# Generative Adversarial Networks For Image to Image Translation

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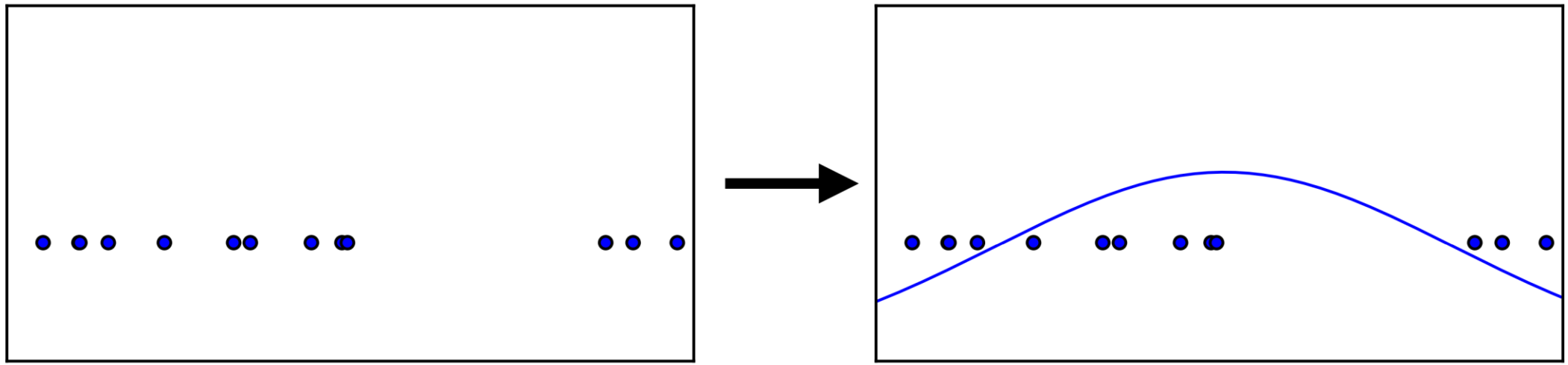
# Generative Modeling: Density Estimation



Training Data

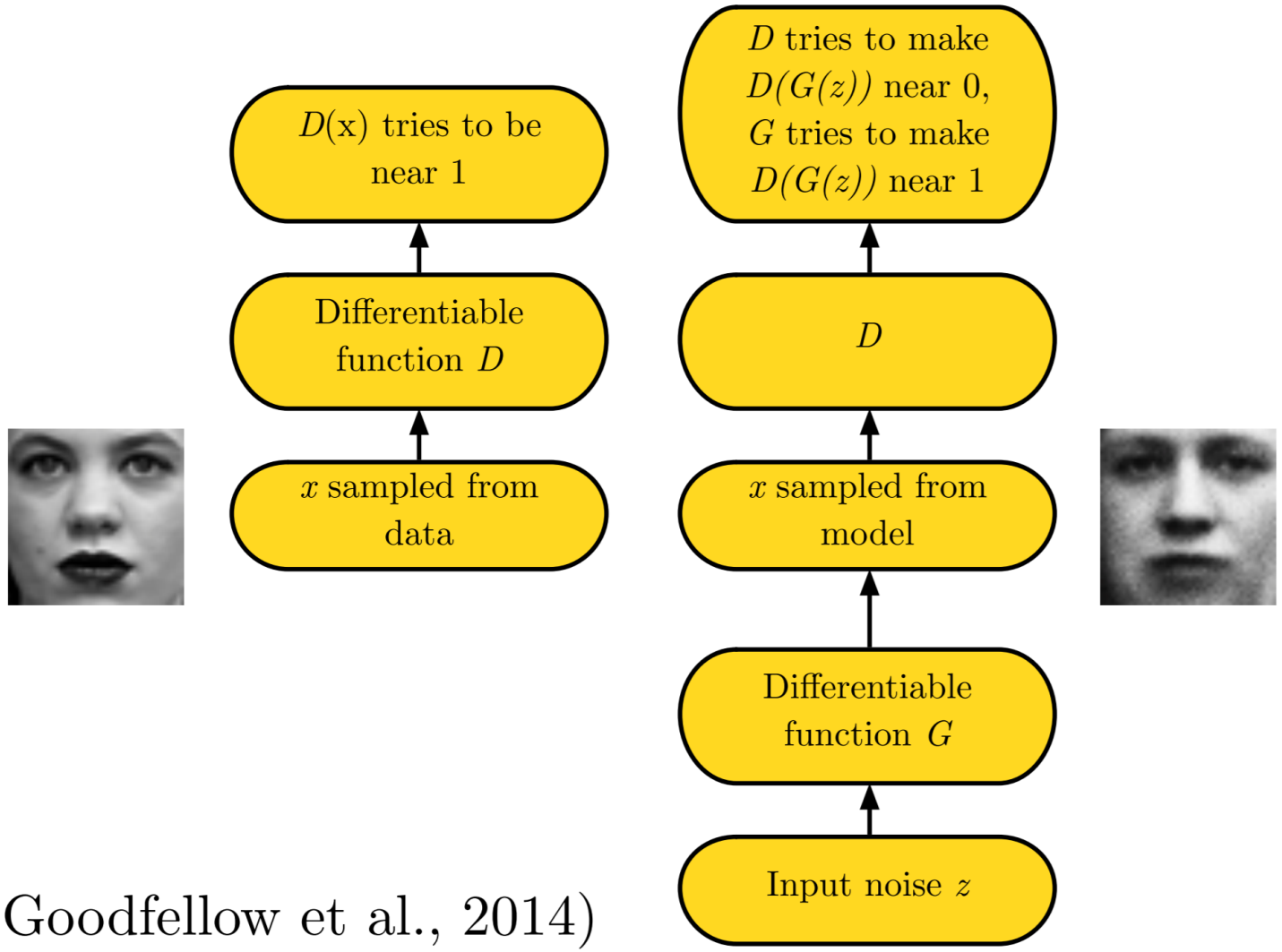
Density Function

# Generative Modeling: Sample Generation

Training Data
(CelebA)

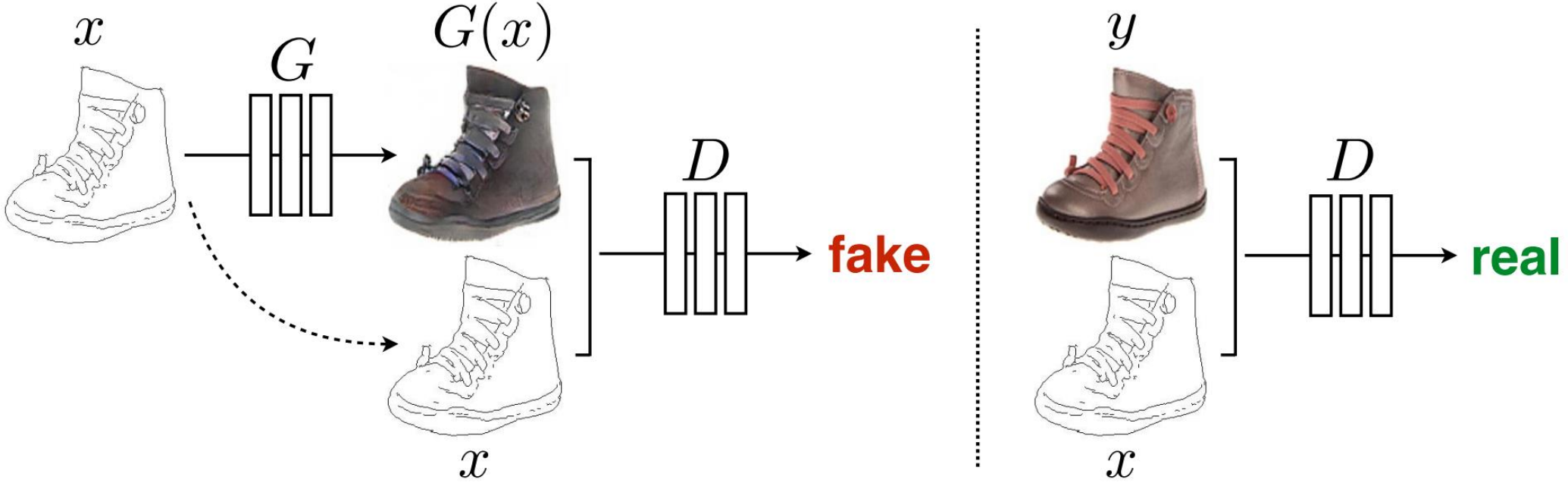
Sample Generator
(Karras et al, 2017)

# Adversarial Nets Framework

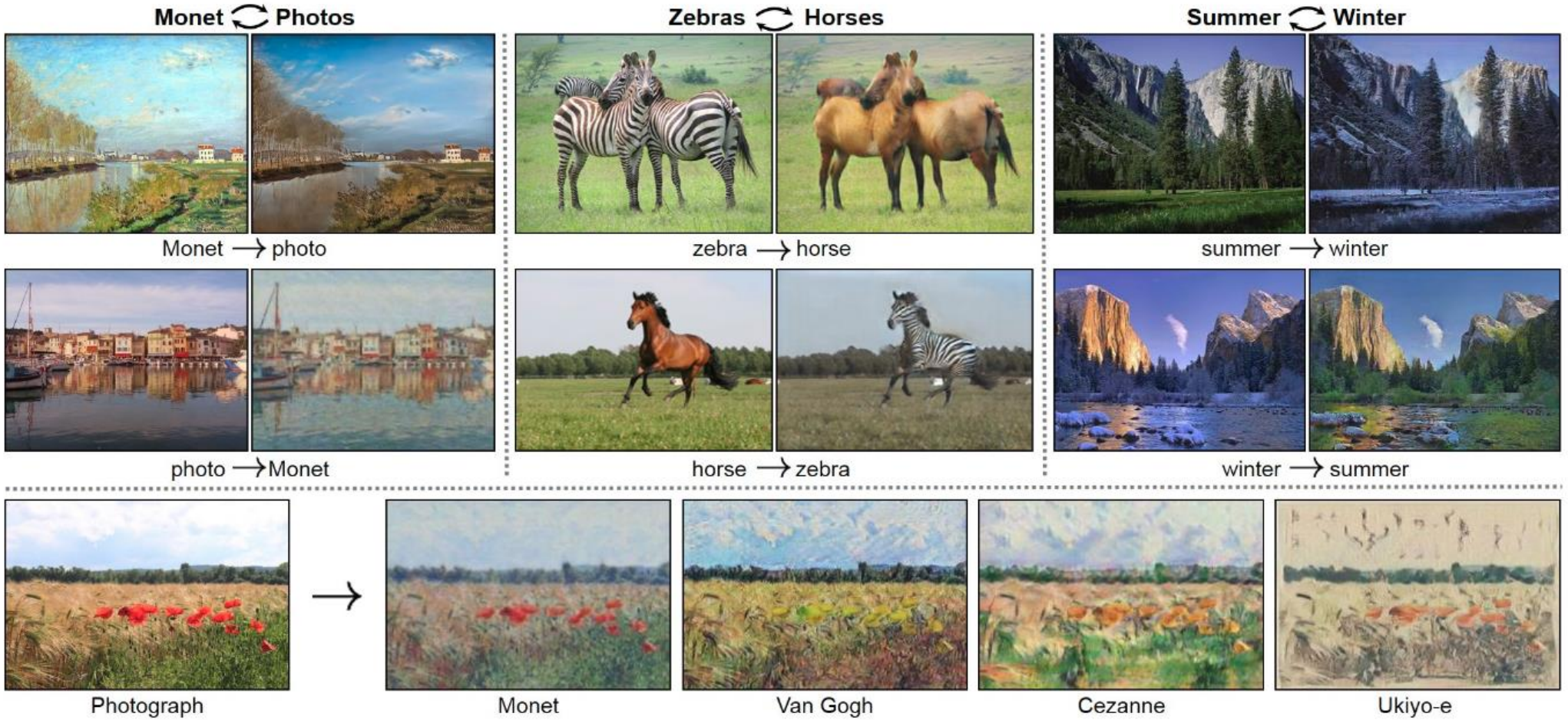



(Goodfellow et al., 2014)

# Conditional GAN

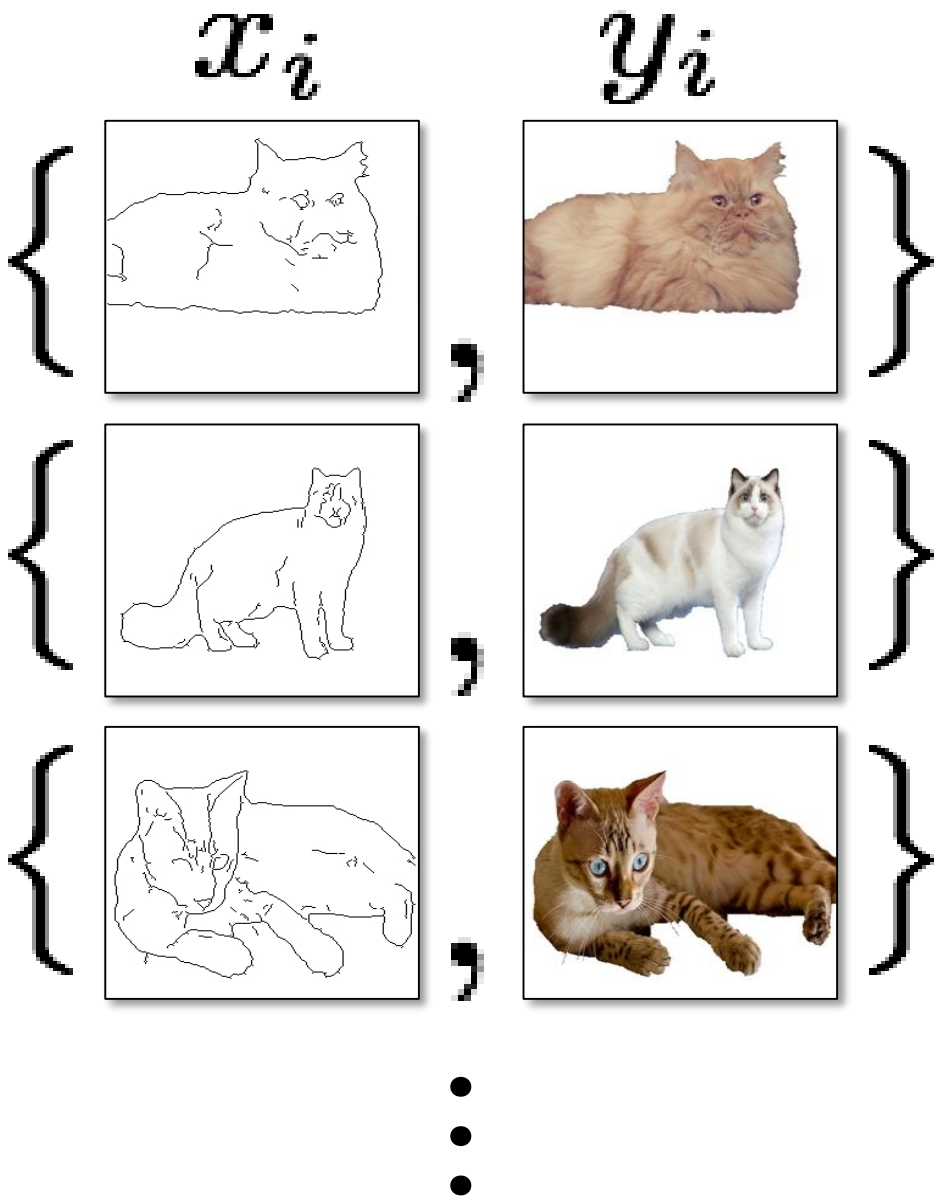


# Image to Image Translation

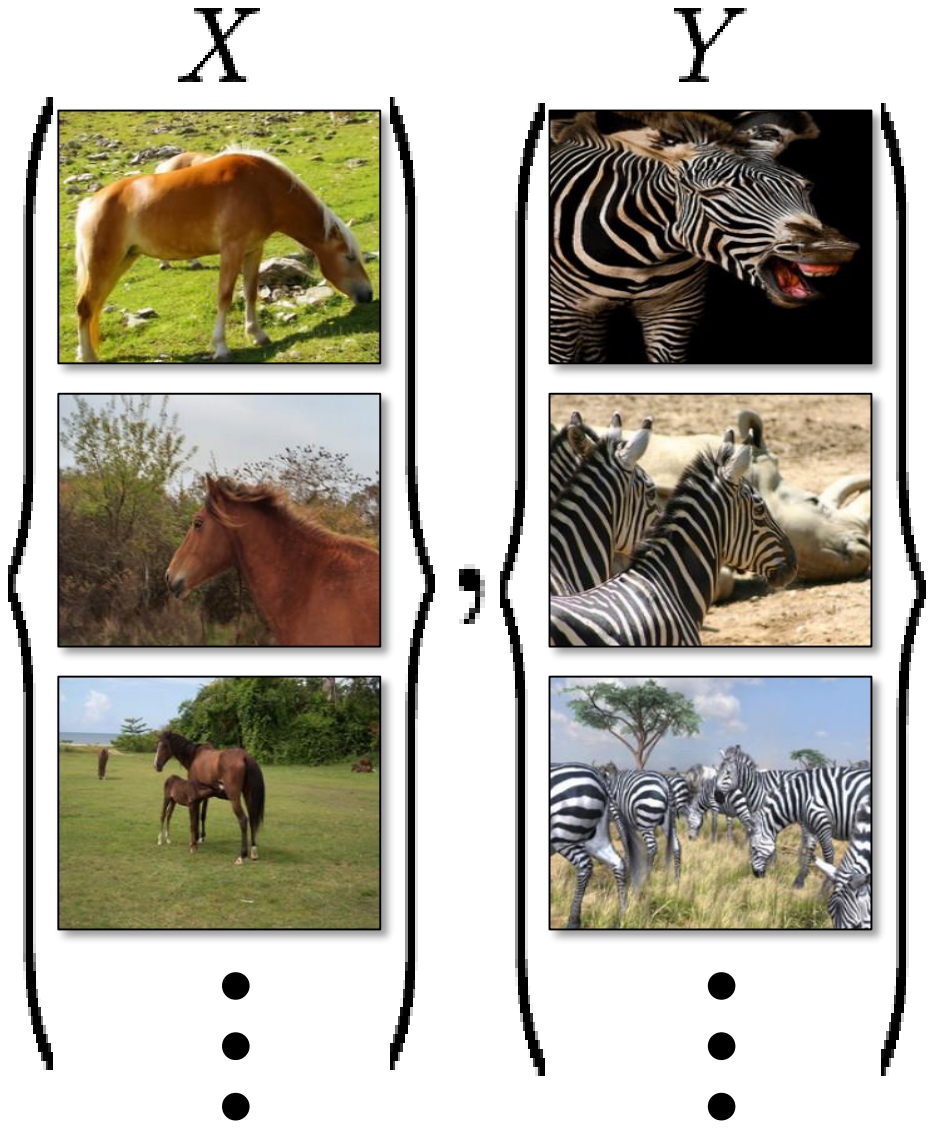


| | Supervised | Unsupervised |
|---|---|---|
| Unimodal | Pix2pix, CRN, SRGAN | DistanceGAN, CycleGAN, DiscoGAN, DualGAN, UNIT, DTN, StarGAN, OST |
| Multimodal | pix2pixHD, BicycleGAN | MUNIT, Augmented CycleGAN |

# Paired



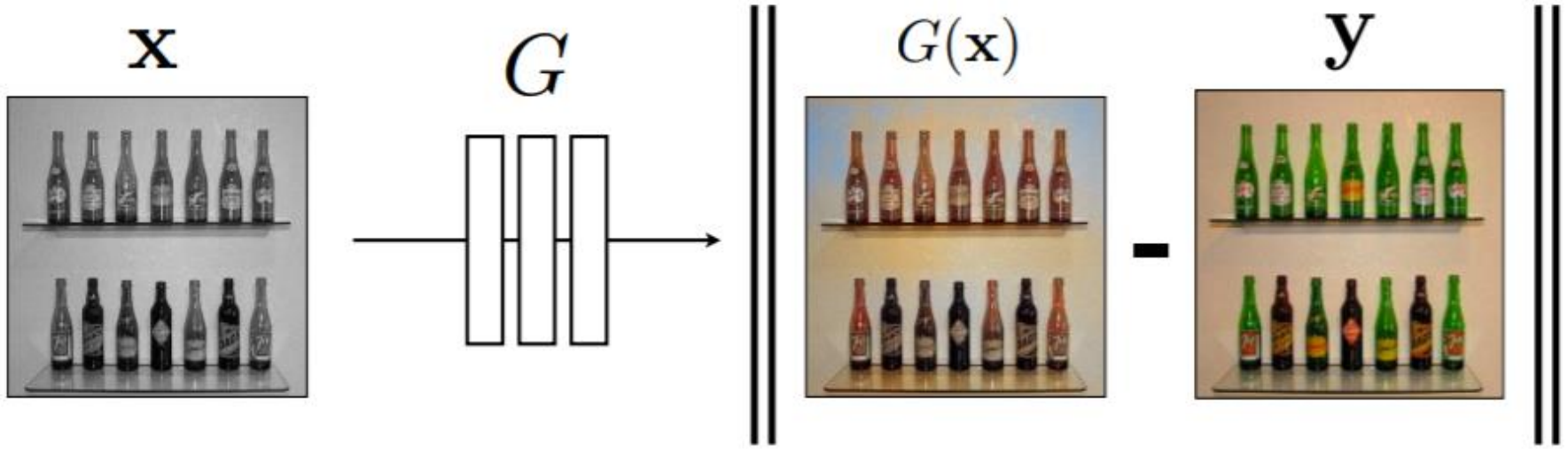

# Unpaired



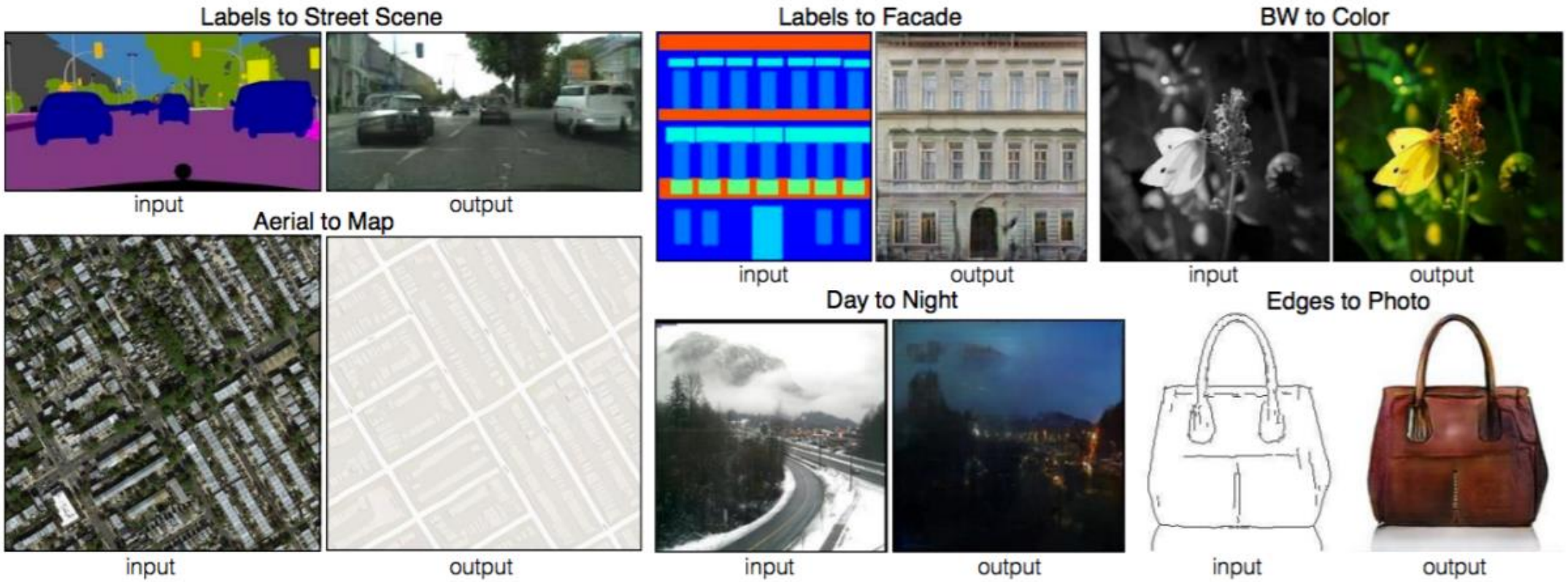
# Fully Supervised: pix2pix

Conditional GAN

$$G^* = \arg\min_G \max_D \mathcal{L}_{cGAN}(G, D) + \lambda \mathcal{L}_{L1}(G).$$




[Isola et al., CVPR 2017]




[Isola et al., CVPR 2017]

# Unsupervised: Circular GANs

**DiscoGAN**: “Learning to Discover Cross-Domain Relations with Generative Adversarial Networks”. Kim et al. ICML’17.

**CycleGAN**: “Unpaired Image-to-Image Translation using Cycle-Consistent Adversarial Networks”. Zhu et al. arXiv:1703.10593, 2017.

**DualGAN**: “ Unsupervised Dual Learning for Image-to-Image Translation”.  Zili et al. arXiv:1704.02510, 2017.

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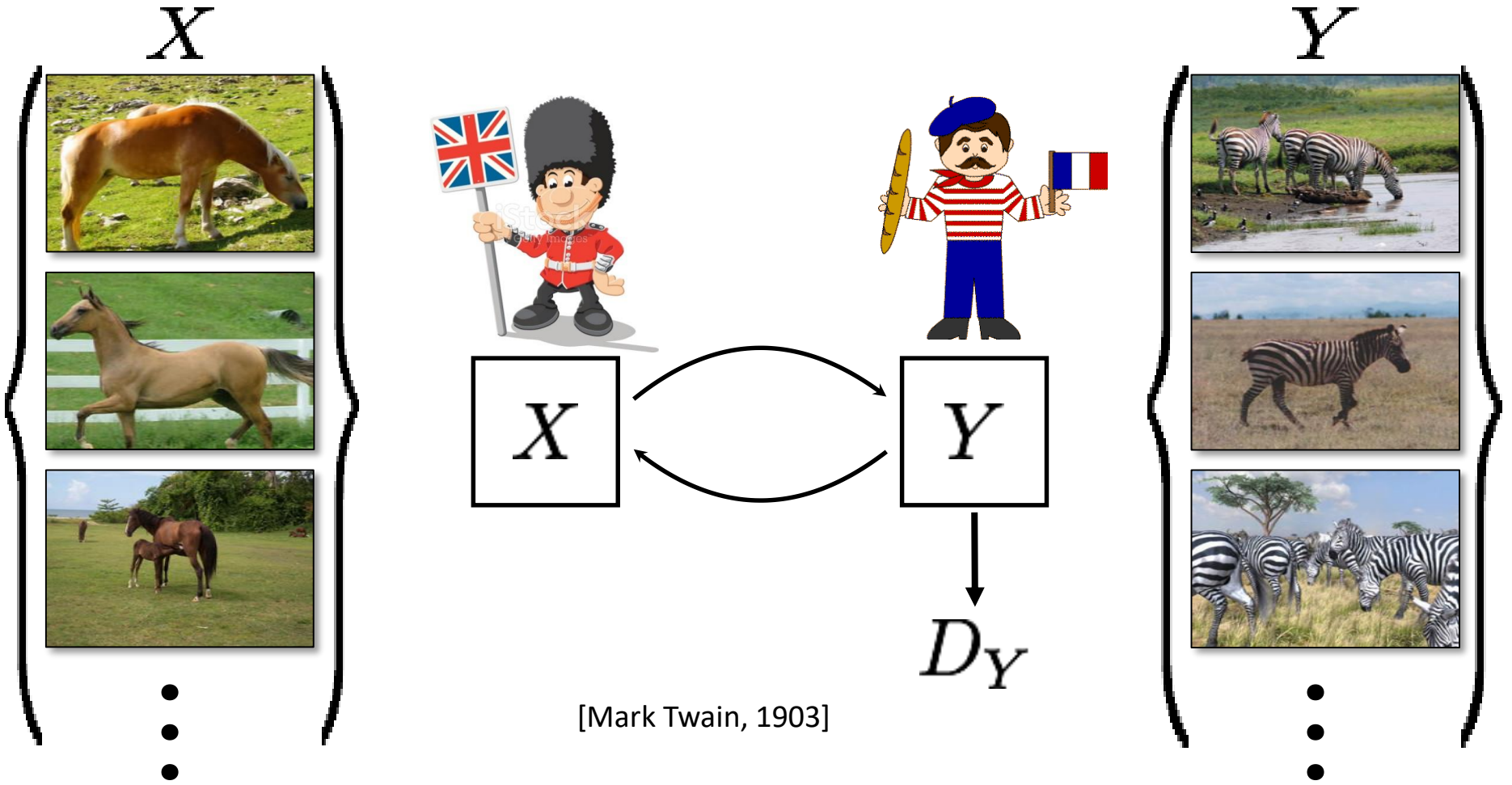
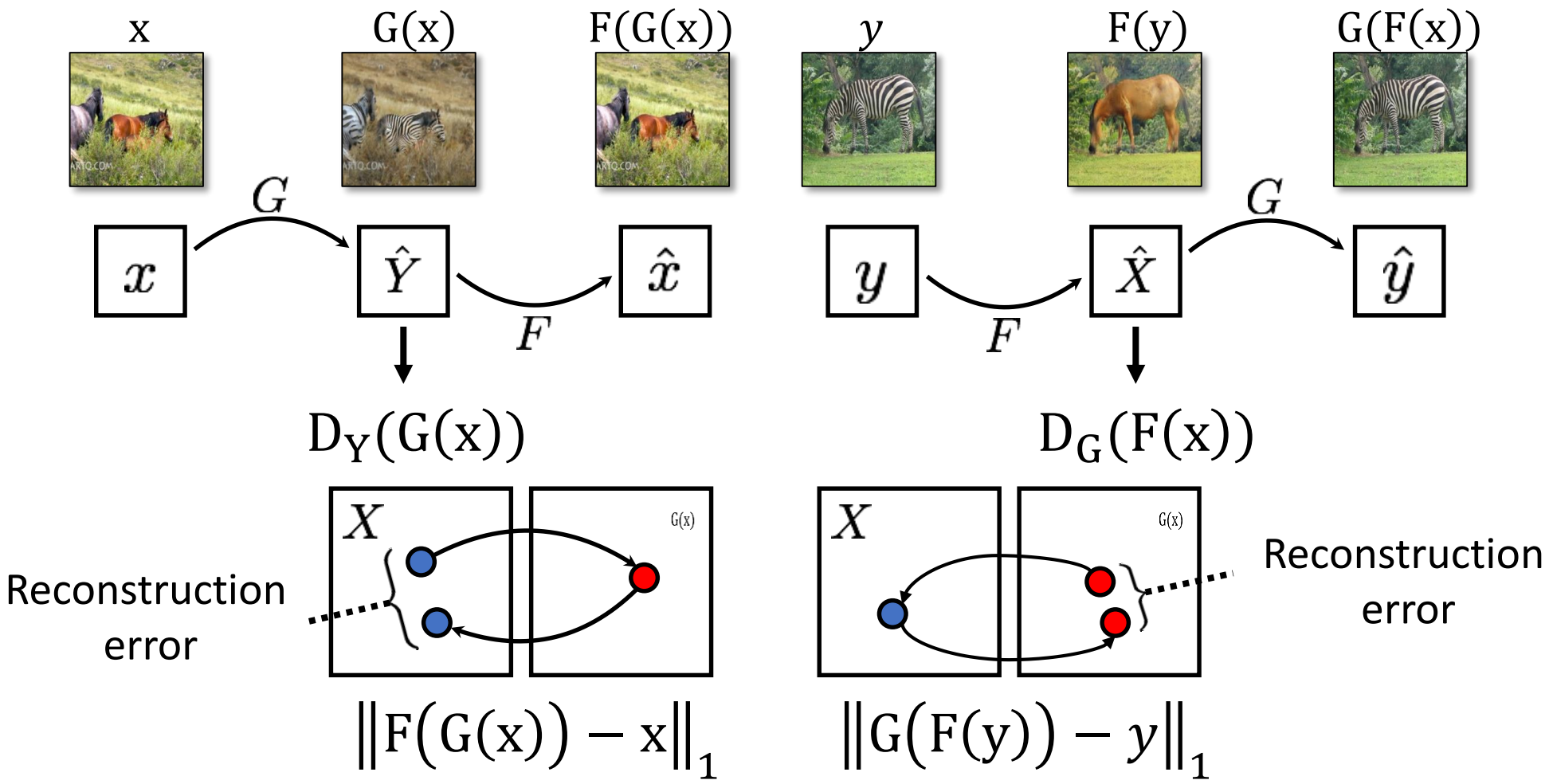
# Cycle-Consistent Adversarial Networks




[Mark Twain, 1903]

[Zhu et al., ICCV 2017]

# Cycle Consistency Loss




See similar formulations [Yi et al. 2017], [Kim et al. 2017]

[Zhu et al., ICCV 2017]

# Collection Style Transfer

Photograph
@ Alexei Efros

Monet

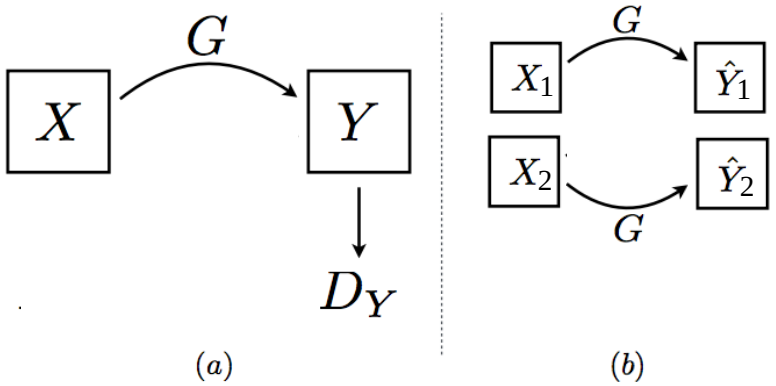
Van Gogh

Cezanne

Ukiyo-e

# DistanceGAN

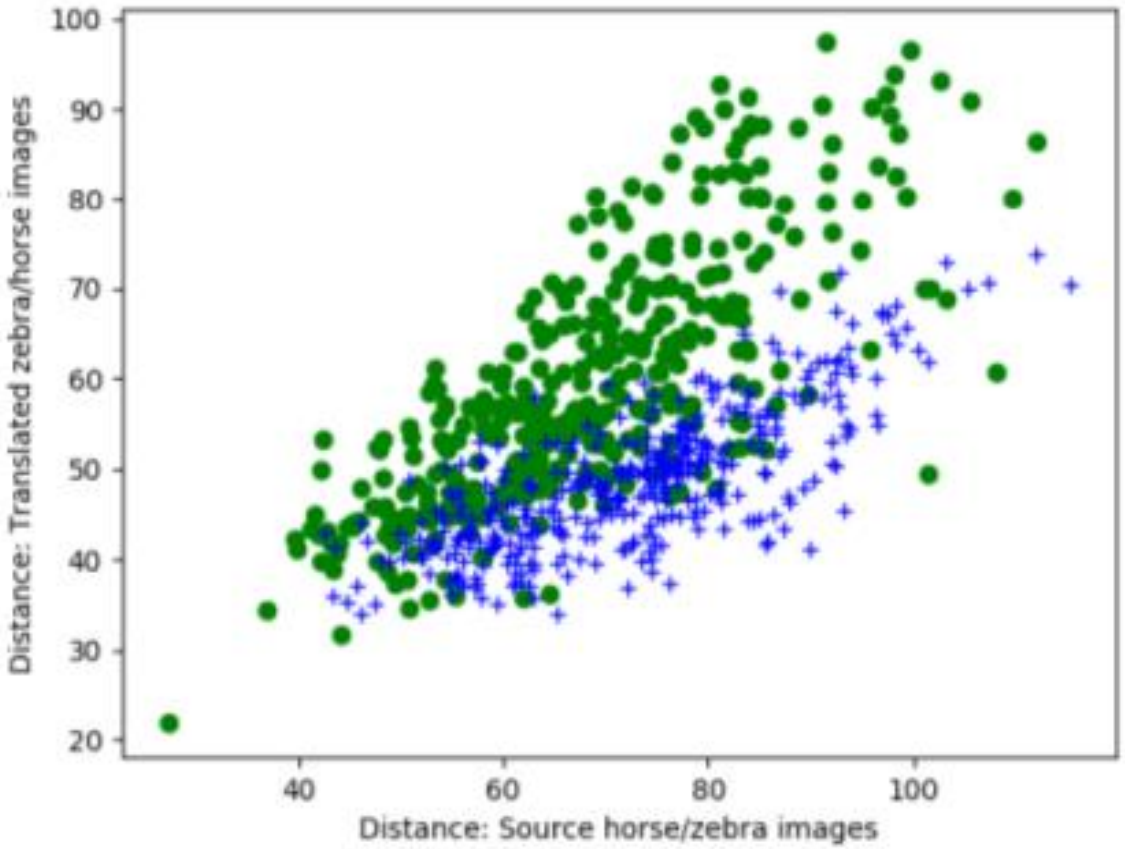
- A pair of images of a given distance are mapped to a pair of outputs with a similar distance
- $|x_i - x_j|_1$ and $|G(x_i) - G(x_j)|_1$ are highly correlated.




$$|x_1 - x_2|_1 \sim |G(x_1) - G(x_2)|_1$$

Benaim et al., NIPS 2017

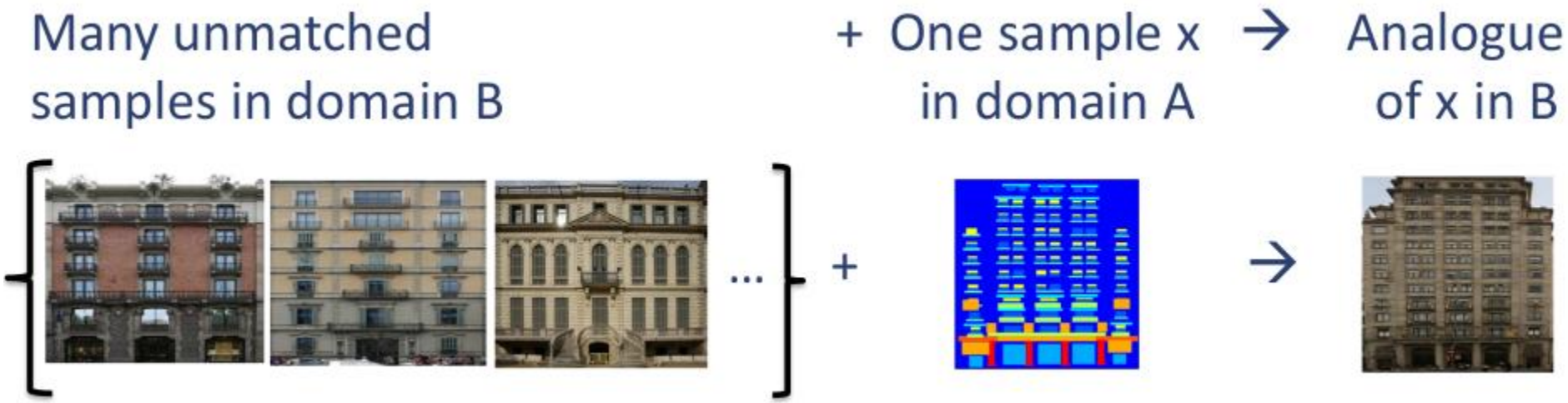
# Motivating distance correlations



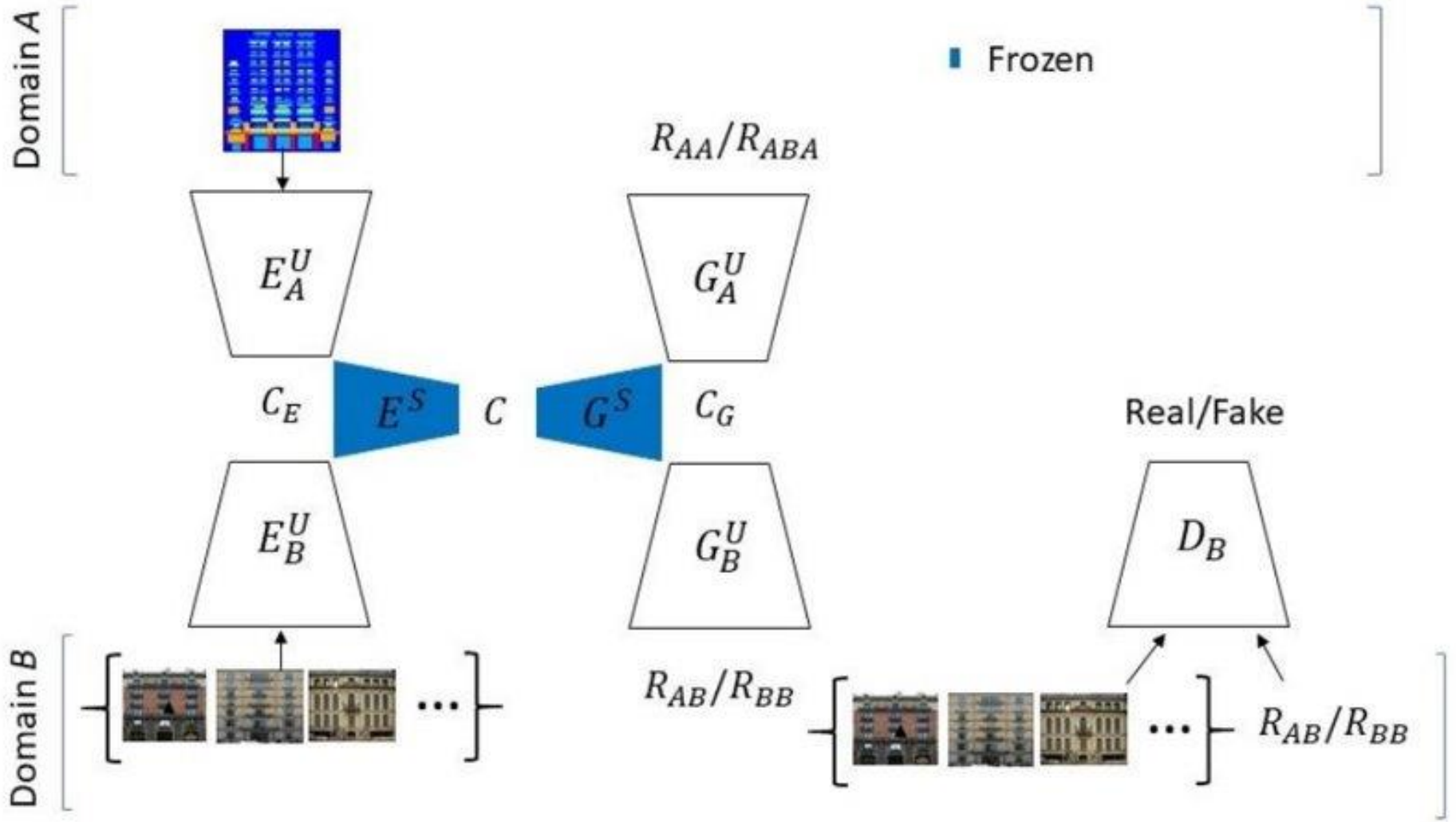

Analysis of CycleGAN's horse to zebra results

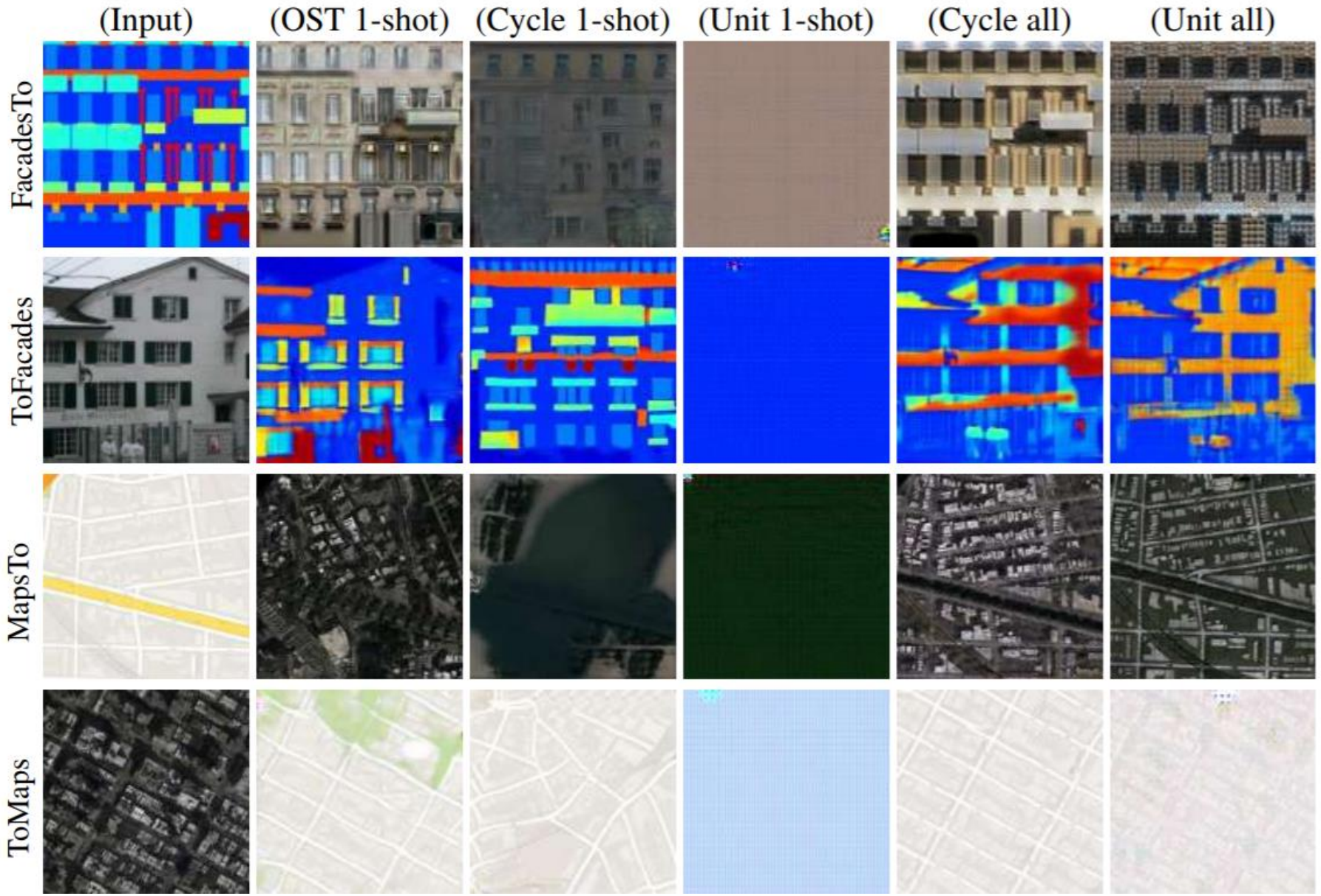
Benaim et al., NIPS 2017

# Less Supervision: Only a single image in domain A

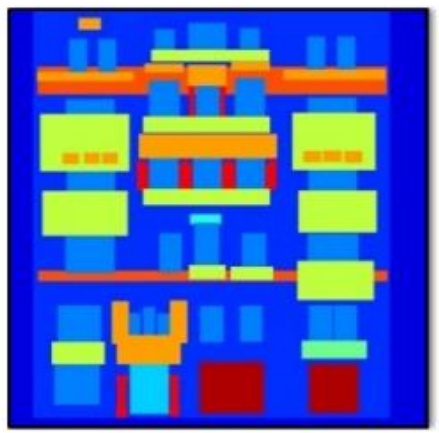



One Shot Unsupervised Cross Domain Translation (NeurIPS 2018)


Domain A
Frozen
$R_{AA}/R_{ABA}$
$E_A^U$
$G_A^U$
$C_E$
$E^S$
$C$
$G^S$
$C_G$
Real/Fake
$E_B^U$
$G_B^U$
$D_B$
Domain B
$R_{AB}/R_{BB}$
$R_{AB}/R_{BB}$


(Input)
(OST 1-shot)
(Cycle 1-shot)
(Unit 1-shot)
(Cycle all)
(Unit all)
FacadesTo
ToFacades
MapsTo
ToMaps

# Modeling multiple possible outputs



Input

?

?

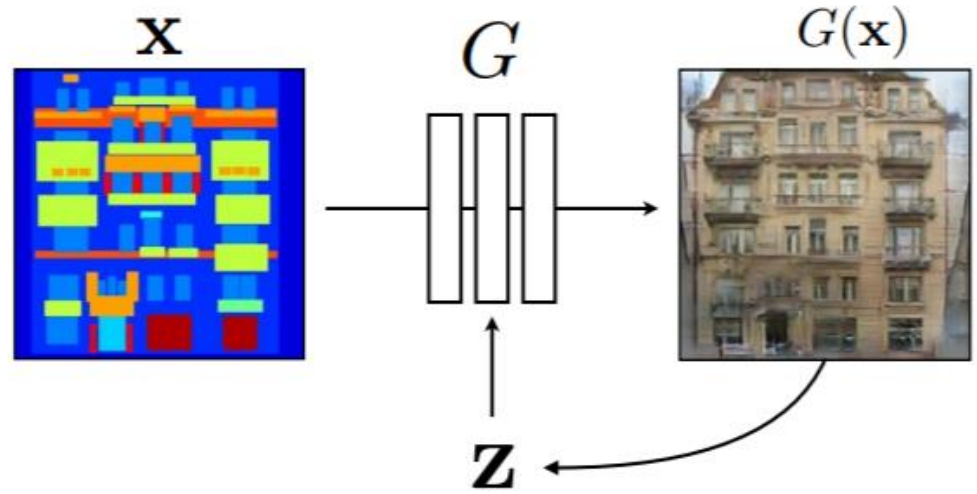
?

?

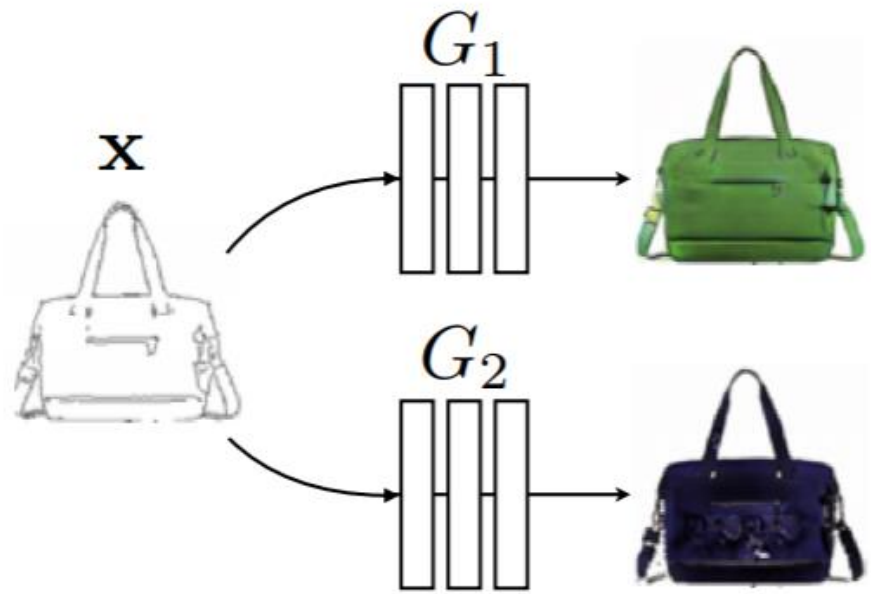
?

Possible outputs

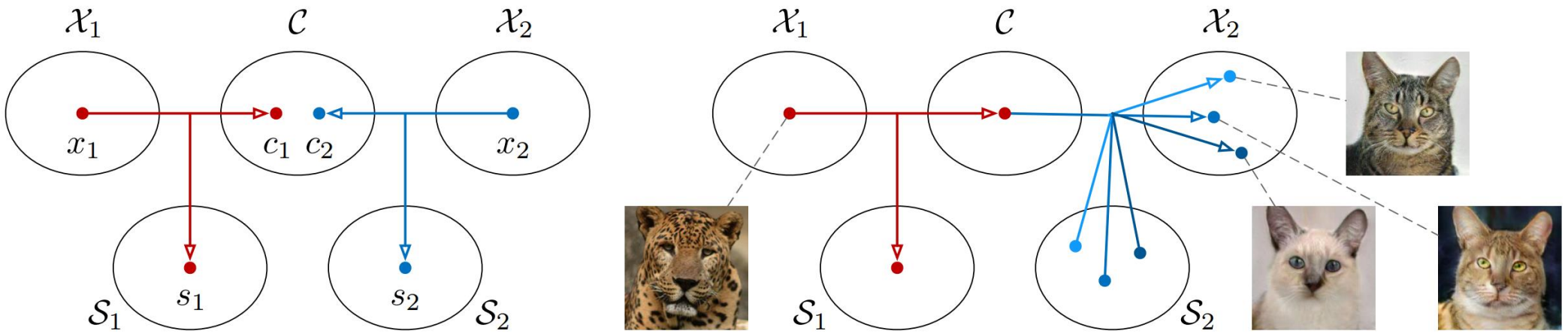
**BiCycleGAN** [Zhu et al., NIPS 2017]
(c.f. InfoGAN [Chen et al. 2016])




**MAD-GAN** [Ghosh et al., CVPR 2018]



# MUNIT: Multimodal Translation




(a) Auto-encoding

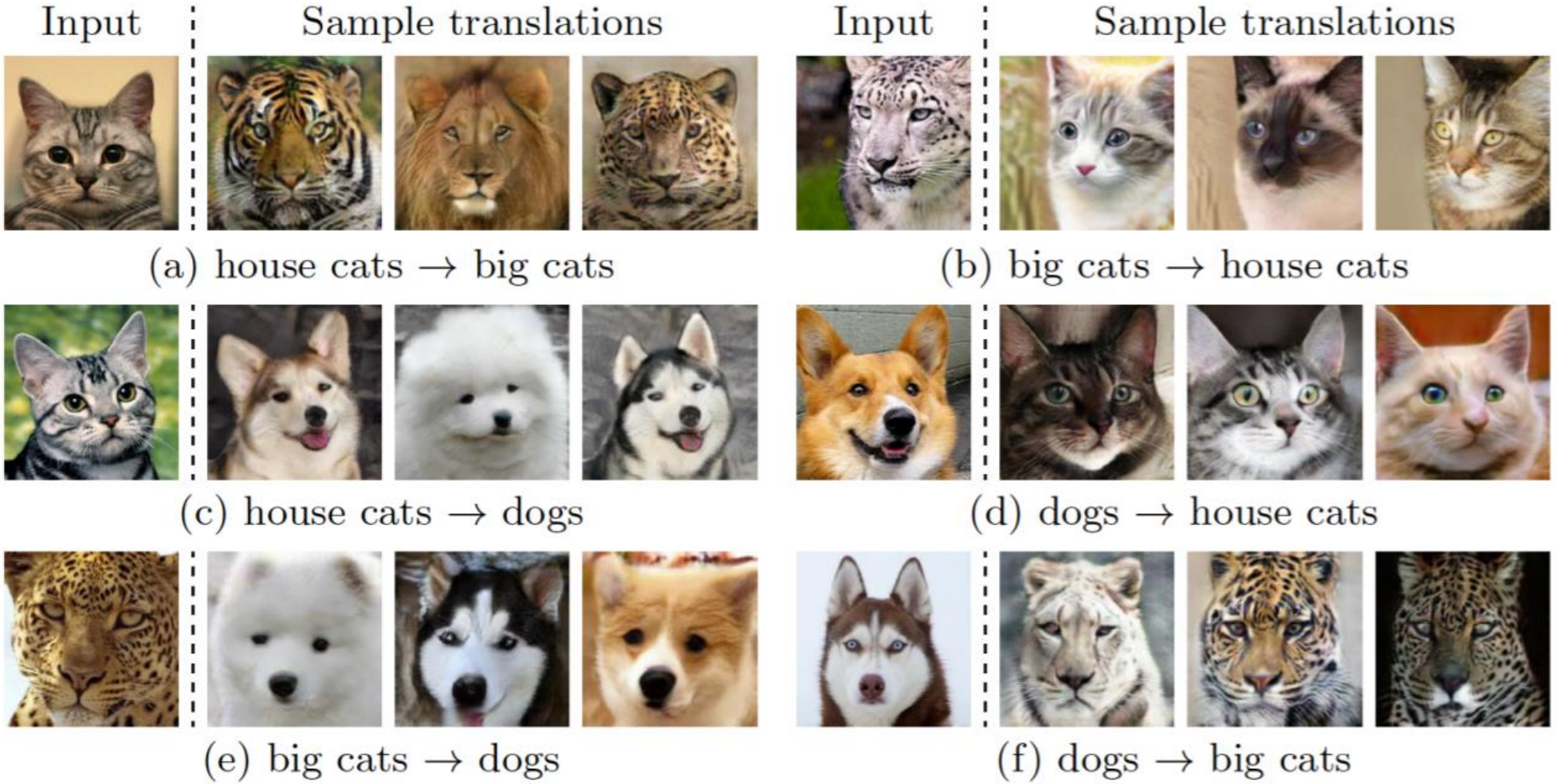
(b) Translation

Huang et al., ECCV 2018

# Sketch to Image Translation

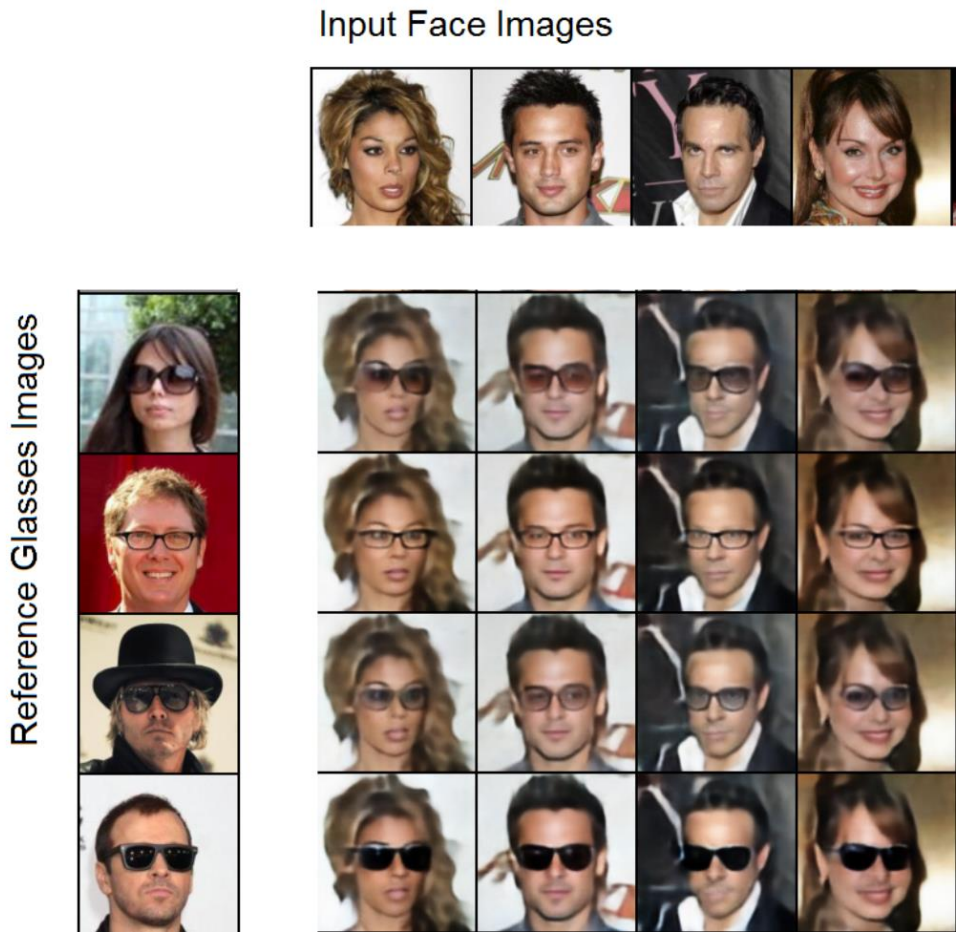

Huang et al., ECCV 2018

# Animal Image Translation

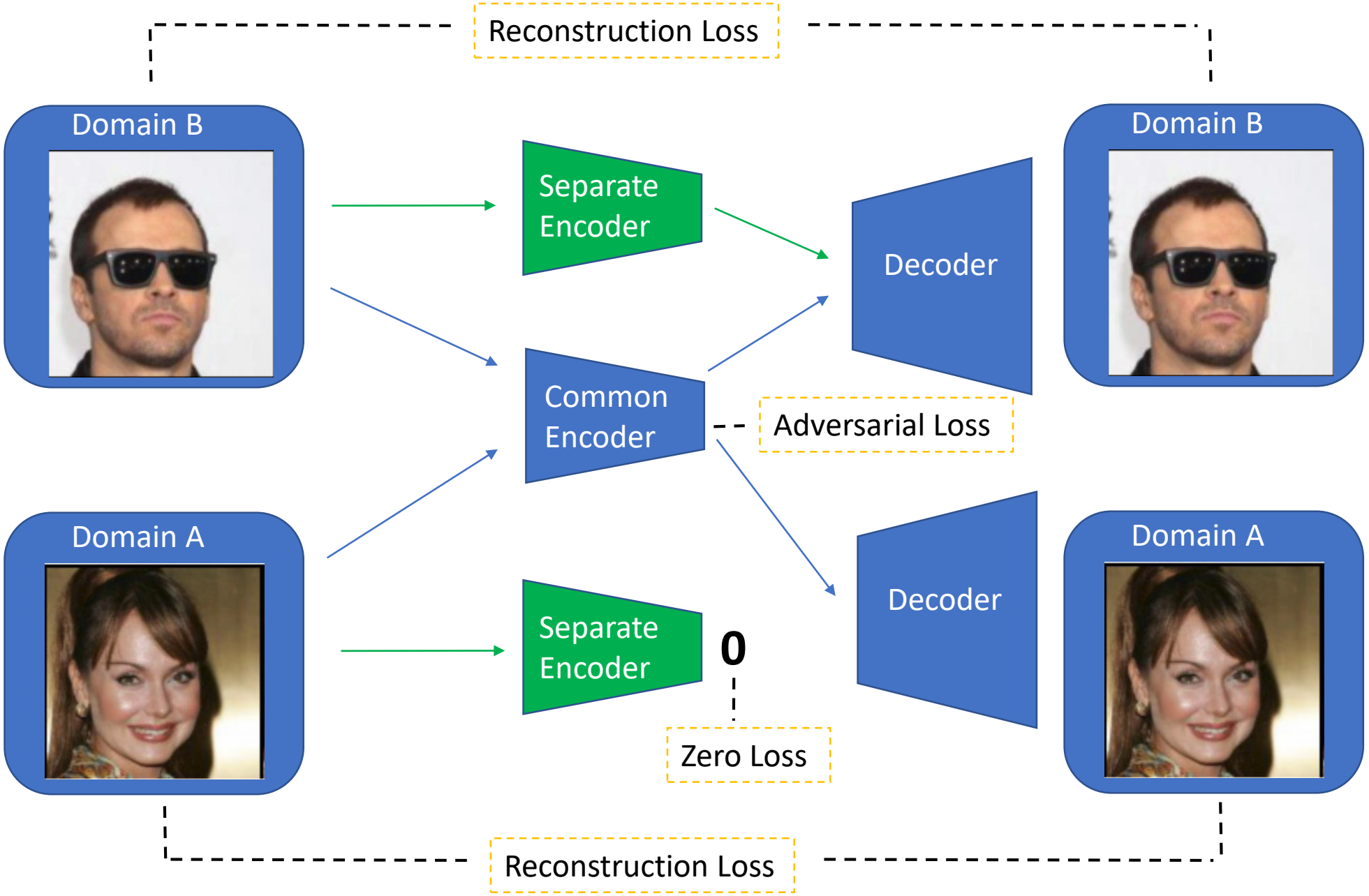



Huang et al., ECCV 2018

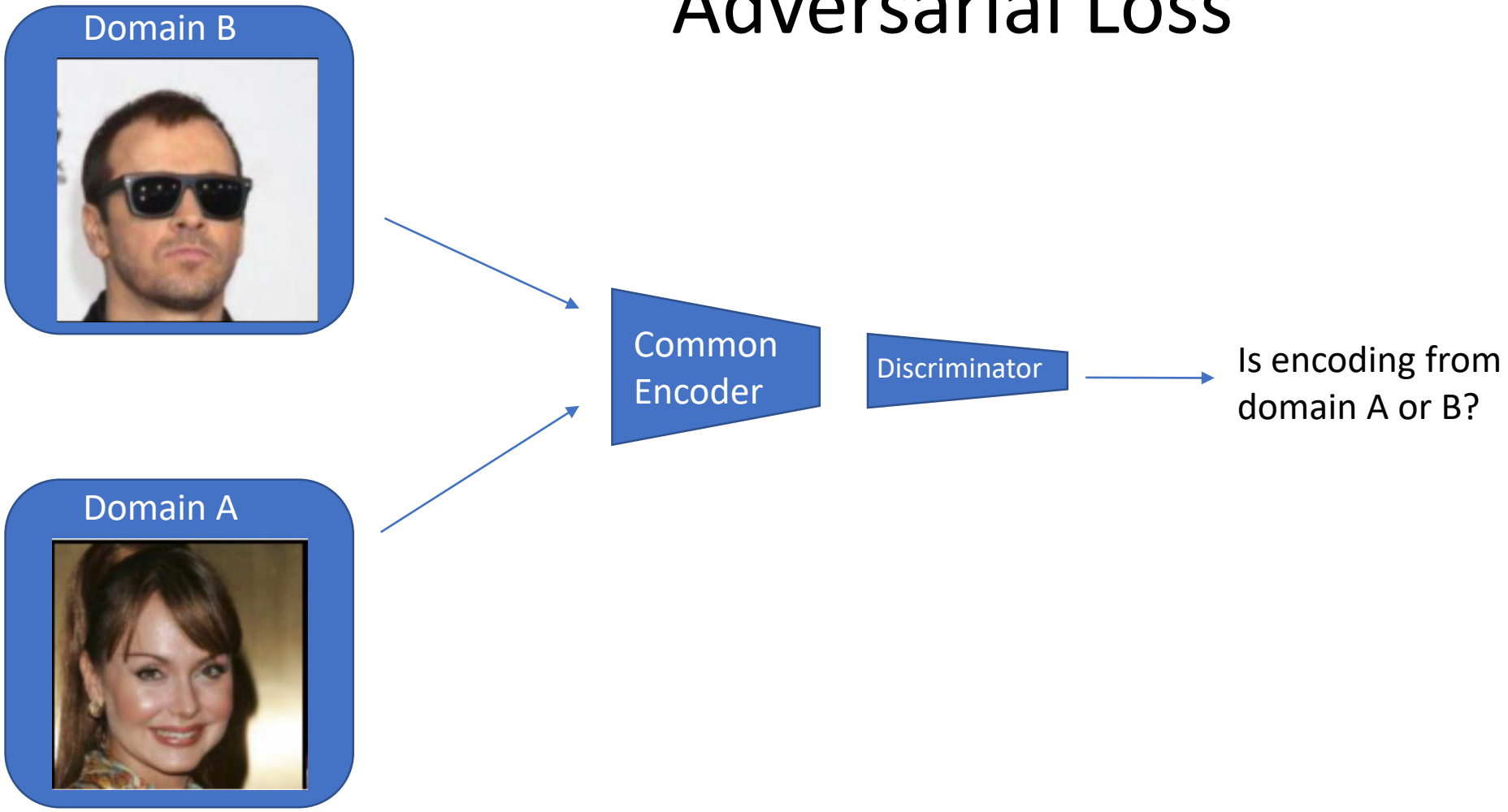
# Full Content Disentanglement




"Emerging Disentanglement in Auto-Encoder Based Unsupervised Image Content Transfer", ICLR 2019


Reconstruction Loss
Domain B
Separate Encoder
Decoder
Domain B
Common Encoder
Adversarial Loss
Domain A
Separate Encoder
0
Decoder
Domain A
Zero Loss
Reconstruction Loss

# Adversarial Loss



# Other Domains?

- Audio Separation: Training data consists of a set of samples of mixed music and an unmatched set of instrumental music.
- Given a mixed sample, wish the separate the voice from the background instrumental music.
- After mapping the audio sample to a Spectrogram, can subtract the “background” from the “mixed” sample in “pixel space”, to get the “voice” only sample.
- Samples at: https://sagiebenaim.github.io/Singing/

"Semi-Supervised Monaural Singing Voice Separation With a Masking Network Trained on Synthetic Mixtures." ICASSP 2019

# Video to Video

- Use GAN to generate each from in a video
- Use optical flow to further constrain the generator
- Samples at: https://github.com/NVIDIA/vid2vid

"High Resolution photorealistic video to video translation." NeurIPS 2018

# Many More Applications

- Many other Vision Applications: Photo Enhancement, Image Dehazing
- Medical Imaging and Biology [Wolterink et al., 2017]
- Voice conversion [Fang et al., 2018, Kaneko et al., 2017]
- Cryptography [CipherGAN: Gomez et al., ICLR 2018]
- Robotics
- NLP: Unsupervised machine translation.
- NLP: Text style transfer.
- …

# Thank You! Questions?