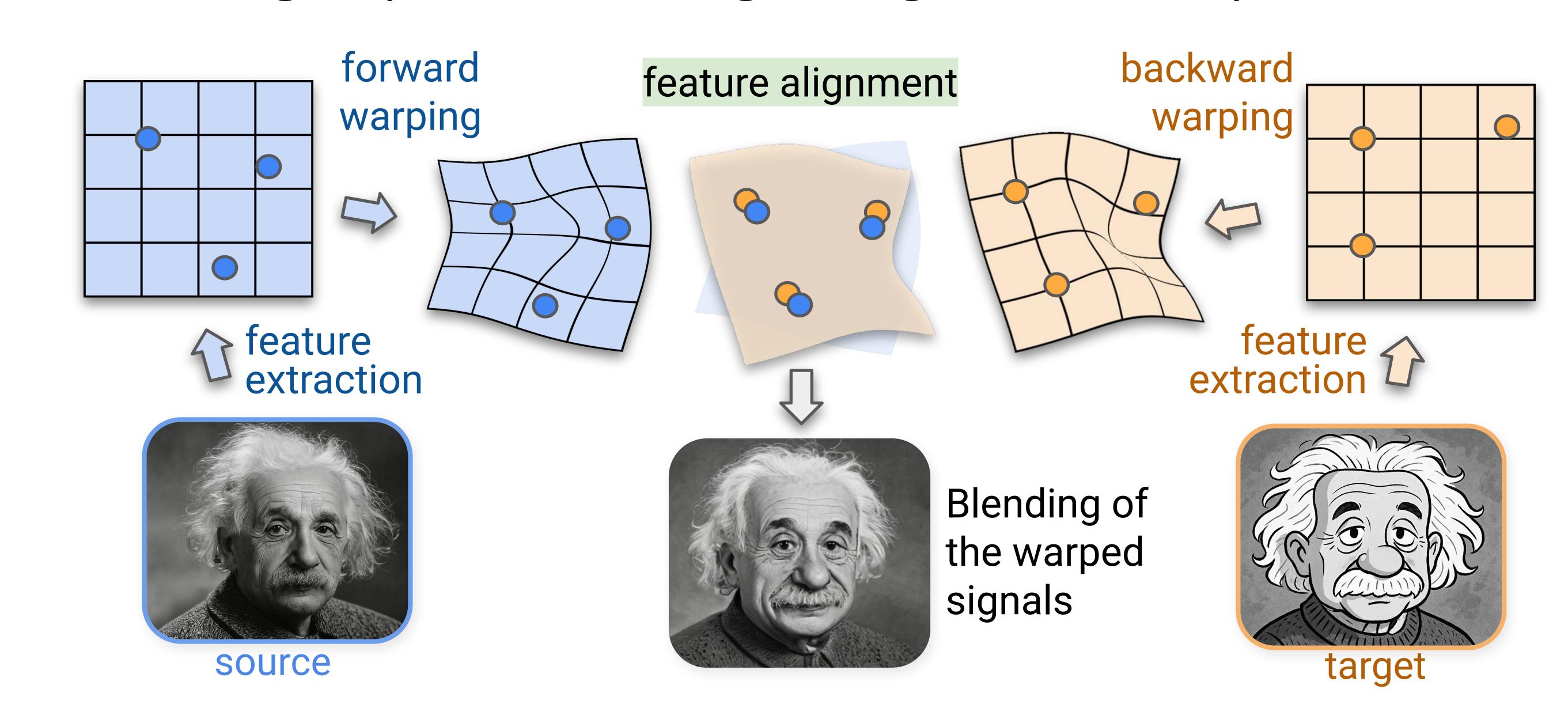Luiz Velho, Nuno Gonçalves, João Pereira, Guilherme Schardong, Tiago Novello

code

NEURAL INFORMATION PROCESSING SYSTEMS

Overview

Morphing consists of interpolating between signals while preserving structure and semantics.
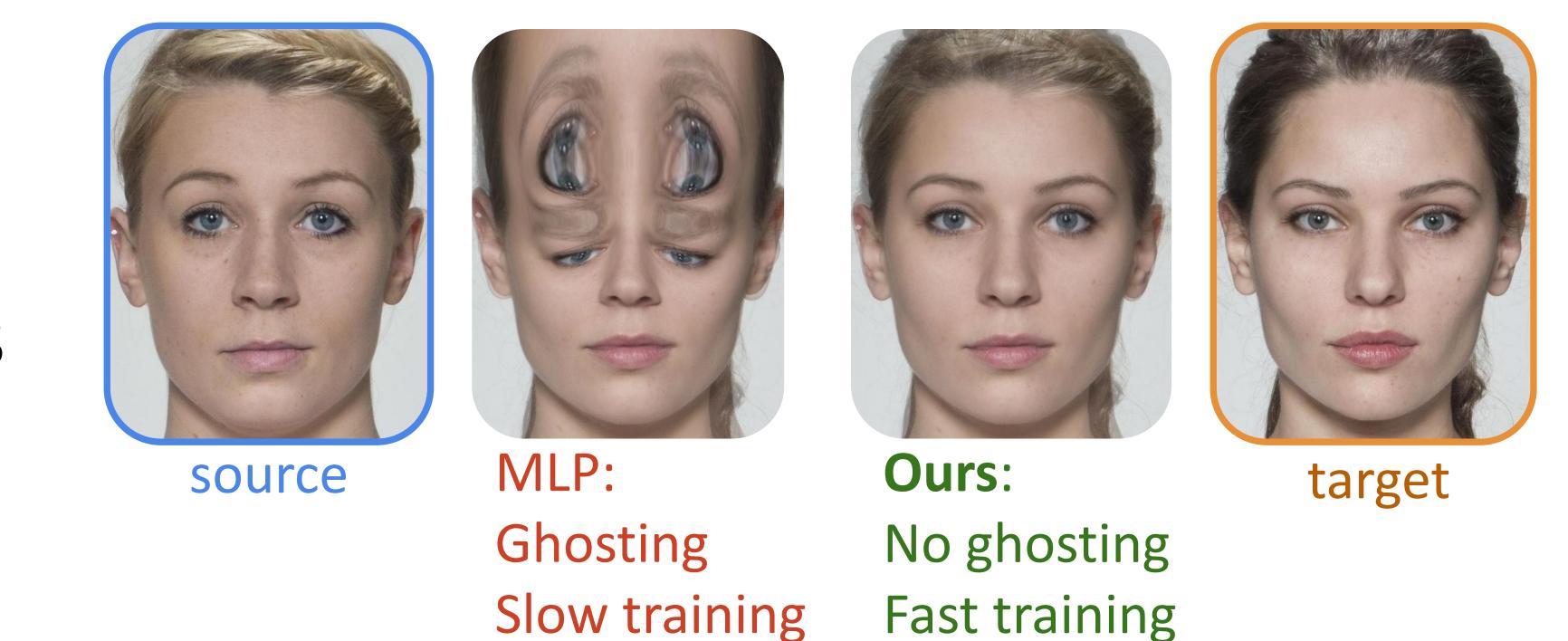

source ↔ target

It requires:
- A time-dependent flow-like **warping** to align features, and
- A **blending** step to mix the aligned signals smoothly.

forward warping — feature alignment — backward warping

feature extraction ← source

feature extraction ← target

Blending of the warped signals

Problem: Traditional MLP warpings require heavy regularization to learn flows, leading to **ghosting** artifacts and **slow**, unstable training.

source | MLP: Ghosting Slow training | **Ours:** No ghosting Fast training | target
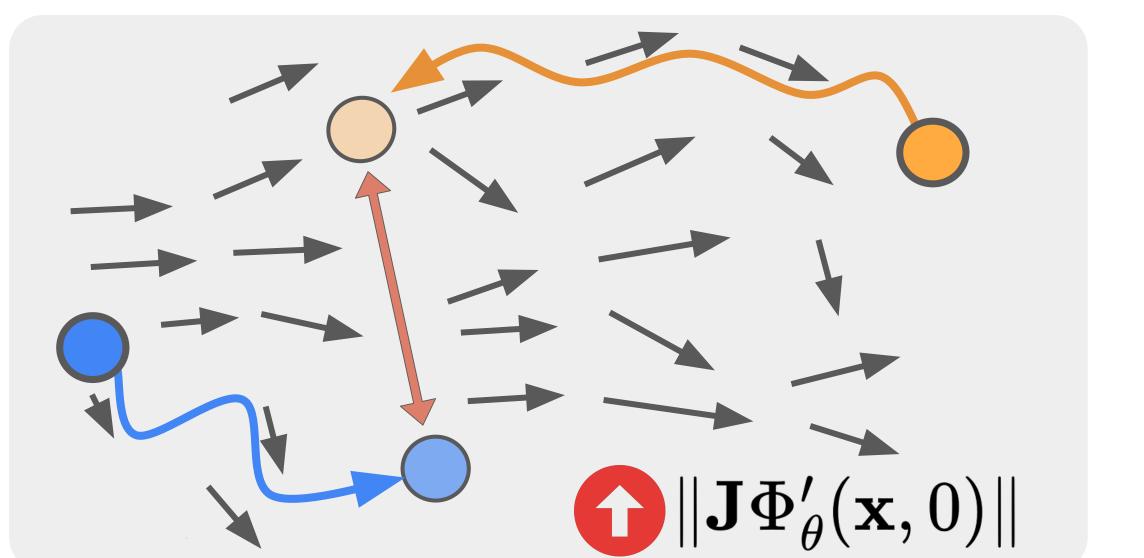
Key contributions:
- Flow-based neural network for structure-preserving warpings that train in seconds.
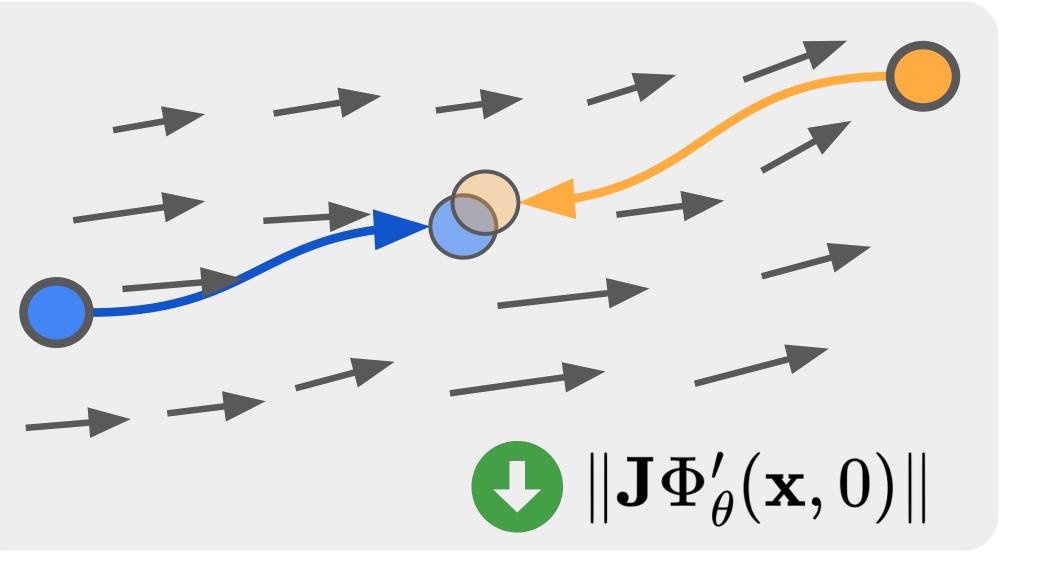- A Gaussian Splatting (3DGS) morphing using union-based blending.

FLOWING

FLOWING formulates warping as a flow operator:

$$\arg\min_\theta \|\mathbf{J}\Phi'_\theta(\mathbf{x},0)\|_2^2 \quad \text{subject to} \quad \Phi_\theta(\,p_i^0\,,t)=\Phi_\theta(\,p_i^1\,,t-1)$$

Flow-based INRs (Neural ODEs and Neural Conjugate Flows) enforce architectural priors that produce fast training and stable feature alignment.
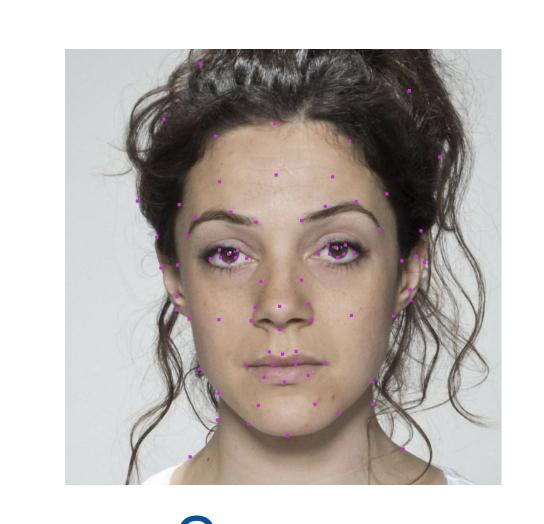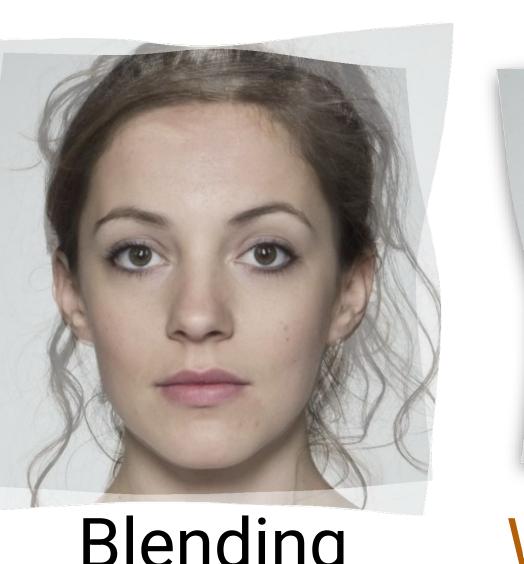

At initialization **forward**/**backward** paths are misaligned and vector field is noisy. $\uparrow\|\mathbf{J}\Phi'_\theta(\mathbf{x},0)\|$

During training, the loss aligns features and minimizes deformation. $\downarrow\|\mathbf{J}\Phi'_\theta(\mathbf{x},0)\|$

Blending: After warping, signals can be blended via linear interpolation or with a generative model (e.g. DiffMorpher).
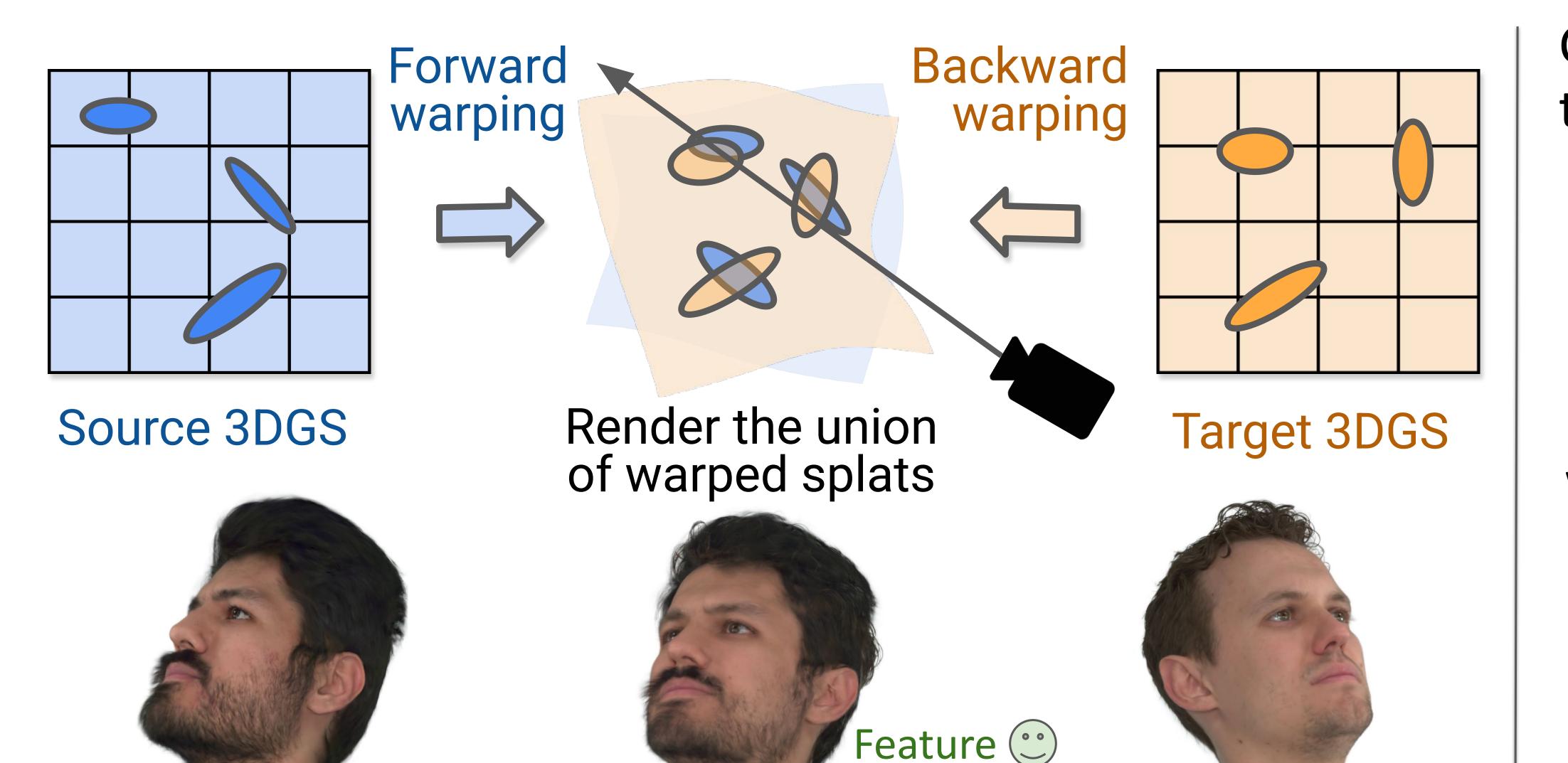

Source | Warped source | Blending | Warped target | Target

FLOWING extends naturally to 3DGS by warping each subject's Gaussians and blending directly in 3D using the **union of warped splats**.
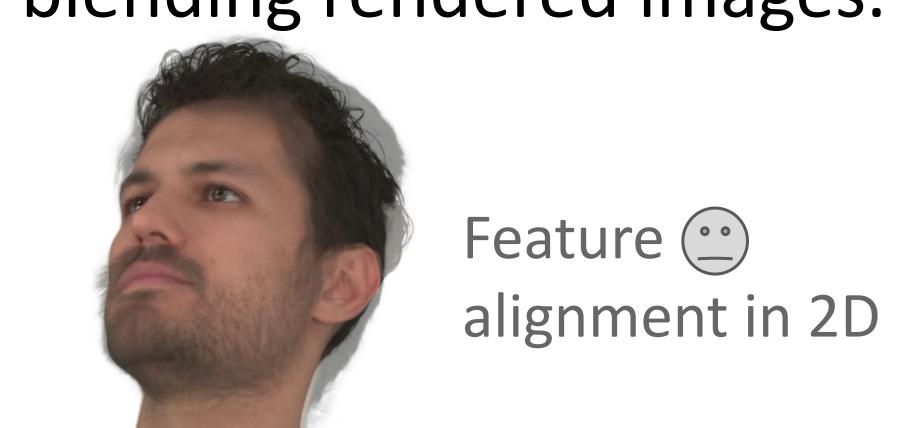

Source 3DGS — Forward warping — Backward warping — Target 3DGS

Render the union of warped splats

Compared to morphing the rendered images or

Feature ☹ alignment in 2D
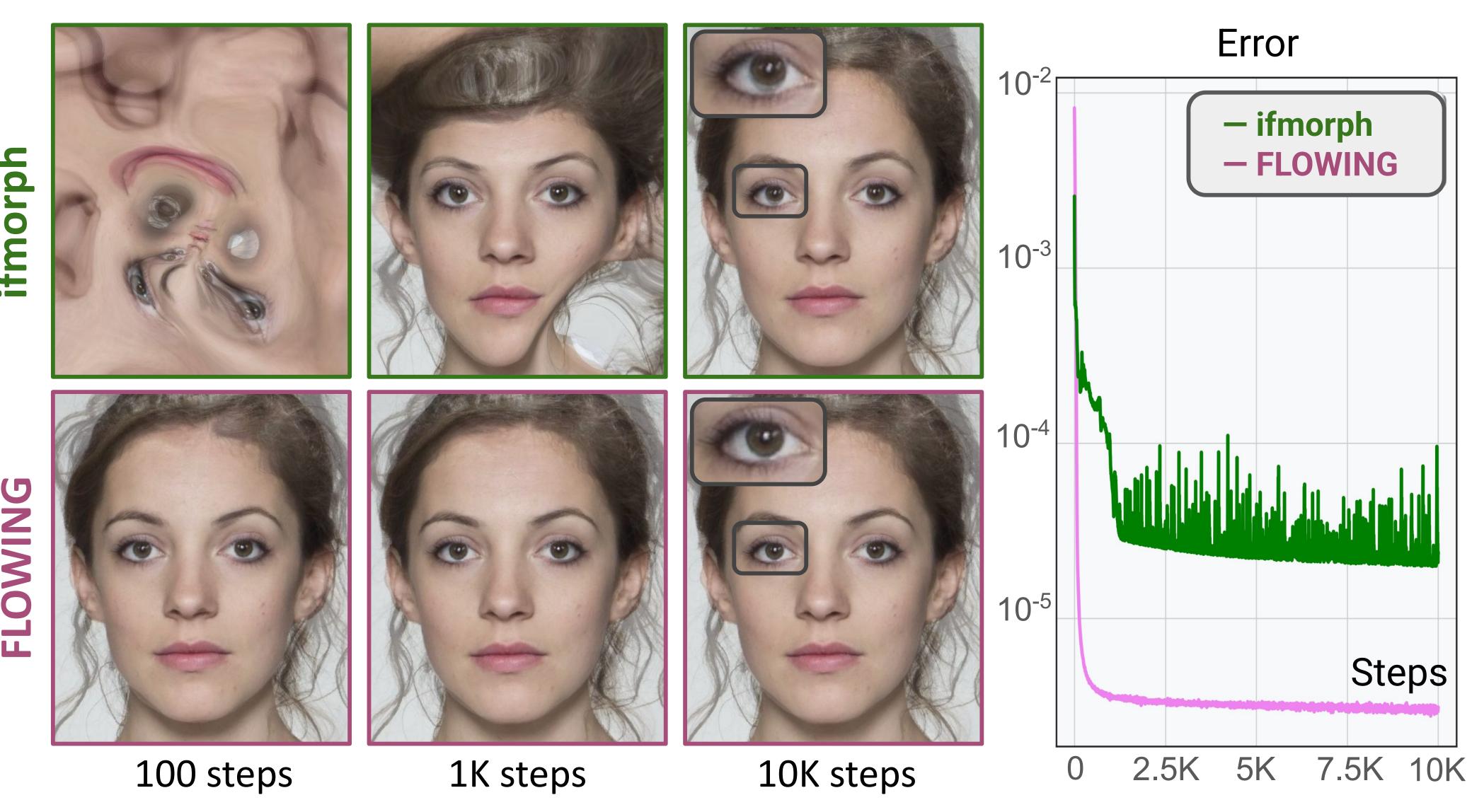
warping 3DGSs followed by blending rendered images.
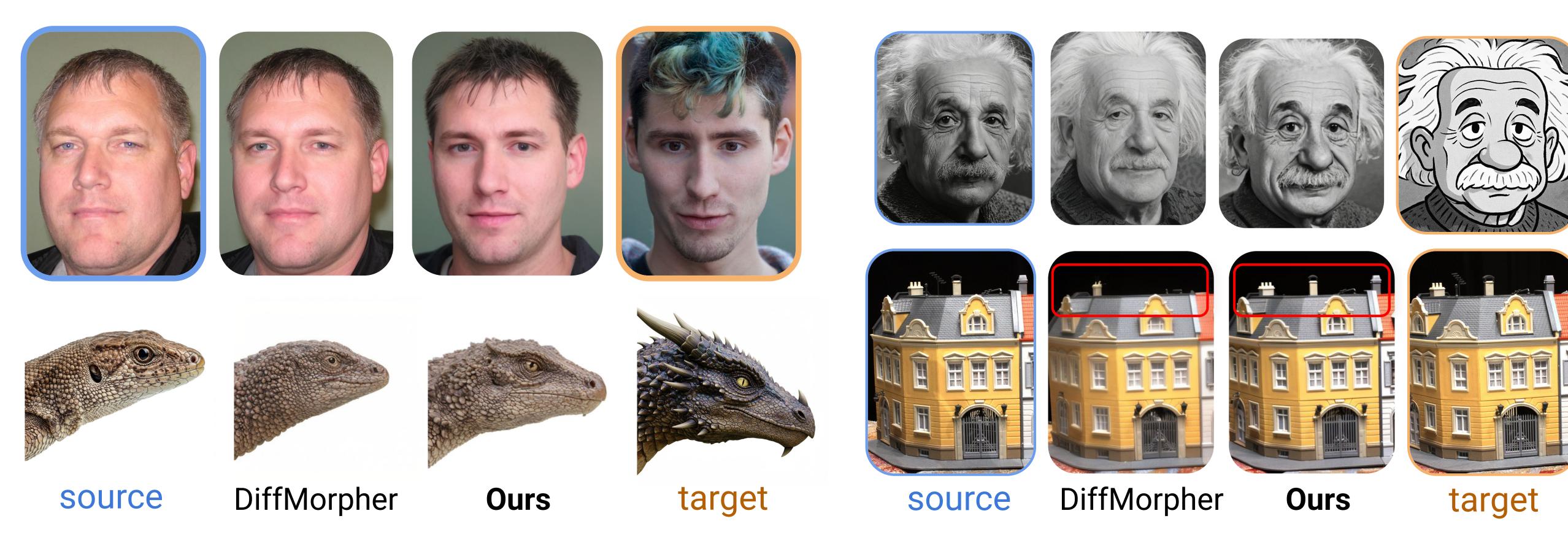
Feature ☹ alignment in 2D

Feature 😊 alignment in 3D

Experiments

FLOWING is *faster*, more *stable*, and produces *cleaner* intermediate **image morphs** than SoTA.

ifmorph / FLOWING

100 steps | 1K steps | 10K steps

Error

— ifmorph
— FLOWING

Steps

Using FLOWING before **generative blending** improves morphing yielding a more coherent interpolation.

source | DiffMorpher | Ours | target

source | DiffMorpher | Ours | target

Union-based 3DGS blending for 3D face morphing.

source ↔ target