3D-Aware Face Swapping

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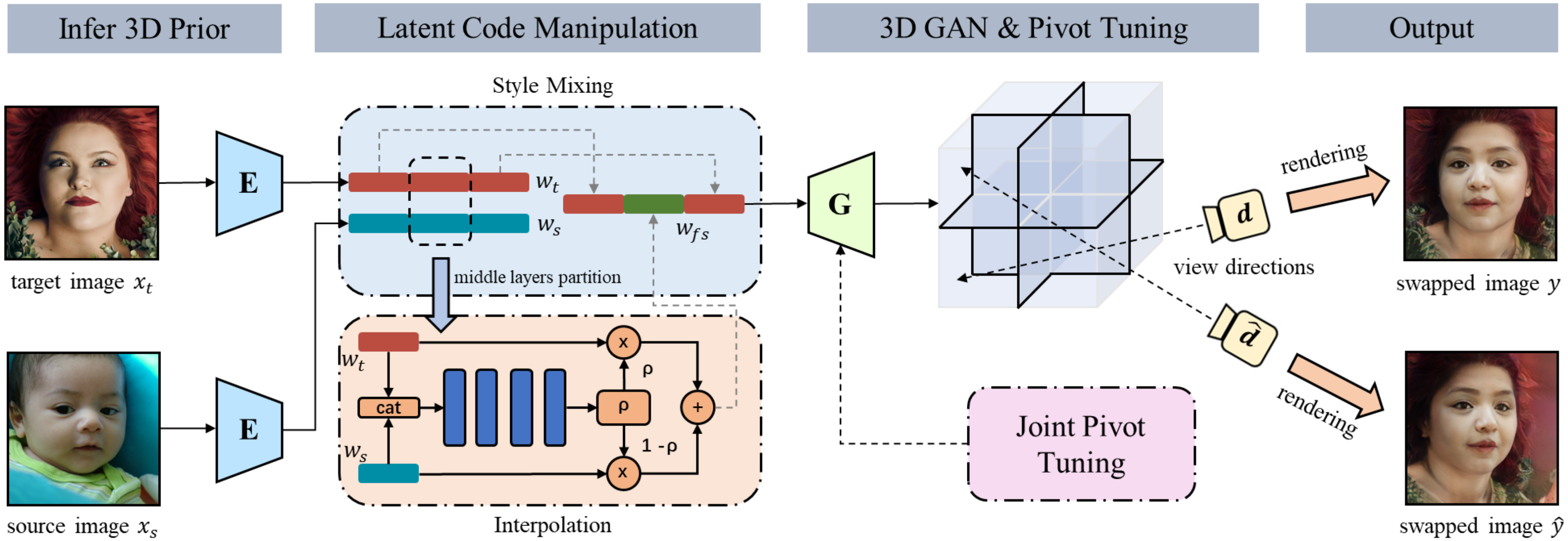
Preview

- Current approaches only learn to swap 2D facial images:
  - Exist undesirable artifacts
  - Transfer less accurate geometric facial features
- We swap face in a 3D-aware manner!



What is Face Swapping?

Source Image

+

Target Image

=

Swapped Face

Motivation

- Existing face swapping approaches
  - 3D-based methods
  - GAN-based methods / GAN-inversion-based methods
- Problems of existing approaches

3D-based Method

GAN-based Method

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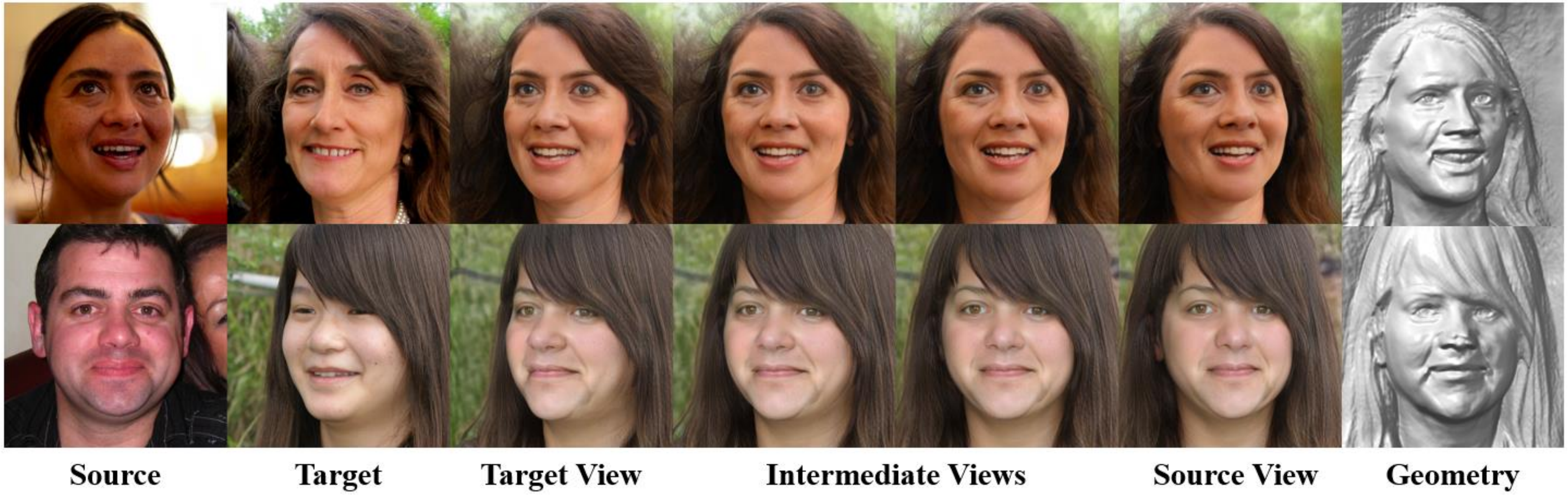
Challenges

- Challenges of 3D-aware face swapping task:
  - How to infer both geometry and texture prior from single-view 2D images?
  - How to leverage such inferred prior to swap face in a 3D-aware manner?



Infer 3D Prior

- How to infer both geometry and texture prior from single-view 2D images?
  - Solution: Introduce a 3D GAN inversion framework to project 2D inputs into 3D latent space.
- Difference between 2D/3D GAN inversion
  - For 2D GAN inversion
    - Formulation

$$\boldsymbol{w}^* = \arg\min_{\boldsymbol{w}} \mathcal{L}(G(\boldsymbol{w}), \boldsymbol{x})$$

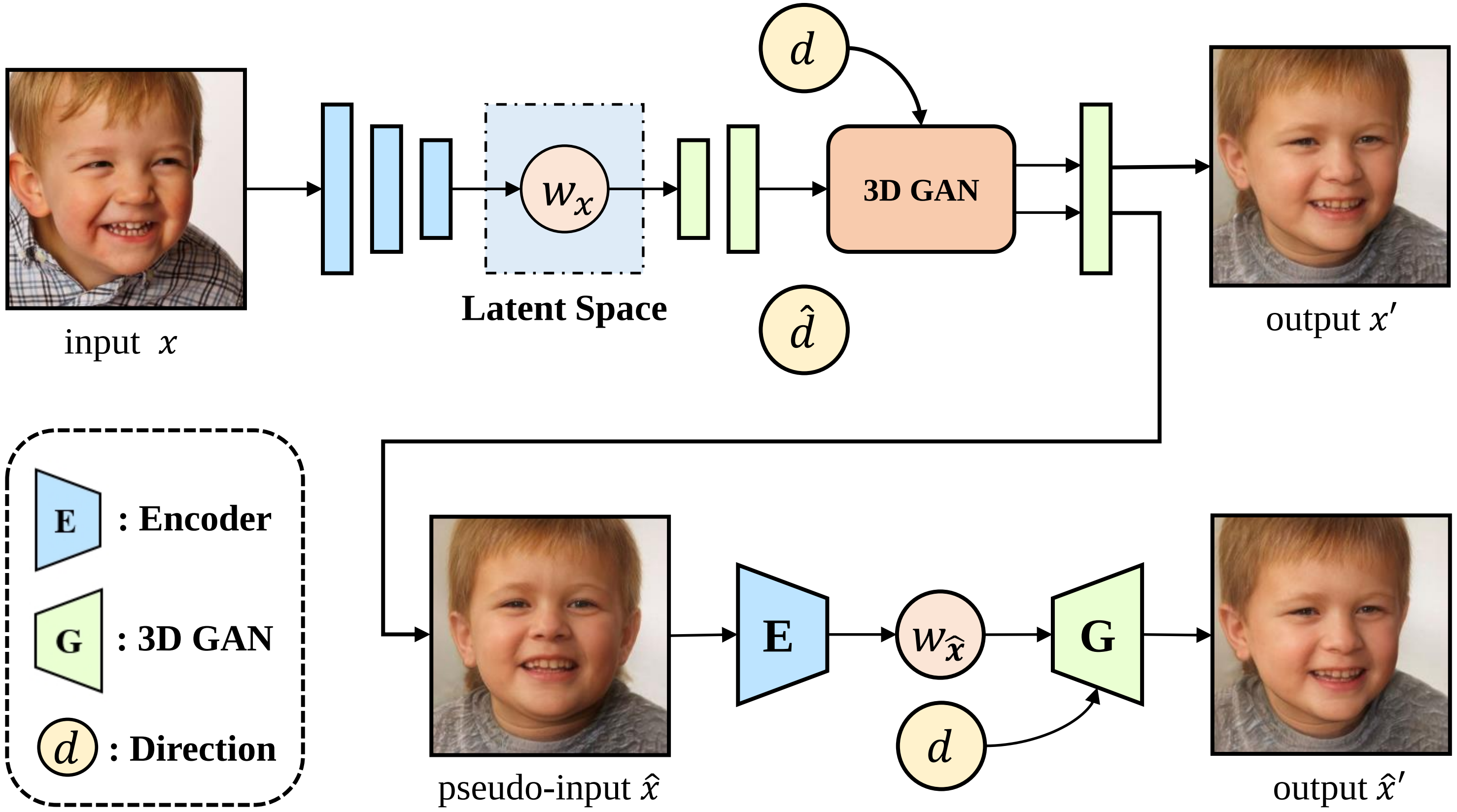
    - Information of camera pose is embedded in the latent space
  - For 3D GAN inversion
    - Formulation

$$\boldsymbol{w}^* = \arg\min_{\boldsymbol{w}} \mathcal{L}(G(\boldsymbol{w}, \boldsymbol{p}), \boldsymbol{x})$$

    - Information of camera pose is disentangled from the latent space

Infer 3D Prior

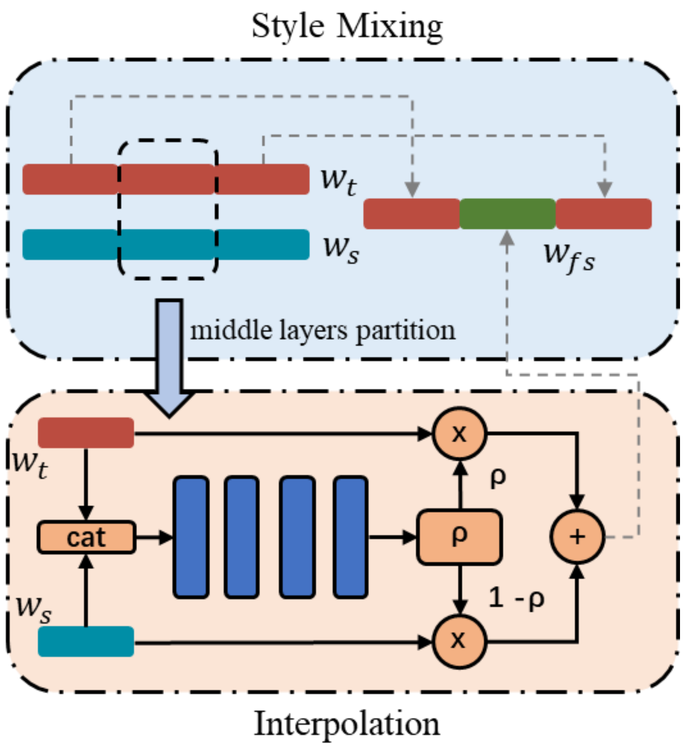
- Pseudo-multi-view train strategy



$$\min_{\theta}\{\mathcal{L}(x,x')+\eta\mathcal{L}(x,\hat{x}')+\mathcal{L}(w_x,w_{\hat{x}})\}$$

Latent Code Manipulation

- How to leverage such inferred prior to swap face in a 3D-aware manner?
  - Solution: Design a face swapping algorithm based on the 3D latent codes and directly synthesize the swapped faces with the 3D-aware generator.



Latent Code Manipulation

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$$w_{fs}^{(i)} = \begin{cases} \rho^{(i)} \times w_t^{(i)} + (1-\rho^{(i)}) \times w_s^{(i)} & i \in [5,9] \\ w_t^{(i)} & otherwise \end{cases}$$

Joint Pivot Tuning

- How to bridge the gap between 2D image generating and 3D rendering?
  - Solution: Implement a "joint" pivot tuning[1] considering both reconstruction quality and face swapping performance.

$$\min_{\theta^*}\{\mathcal{L}(x_{s/t}\ ,\ \mathcal{G}_{\theta^*}(w_{s/t}, d_{s/t})) + \\ \mathcal{L}(x_t \cdot M_f\ ,\ \mathcal{G}_{\theta^*}(w_{fs}, d_t) \cdot M_f)\},$$

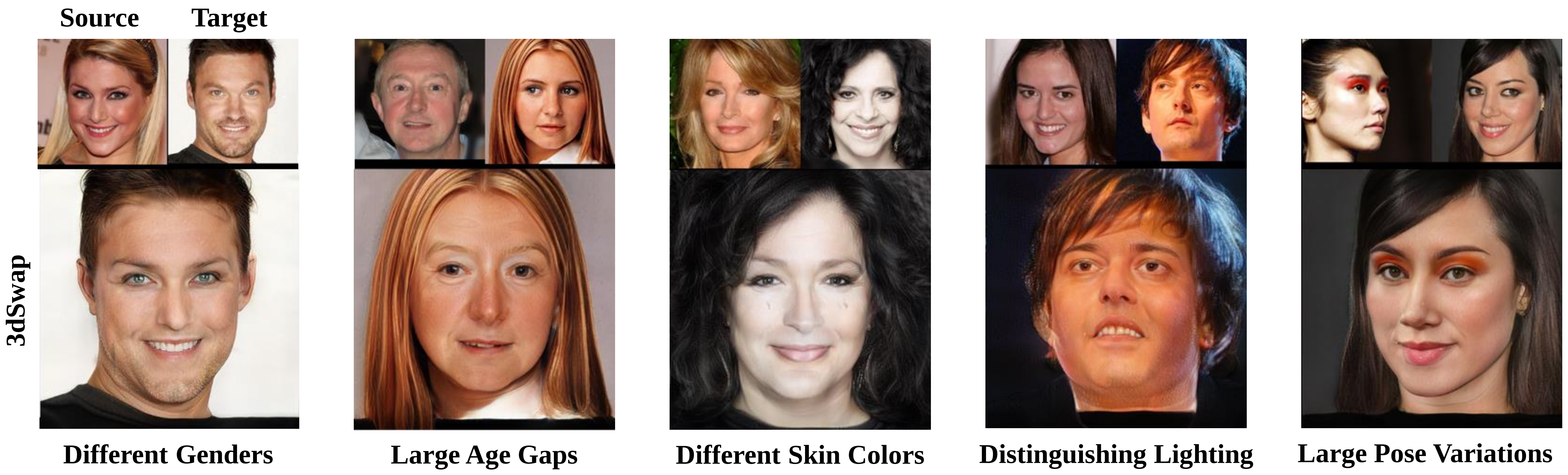
- Finally, we can synthesize the swapped face $\boldsymbol{y}$ in any direction $\boldsymbol{d}$ by:

$$y = \mathcal{G}_{\theta^*}(w_{fs}, d)$$

1. D. Roich, R. Mokady, A. Bermano, and D. Cohen-Or. "Pivotal tuning for latent-based editing of real images." TOG, pages 1-13, 2022.

Experiments on CelebA-HD Dataset

- CelebA-HD[1] is a large-scale high-quality face attributes dataset.
- Robustness of 3dSwap is validated under several challenging settings:

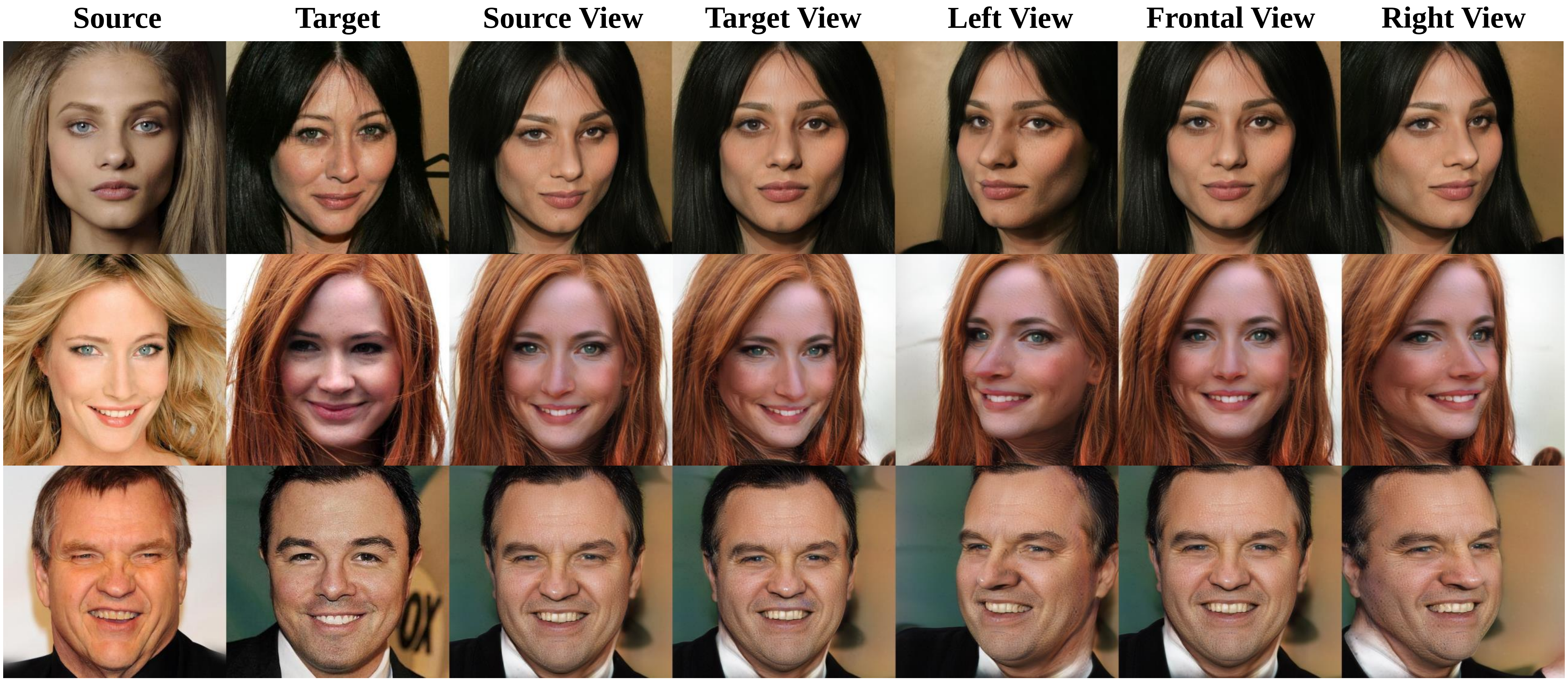


1. T. Karras, T. Aila, S. Laine and J. Lehtinen. “Progressive growing of GANs for improved quality, stability, and variation.” In ICLR, 2018.

Comparison with 2D Approaches

Source	Target	SimSwap	MegaFS	InfoSwap	Xu *et al.*	Ours

Multi-view Results on CelebA-HD



Conclusion

- We propose the first 3D-aware face swapping framework, where:
  - Infer both geometry and texture facial prior from a single-view image with 3D GAN inversion
  - Design an unique latent code manipulation algorithm for face swapping
  - Bridge the image quality between 2D generating and 3D rendering with a joint pivot tuning

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Project Page

https://lyx0208.github.io/3dSwap

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Thanks!

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