



Interacting with Deep Generative Models for Content Creation

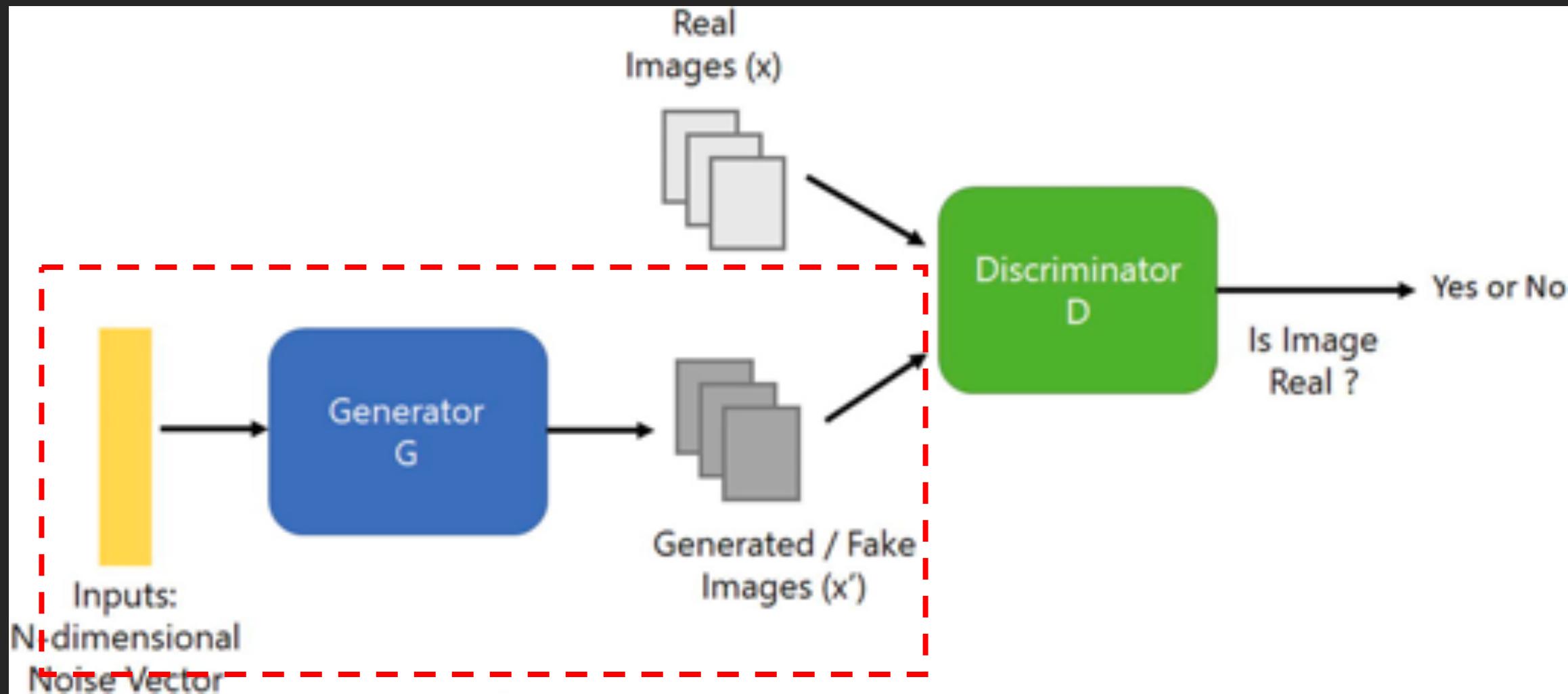
Bolei Zhou

The Chinese University of Hong Kong

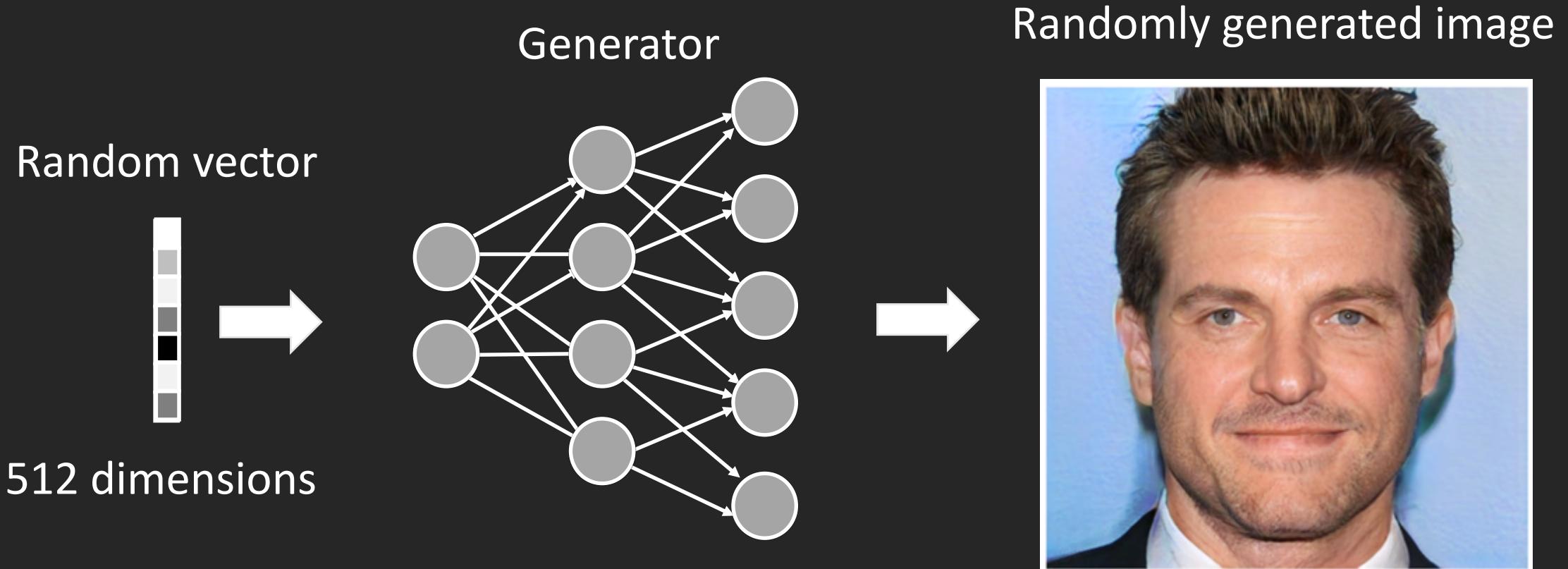
Tutorial Outline

- Session 1: Overview of the generative models
- Session 2: Interacting with the generative models

What have been learned inside the GANs?



Deep Generative Model



How to Customize the Output?

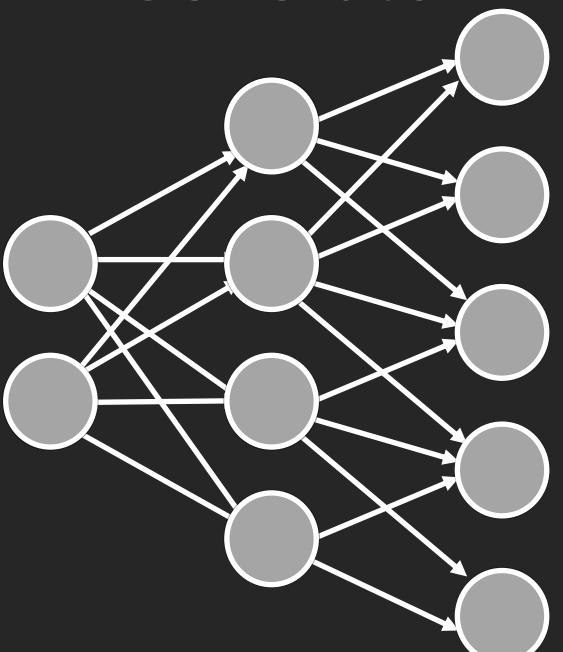
Latent space



512 dimensions



Generator



Output



Different angle

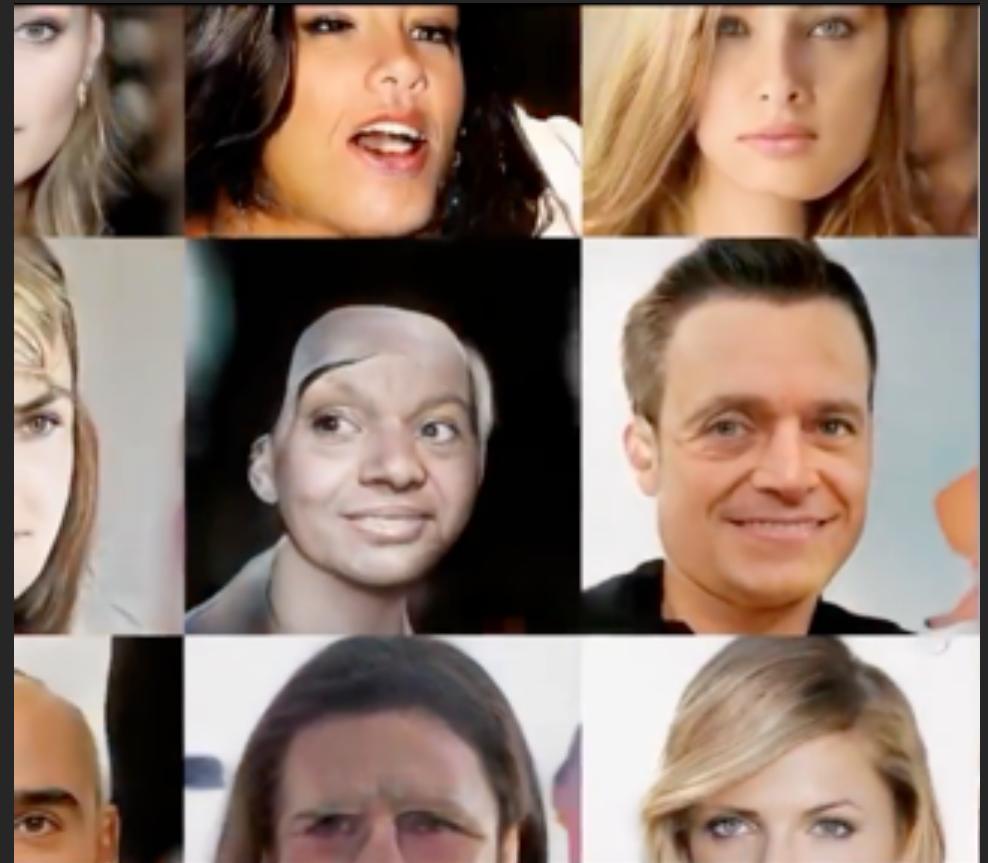
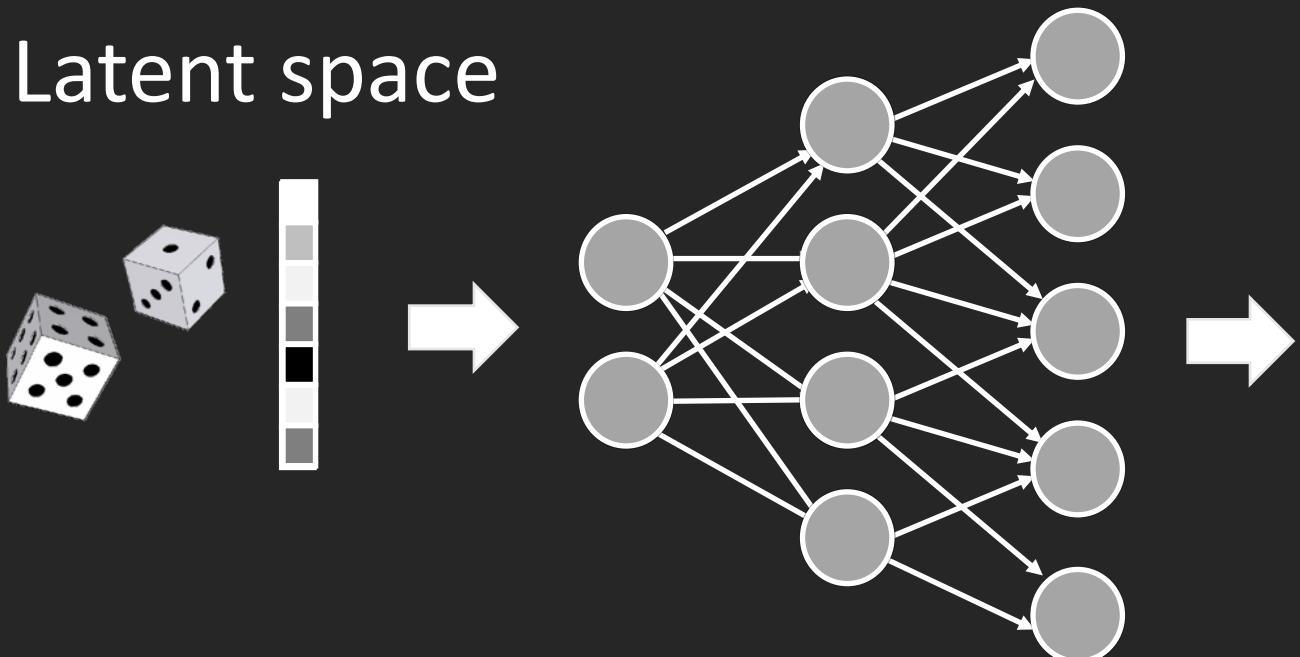


Different age

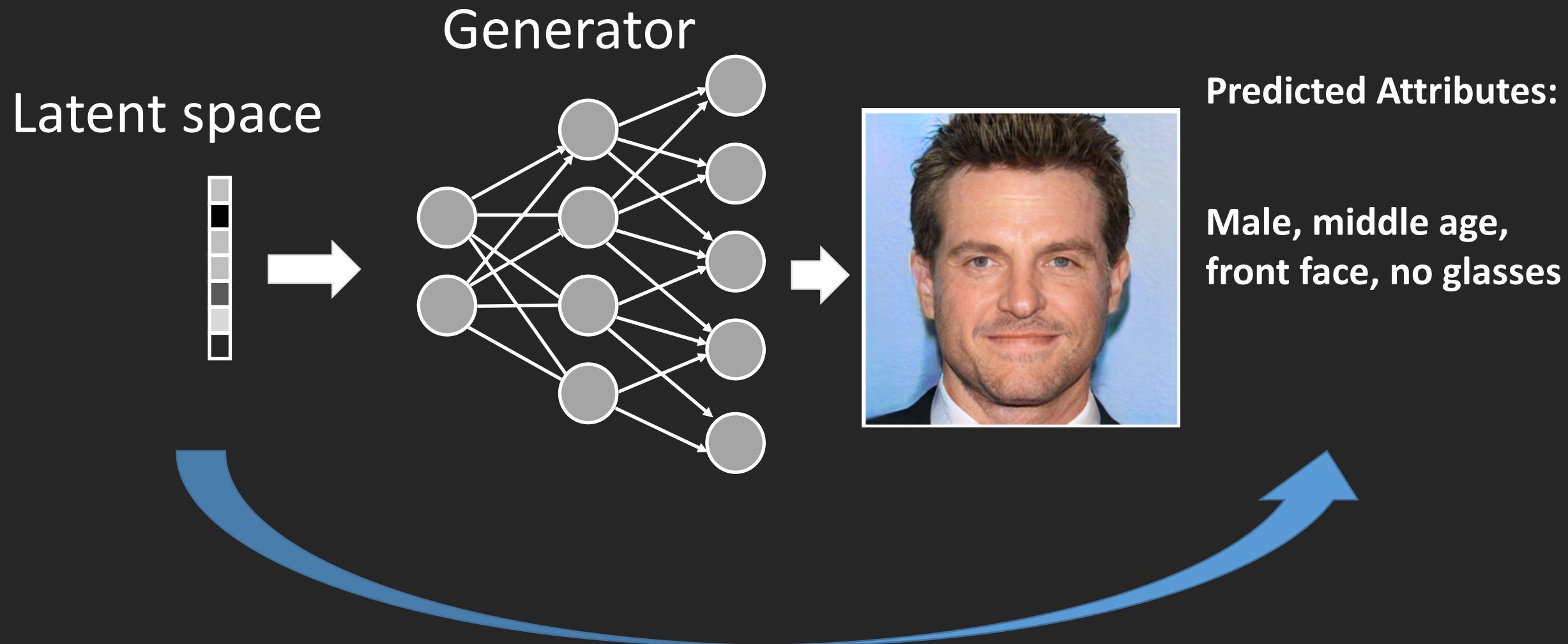


Random Walk in the Latent Space

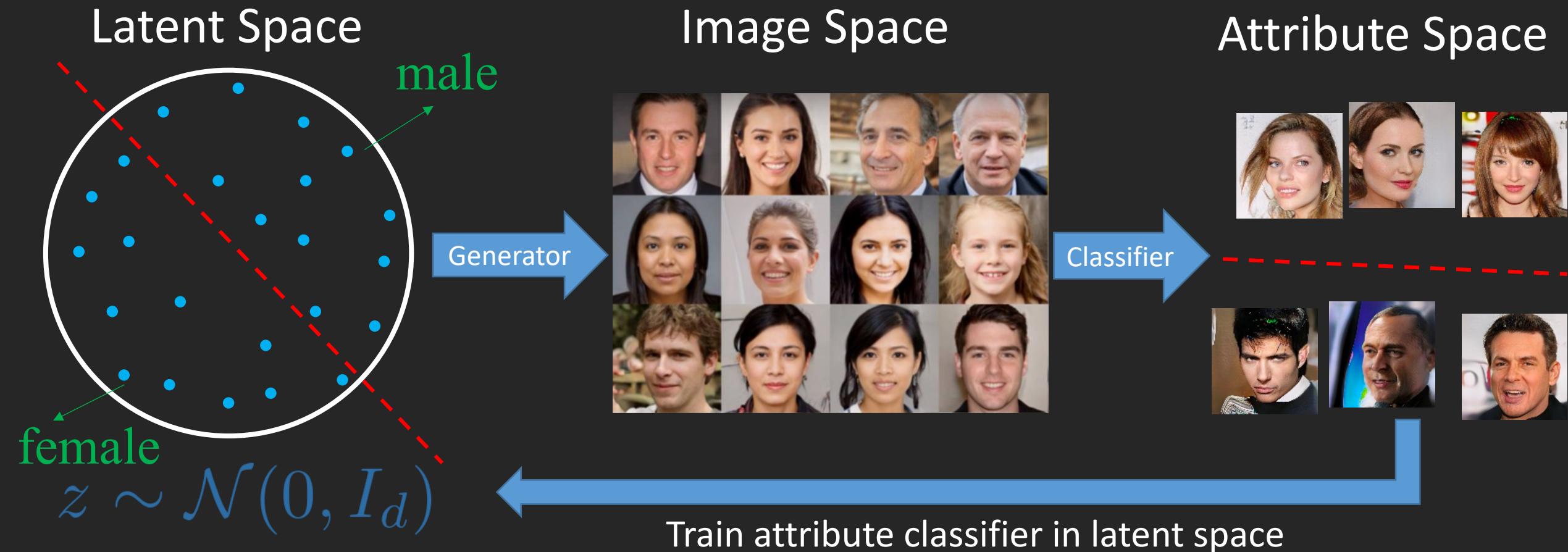
Latent space



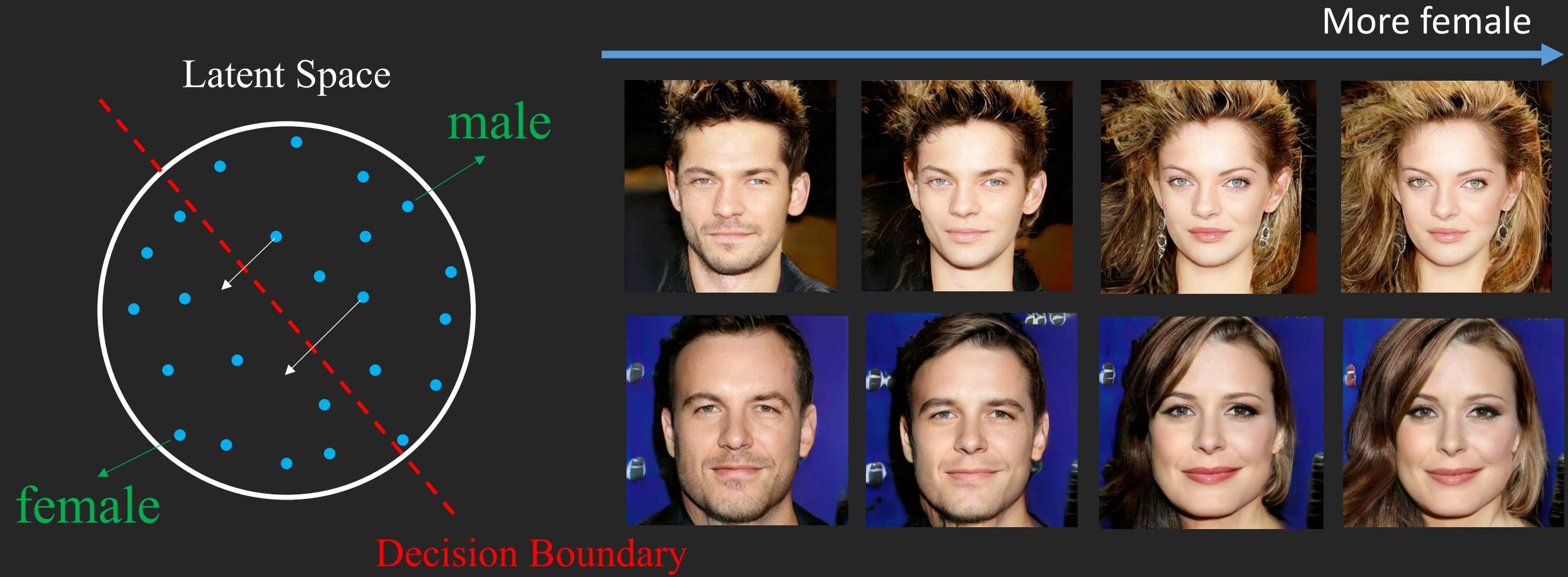
Causal Relations in the Latent Space



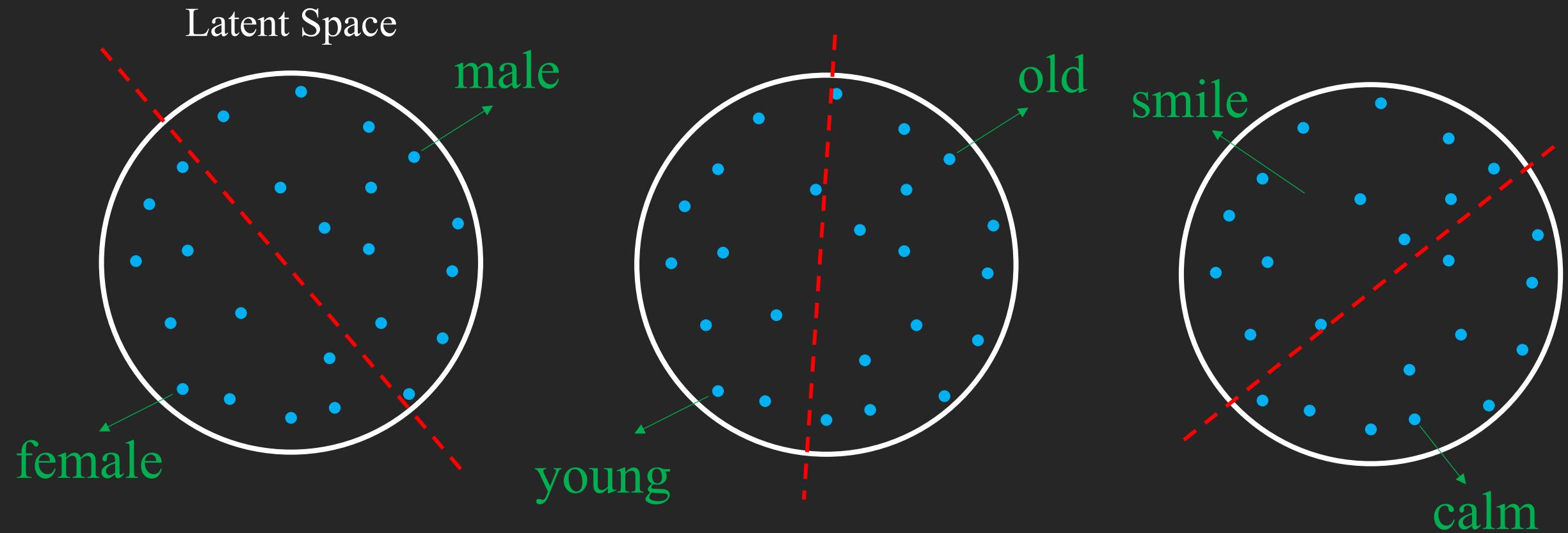
InterFaceGAN: Interpreting Semantics in Face GANs



Varying the Latent Code through Boundary



Various Attribute Boundaries to Divide the Latent Space



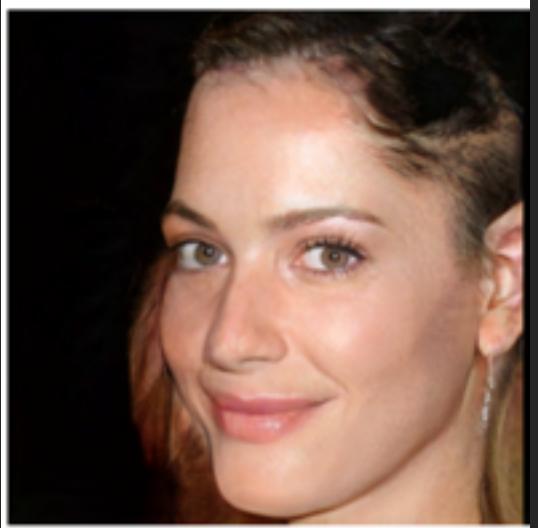
Make me cooler



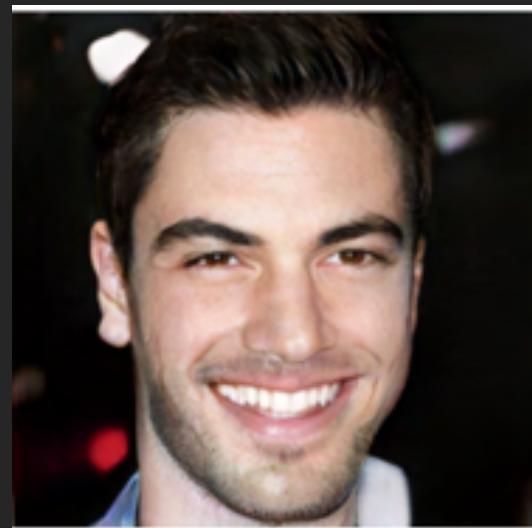
Make me younger



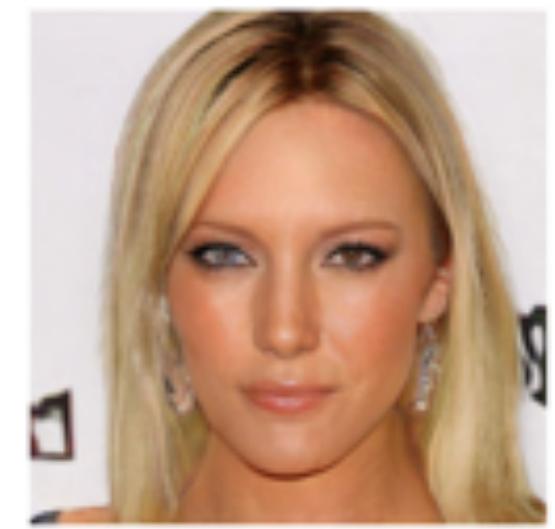
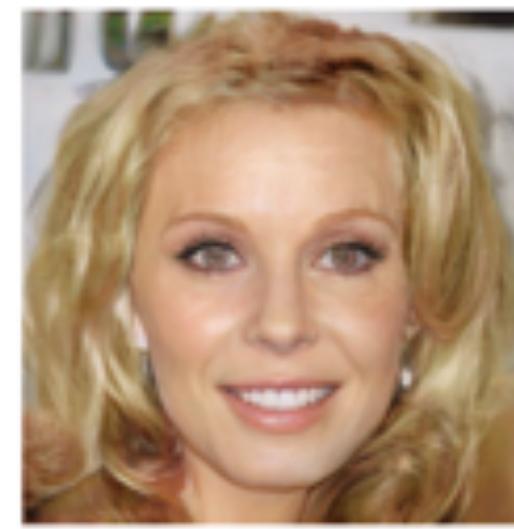
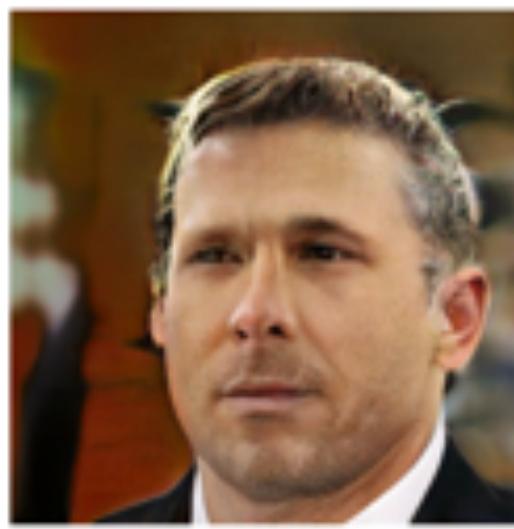
Make me front faced



Make me more man



Correcting the Mistakes Made by GAN



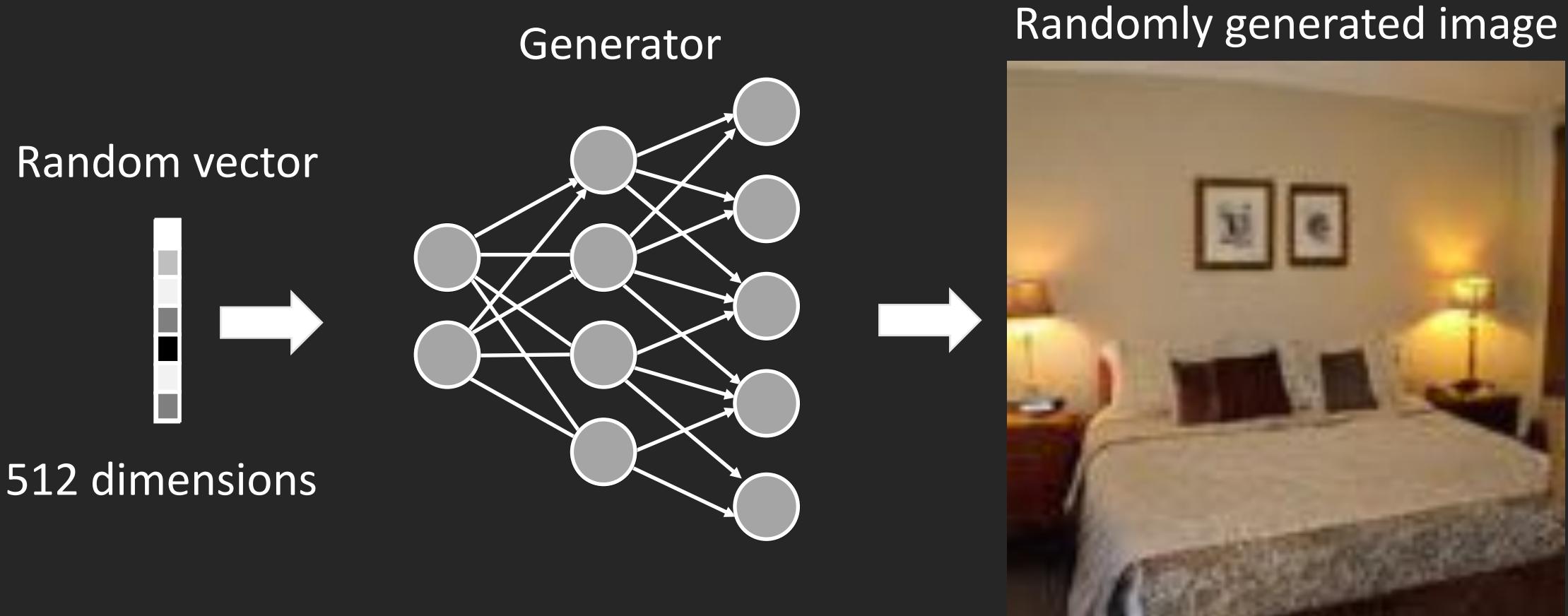
Demo Video

Face Manipulation
with InterpretGAN

Code for InterfaceGAN

- <https://github.com/genforce/interfacegan>
- Colab live demo:
<https://colab.research.google.com/github/genforce/interfacegan/blob/master/docs/InterFaceGAN.ipynb>

Latent Semantics in GANs for Scene Synthesis



Random Walk in Latent Space of Bedroom



Multiple Levels of Abstractions for Scenes

Scene category:

bedroom

Scene attributes:

nature lighting

wood

foliage

...

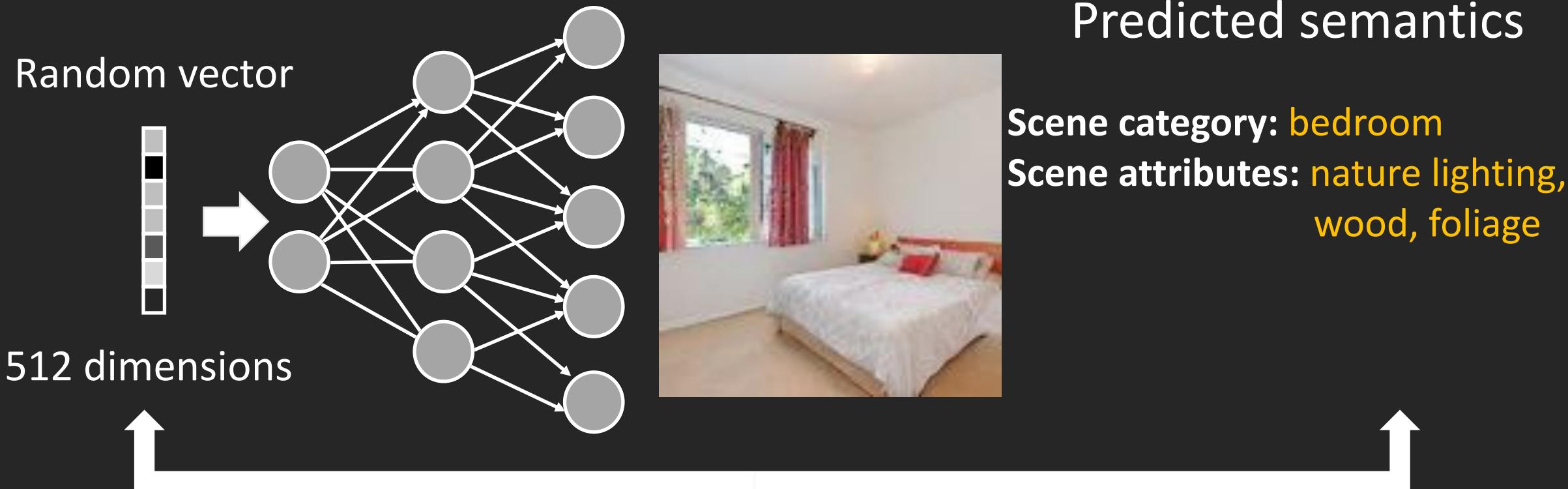
Layout



Segmentation



Identifying the Causality in Latent Space



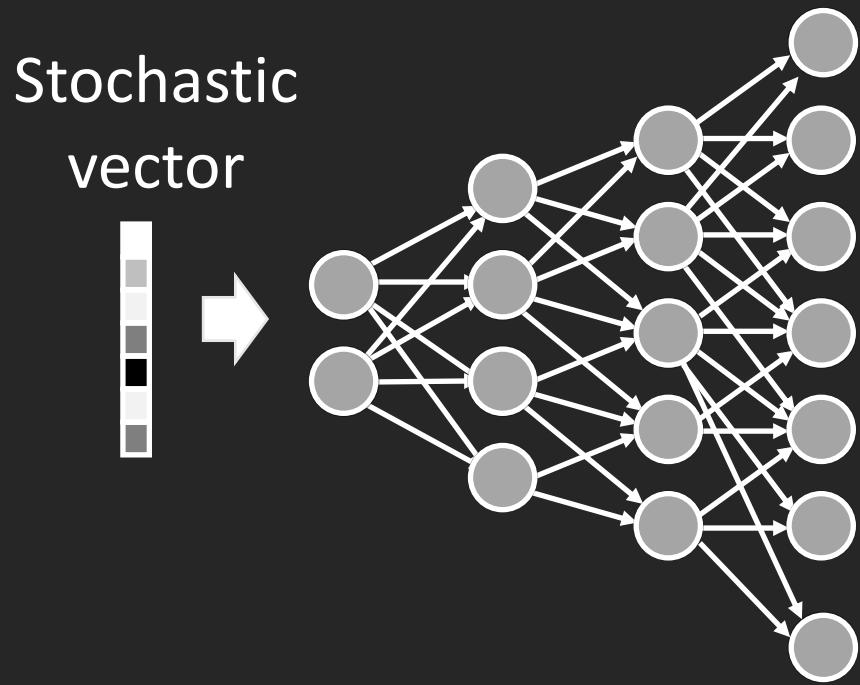
Result on turning up the lights



Result on ageing the scenes

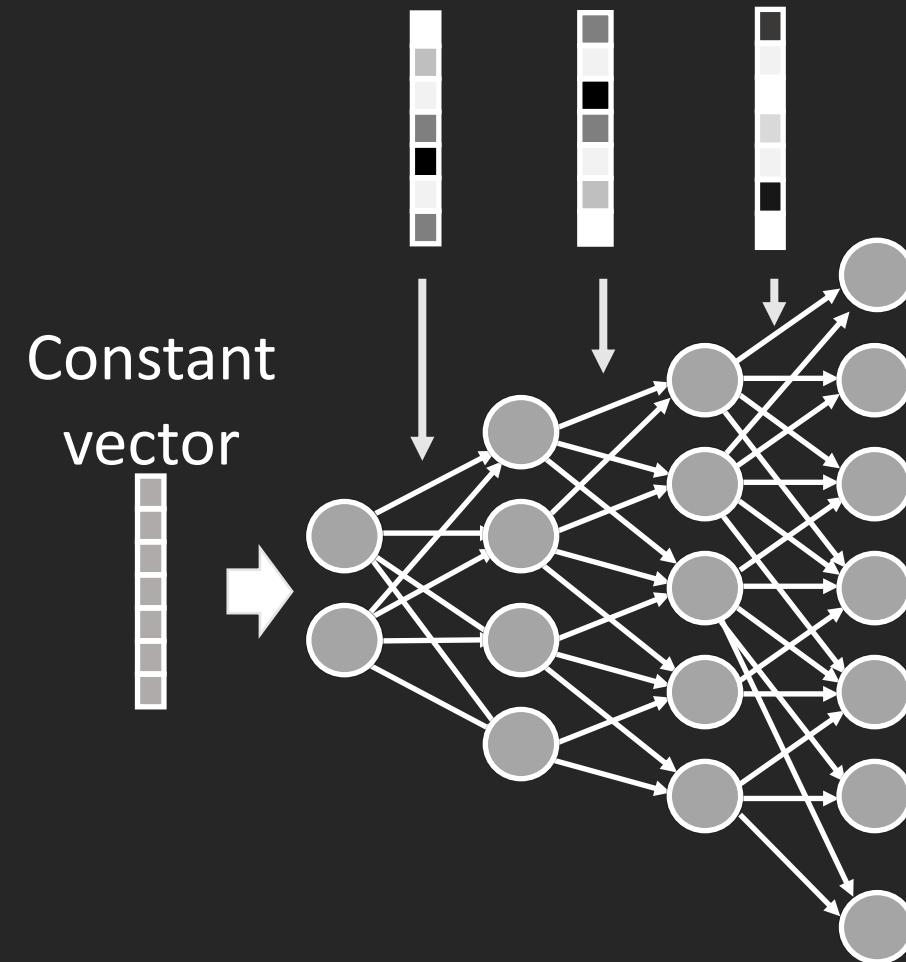


Layer-wise Stochasticity



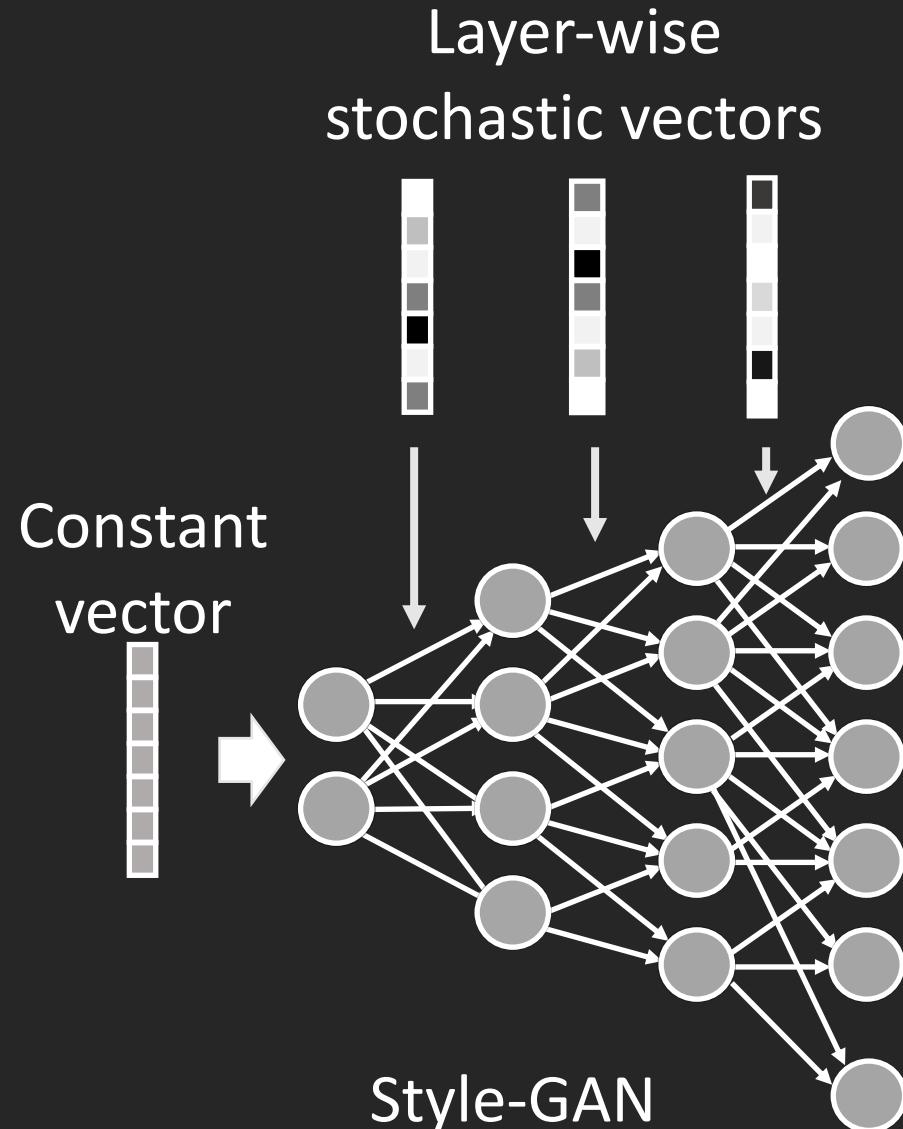
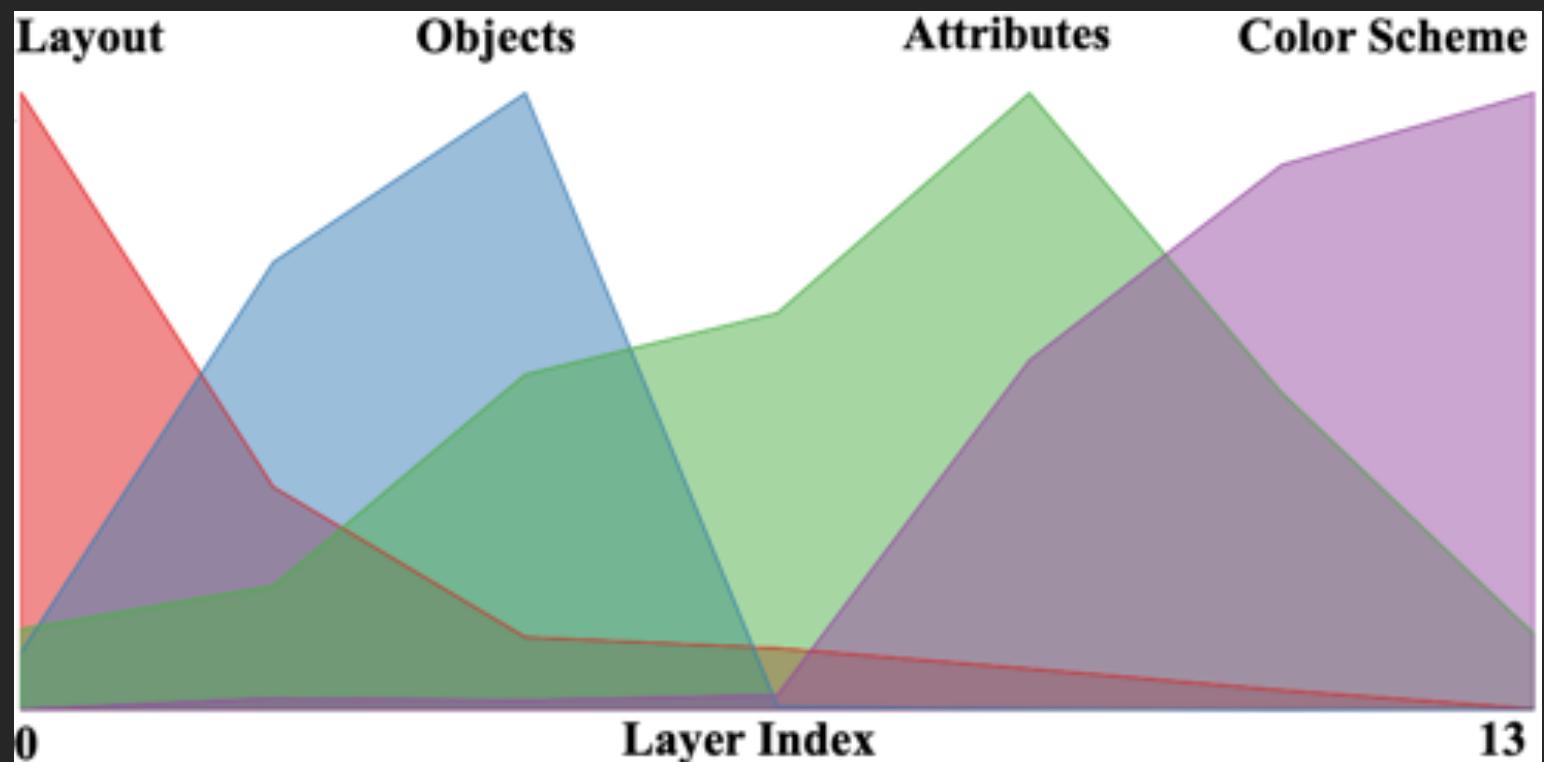
DC-GAN, PG-GAN

Layer-wise
stochastic vectors

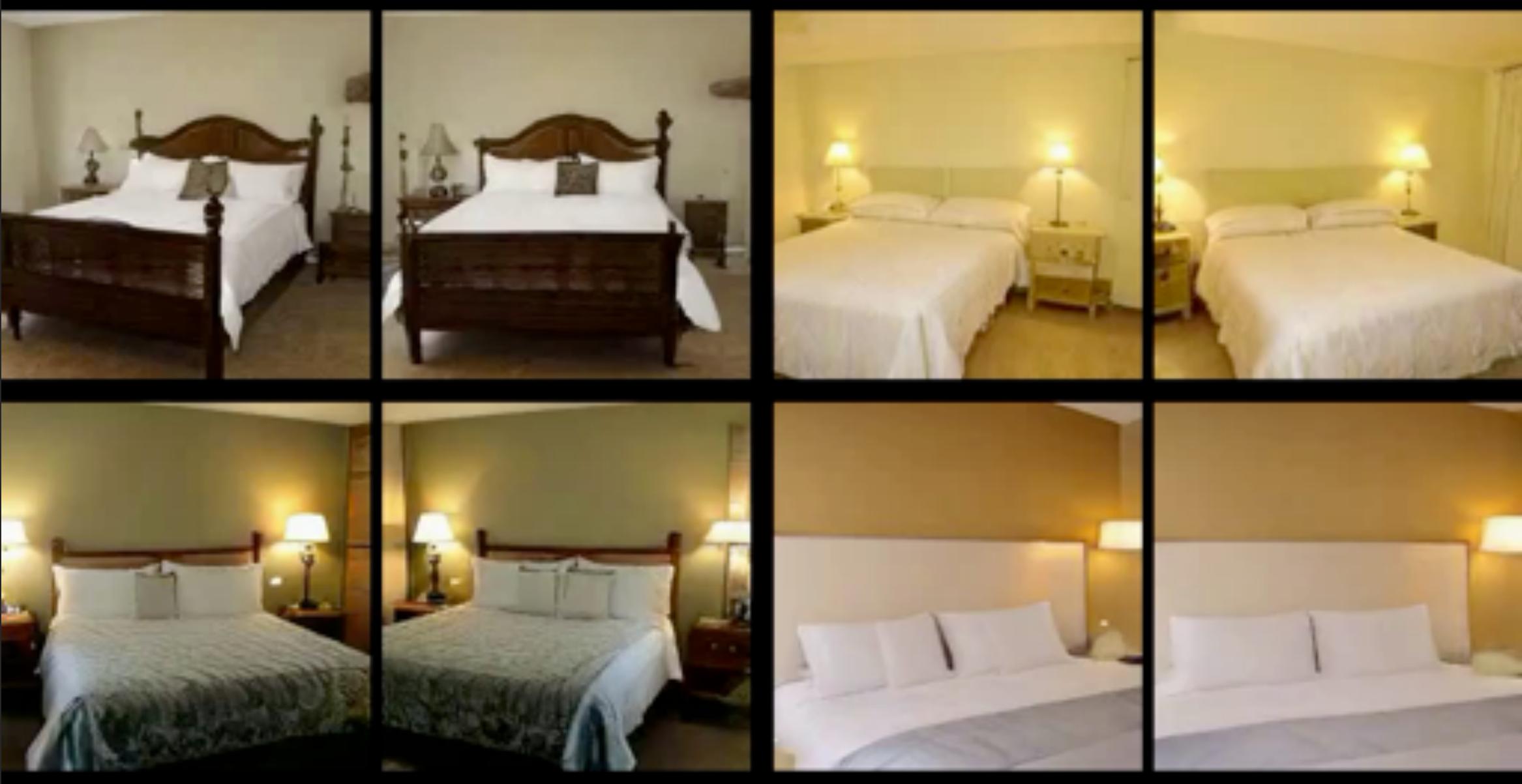


Style-GAN [Karras et al]

Semantic hierarchy emerges across the layers of generator



Varying viewpoints



Bedroom to Dining Room



Code of HiGAN

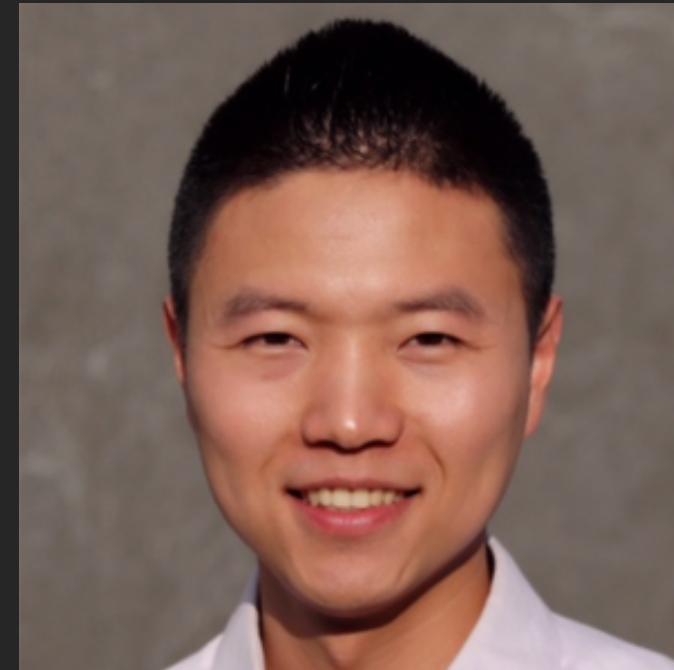
- <https://github.com/genforce/higan>
- Colab live demo:
https://colab.research.google.com/github/genforce/higan/blob/master/docs/HiGAN_Bedroom.ipynb

How to edit my own face?

Make me cooler



Make me younger



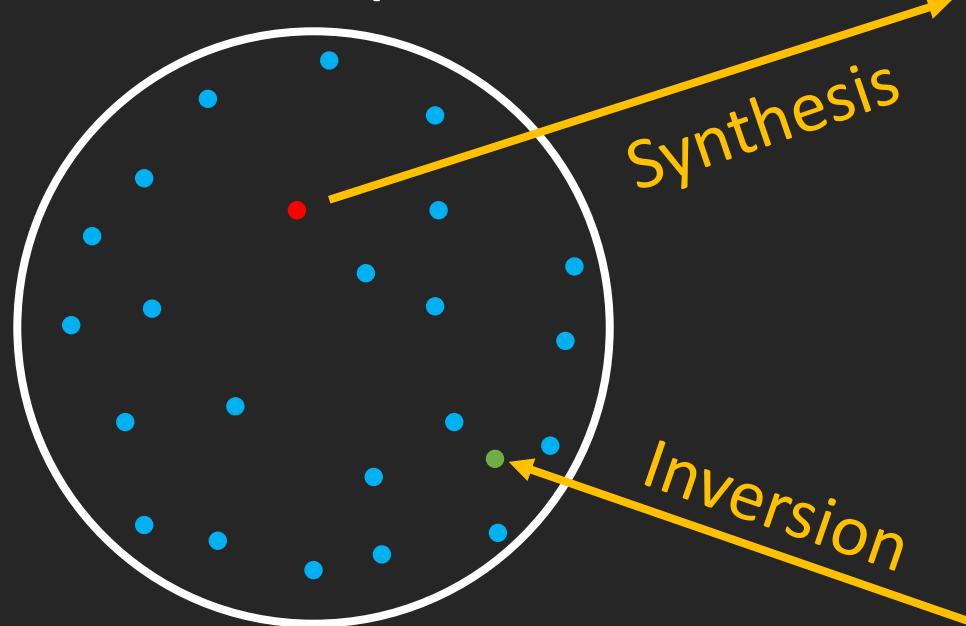
My Profile photo

GAN-Synthesized Image

GAN Inversion: Inverting Real Face to Latent Code

$$\mathbf{x} = G(\mathbf{z})$$

Latent Space \mathbf{z}



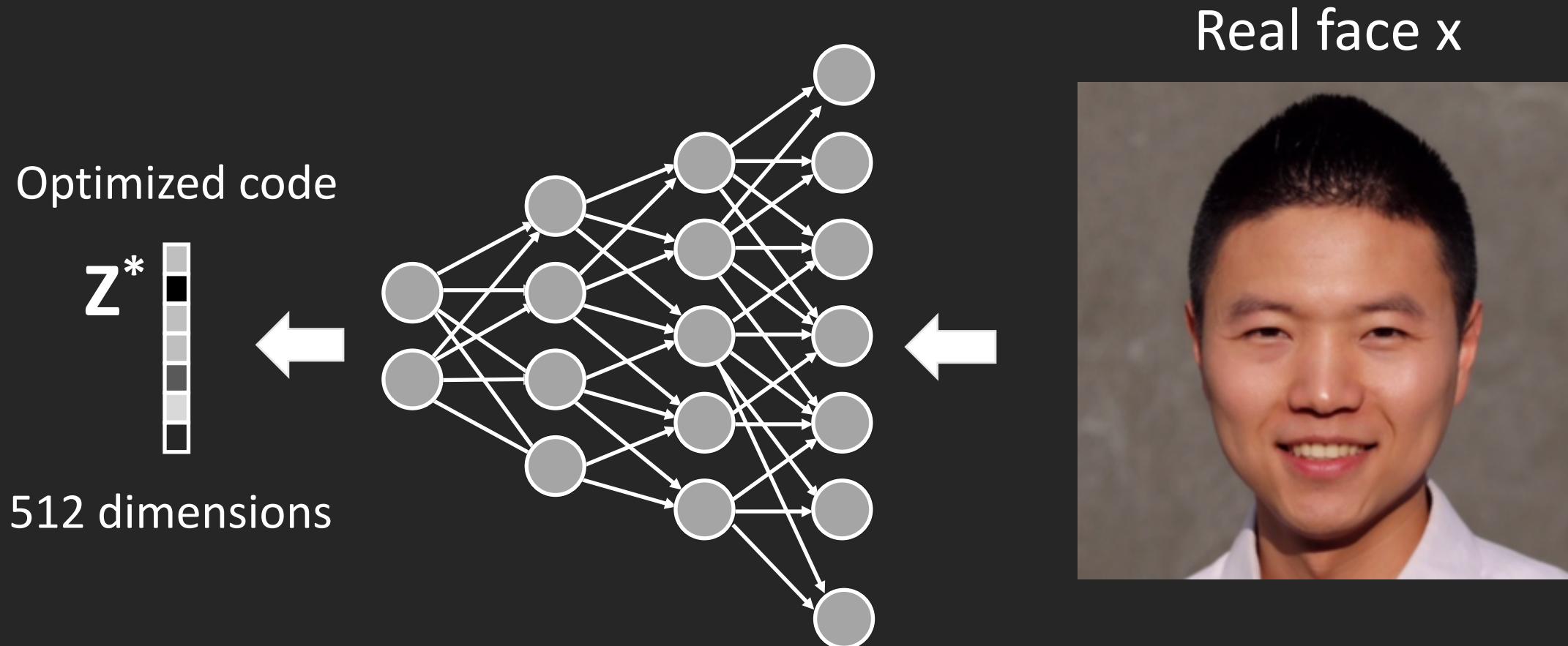
$$\mathbf{z}^* = \arg \min_{\mathbf{z}} \|G(\mathbf{z}) - \mathbf{x}\|^2$$



Real Image \mathbf{x}



GAN Inversion



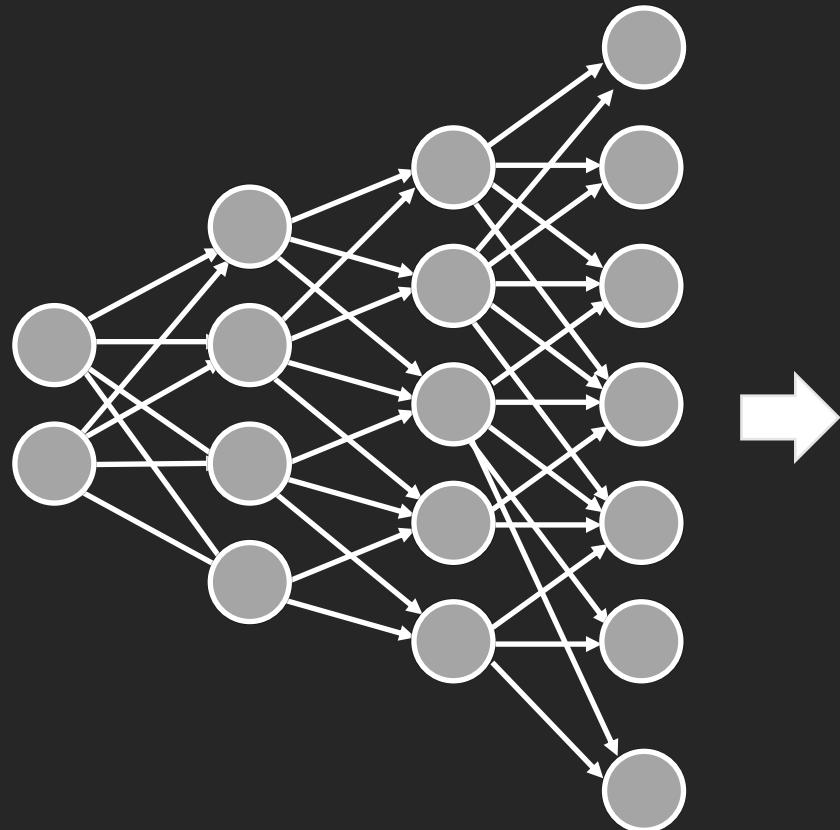
$$\mathbf{z}^* = \arg \min_{\mathbf{z}} \|G(\mathbf{z}) - \mathbf{x}\|^2$$

GAN Inversion

Optimized code



512 dimensions



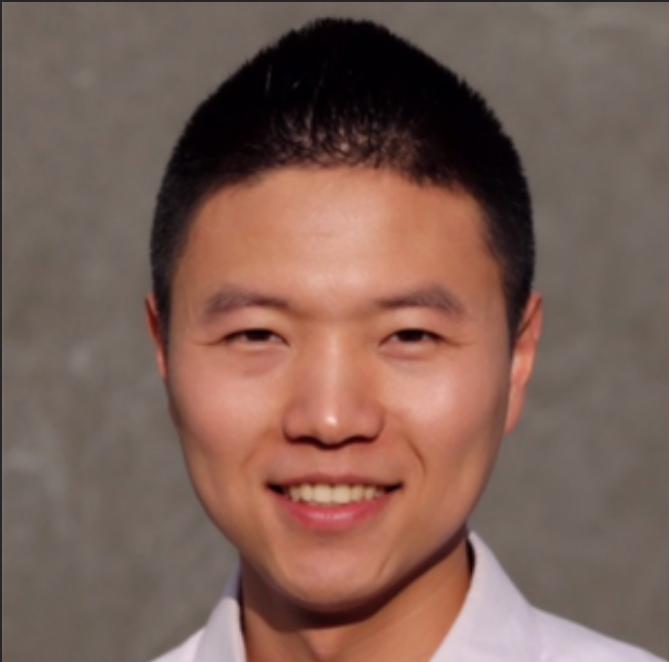
Reconstructed face



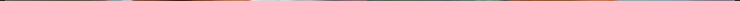
GAN inversion is challenging!

$$\mathbf{z}^* = \arg \min_{\mathbf{z}} ||G(\mathbf{z}) - \mathbf{x}||^2$$

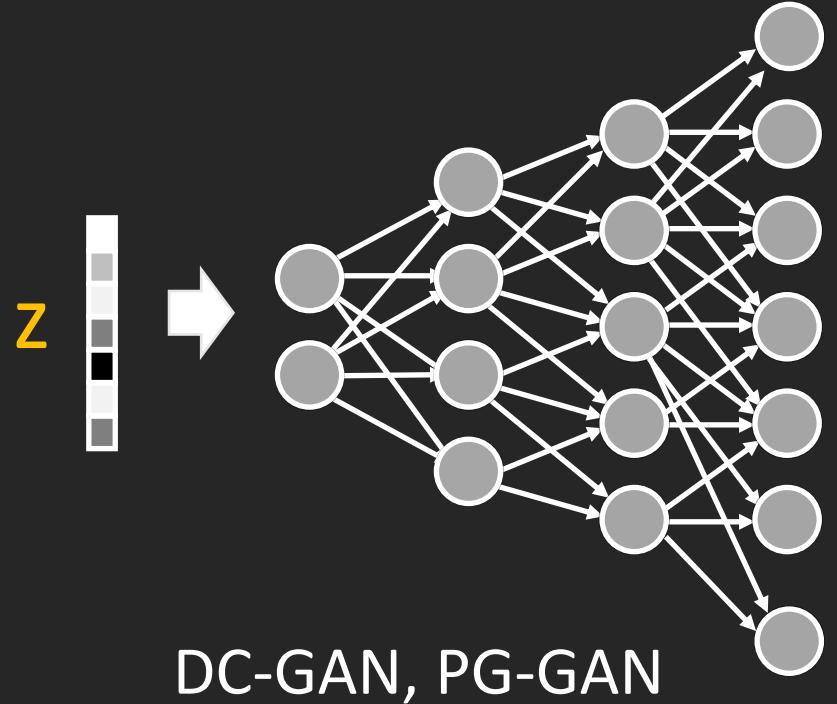
Inversion



Different initialization



Extended latent codes



$$\mathbf{z}^* = \arg \min_{\mathbf{z}} \|G(\mathbf{z}) - \mathbf{x}\|^2$$

$$\mathbf{z}_1^*, \mathbf{z}_2^*, \dots = \arg \min_{\mathbf{z}_1, \mathbf{z}_2, \dots} \|G(\mathbf{z}_1, \mathbf{z}_2, \dots) - \mathbf{x}\|^2$$

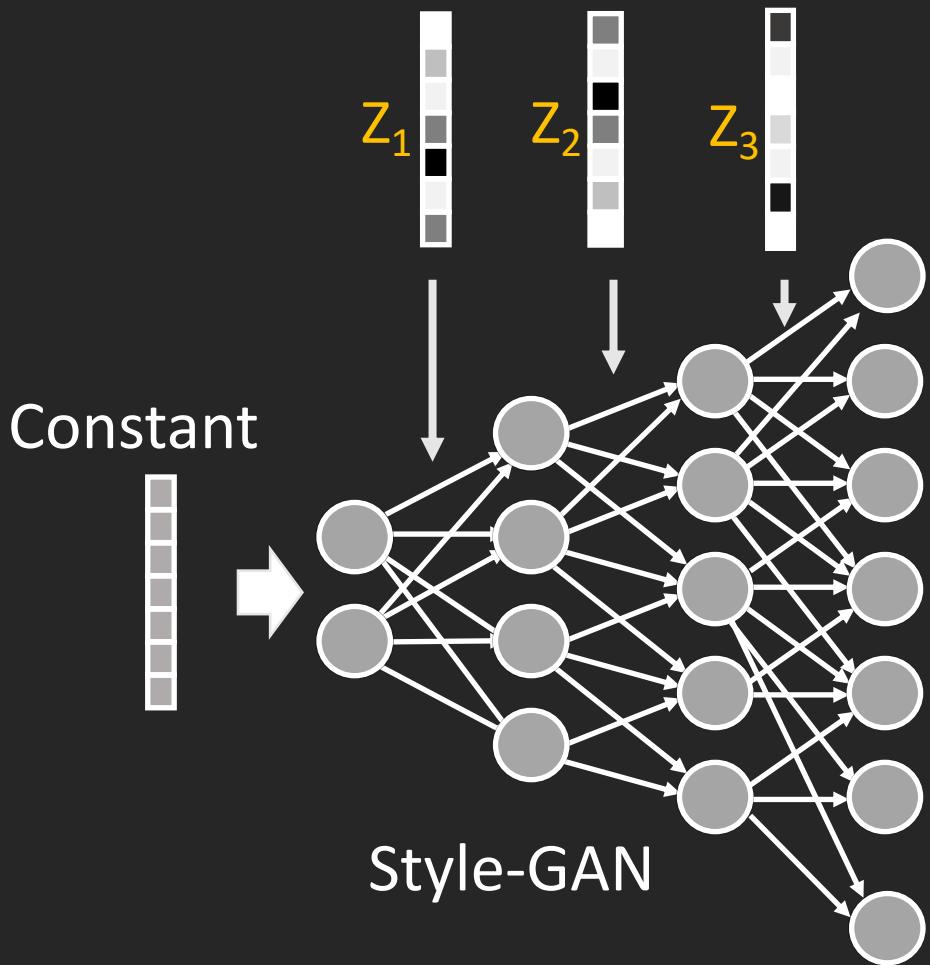
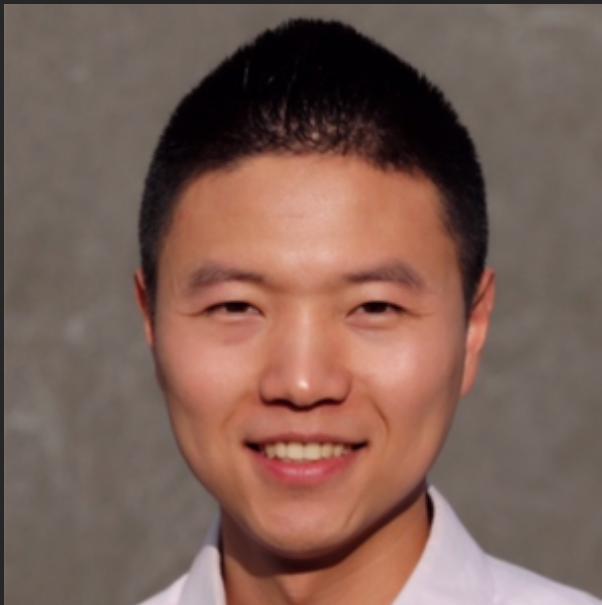


Image2StyleGAN: it works to some degree

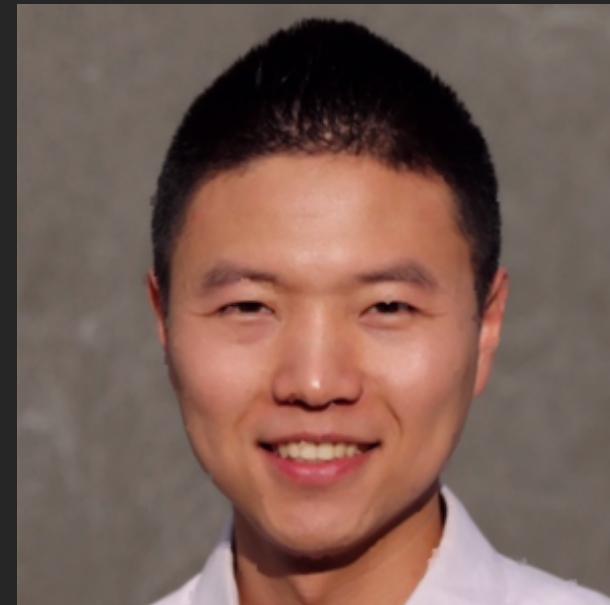
Target



Inversion from
single code
512 dimensions



Inversion from
Image2StyleGAN
14x512 dimensions



But it seems overfitting the target image

Target



Image2StyleGAN



Target



Image2StyleGAN



* Generator is trained on human faces only

But it seems overfitting the target image

Inverted codes don't very well support the manipulation

Target



Image2StyleGAN



Add smile

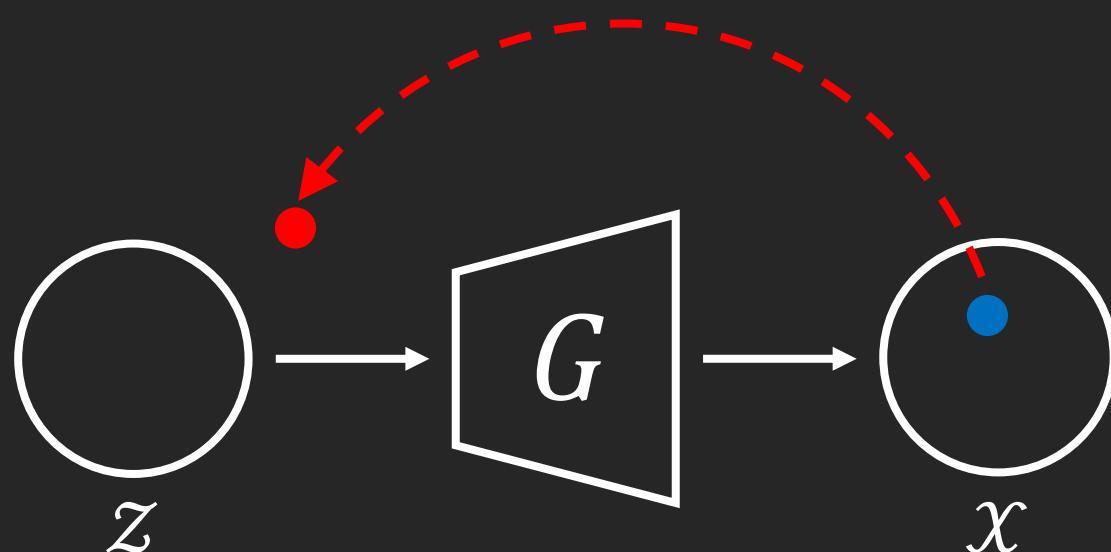


Add glasses



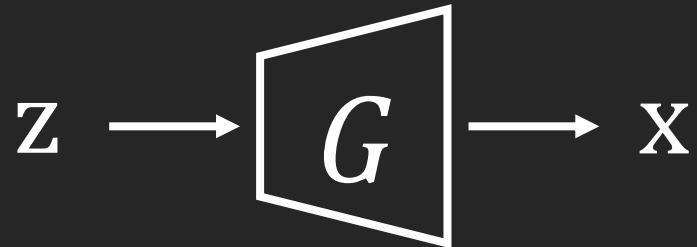
Issue: resulting code might be out of the original latent domain

$$\mathbf{z}^* = \arg \min_{\mathbf{z}} \|\mathbf{G}(\mathbf{z}) - \mathbf{x}\|^2$$

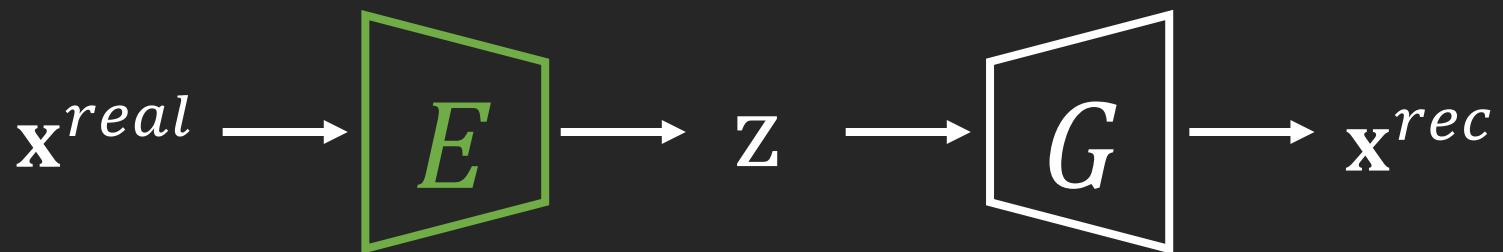


Out-of-Domain Inversion

GAN lacks the inference ability:



Many recent works on adding encoder to GAN generator:



BigBiGAN (NeurIPS'19)



Input



Reconstruction

Adversarial Latent Autoencoders (CVPR'20)



Input

Reconstruction

In-Domain Inversion (ECCV'20)

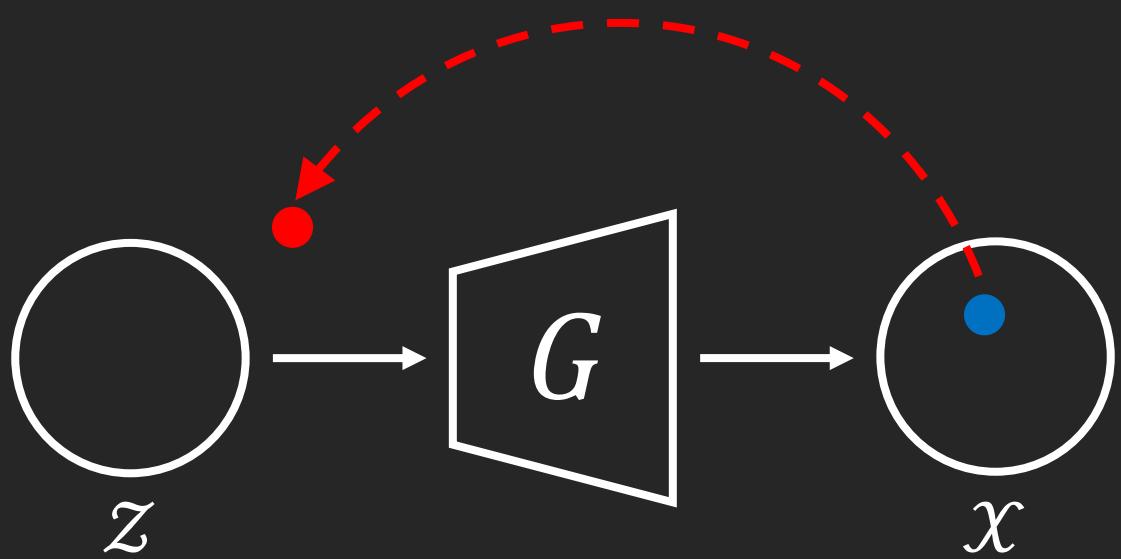


Input

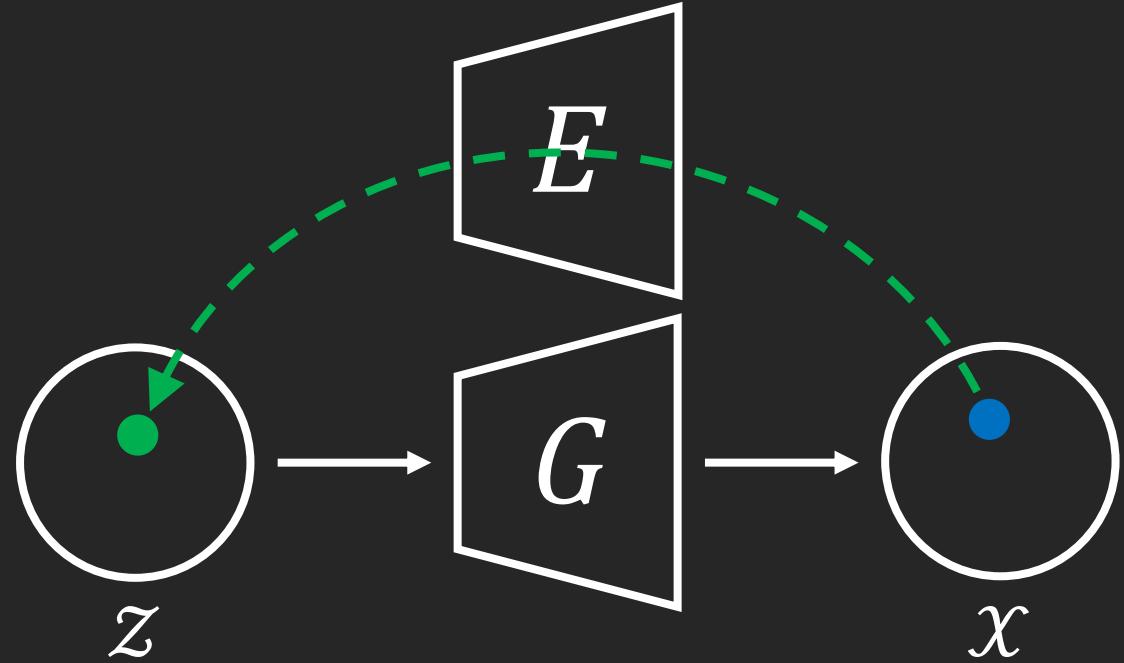
Reconstruction

Encoder-constrained Optimization

$$\mathbf{z}^* = \arg \min_{\mathbf{z}} \|\mathbf{G}(\mathbf{z}) - \mathbf{x}\|^2$$



Unconstrained Inversion



In-Domain Inversion

$$\mathbf{z}^* = \arg \min_{\mathbf{z}} \|\mathbf{G}(\mathbf{z}) - \mathbf{x}\|^2 + \|\mathbf{z} - E(\mathbf{G}(\mathbf{z}))\|^2$$

Comparison with Image2StyleGAN

Image2StyleGAN



In-Domain Inversion



Target

Reconstruction

Decrease age

Add smile

Add glasses

Demo of image manipulation



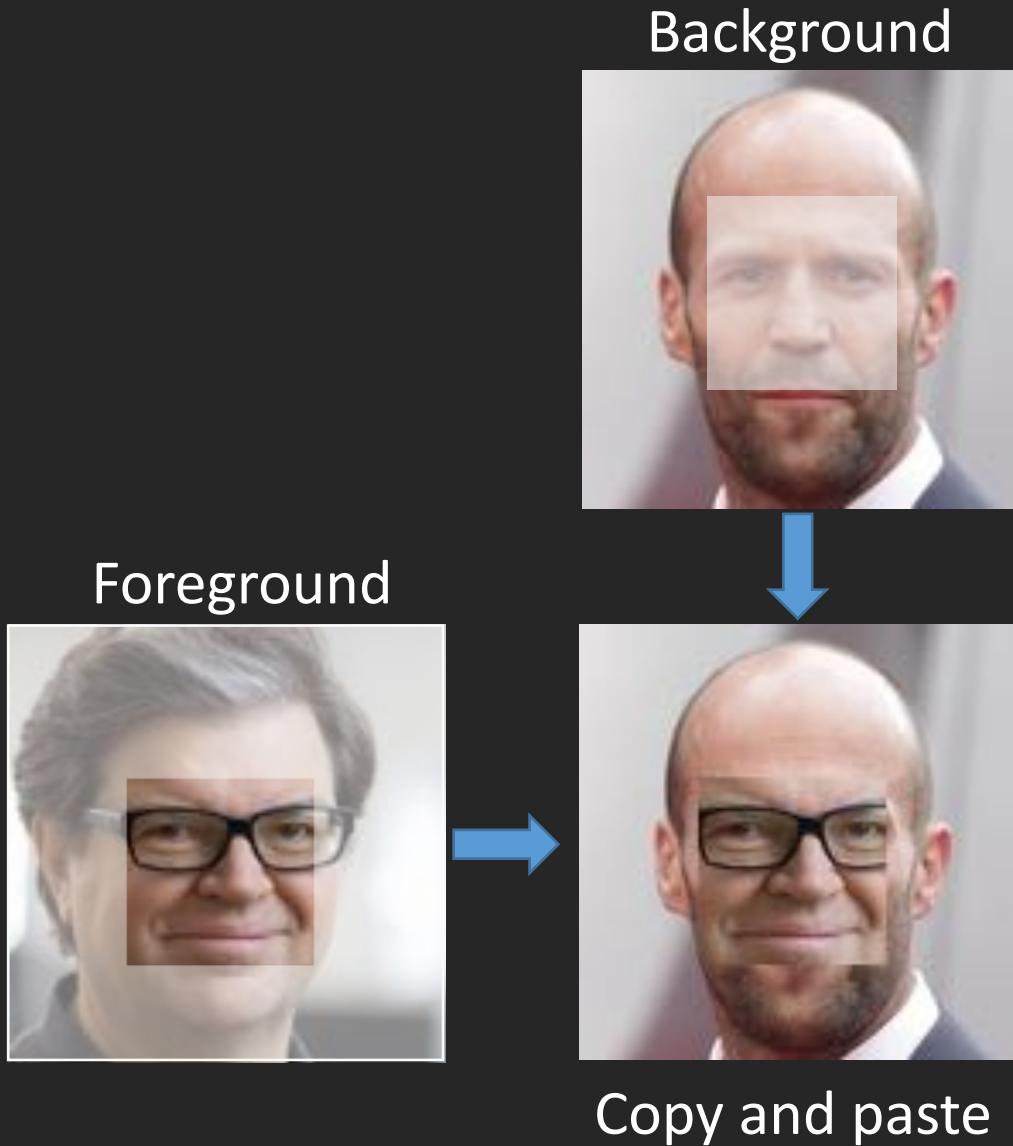
Expression

Demo of image interpolation



Face

Semantic Diffusion



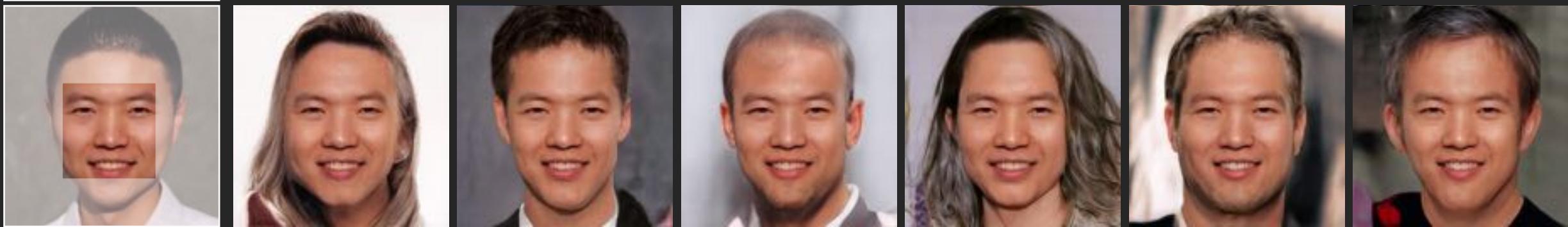
$$\begin{aligned} \mathbf{z}^* = \operatorname{argmax}_{\mathbf{z}} & ||\mathbf{m} \bullet G(\mathbf{z}) - \mathbf{m} \bullet \mathbf{x}||^2 \\ & + ||\mathbf{z} - E(G(\mathbf{z}))||^2 \end{aligned}$$



Background



Foreground

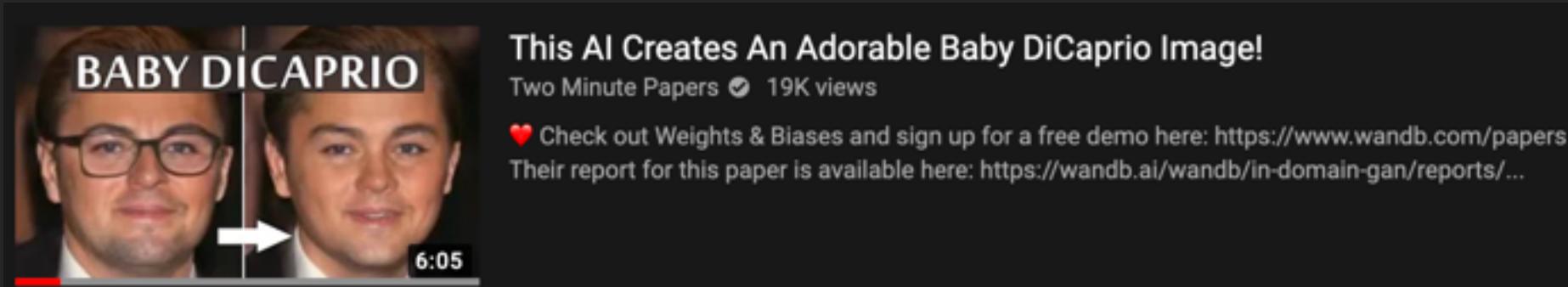


Live Demo: Try your own image!

- Colab:

https://colab.research.google.com/github/genforce/idinvert_pytorch/blob/master/docs/Idinvert.ipynb

Two Minute Papers Channel's report



<https://www.youtube.com/watch?v=2qMw8sOsNg0>

Tutorial Summary

- Overview of the generative models
- Interacting with deep generative models
- Slide: <https://github.com/zhoubolei/introGM>
- GenForce: <https://genforce.github.io/>

 GenForce
Research Initiative on Generative Modeling
May Generative Force Be with You

Projects

**GenForce Lib**
Yujun Shen, Yinghao Xu, Ceyuan Yang, Jiapeng Zhu, Bolei Zhou
This is an efficient PyTorch library for deep generative modeling.
[Code] [Colab]

**Generative Hierarchical Features from Synthesizing Images**
Yinghao Xu*, Yujun Shen*, Jiapeng Zhu, Ceyuan Yang, Bolei Zhou
arXiv.2007.10379 preprint
[Paper] [Project Page] [Code]

**Closed-Form Factorization of Latent Semantics in GANs**
Yujun Shen, Bolei Zhou
arXiv.2007.06600 preprint
[Paper] [Project Page] [Code] [Demo Video]

**InterFaceGAN: Interpreting the Disentangled Face Representation Learned by GANs**
Yujun Shen, Ceyuan Yang, Xiaou Tang, Bolei Zhou
IEEE Transactions on Pattern Recognition (TPAMI), Oct 2020
[Paper] [Project Page] [Code] [Demo Video]

**In-Domain GAN Inversion for Real Image Editing**
Jiapeng Zhu*, Yujun Shen*, Deli Zhao, Bolei Zhou
European Conference on Computer Vision (ECCV), 2020
[Paper] [Project Page] [Code] [Demo Video]