Generative Adversarial Networks

Ian Goodfellow
Research Scientist
OpenAI

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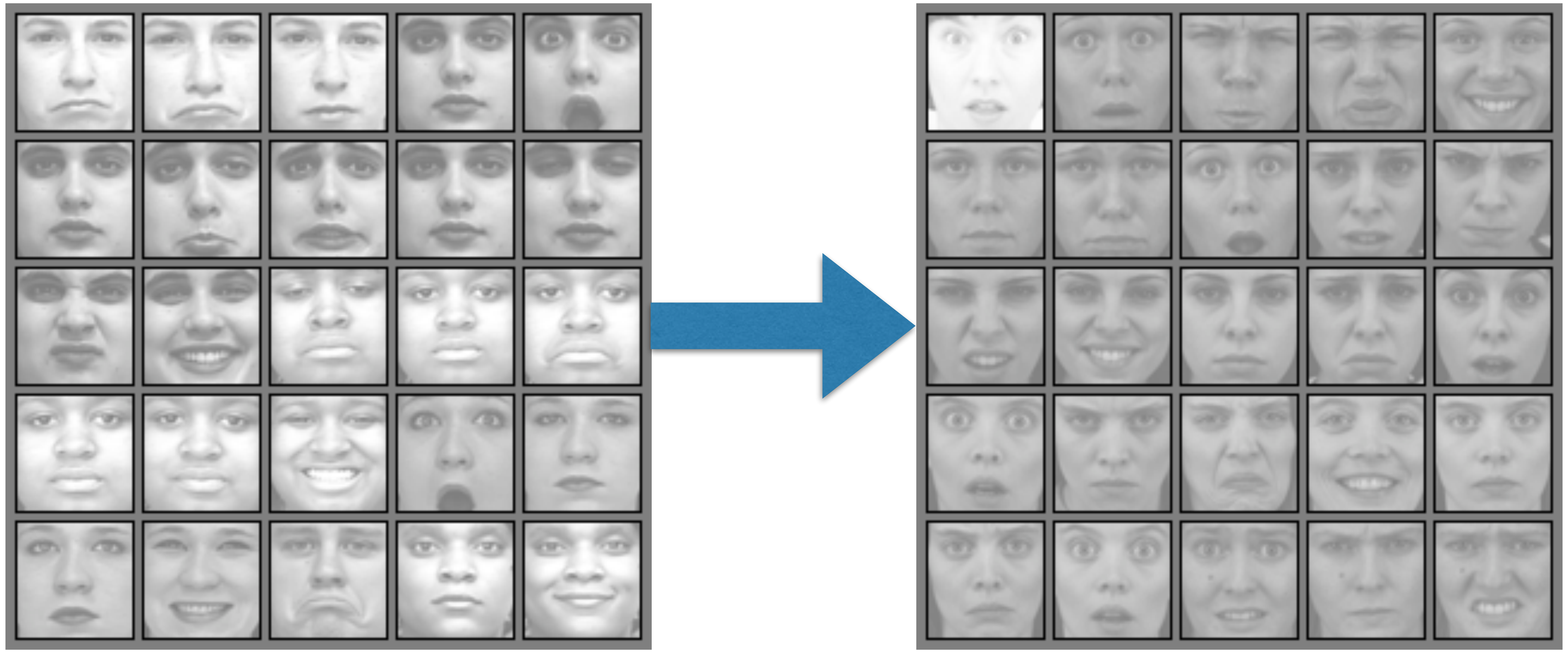
Generative Modeling

- Have training examples: $\boldsymbol{x} \sim p_{\text{train}}(\boldsymbol{x})$

- Want a model that can draw samples: $\boldsymbol{x} \sim p_{\text{model}}(\boldsymbol{x})$

- Want $p_{\text{model}}(\boldsymbol{x}) = p_{\text{data}}(\boldsymbol{x})$



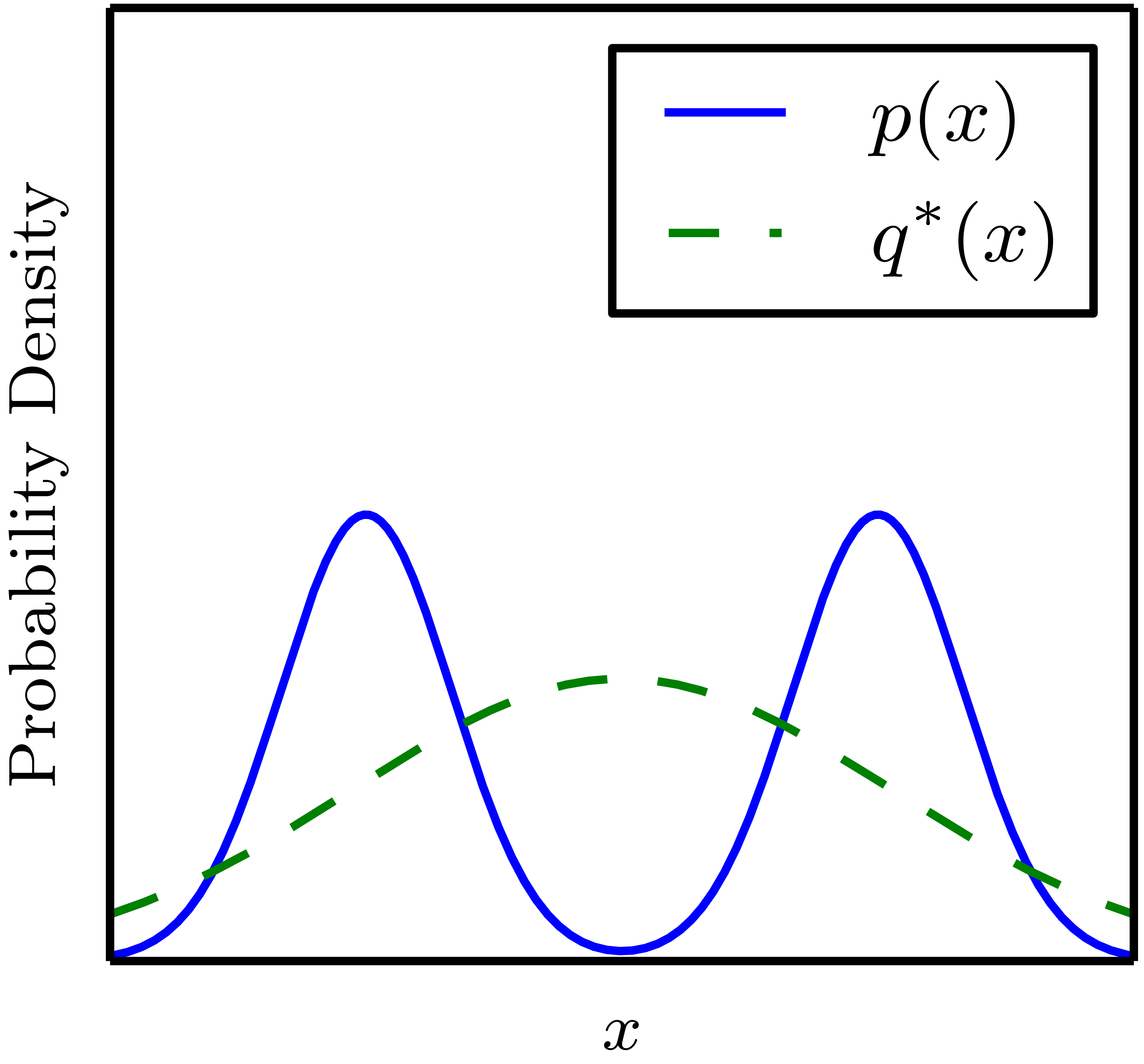
(Images from Toronto Face Database)

Example Applications

- Image manipulation
- Text to speech
- Machine translation

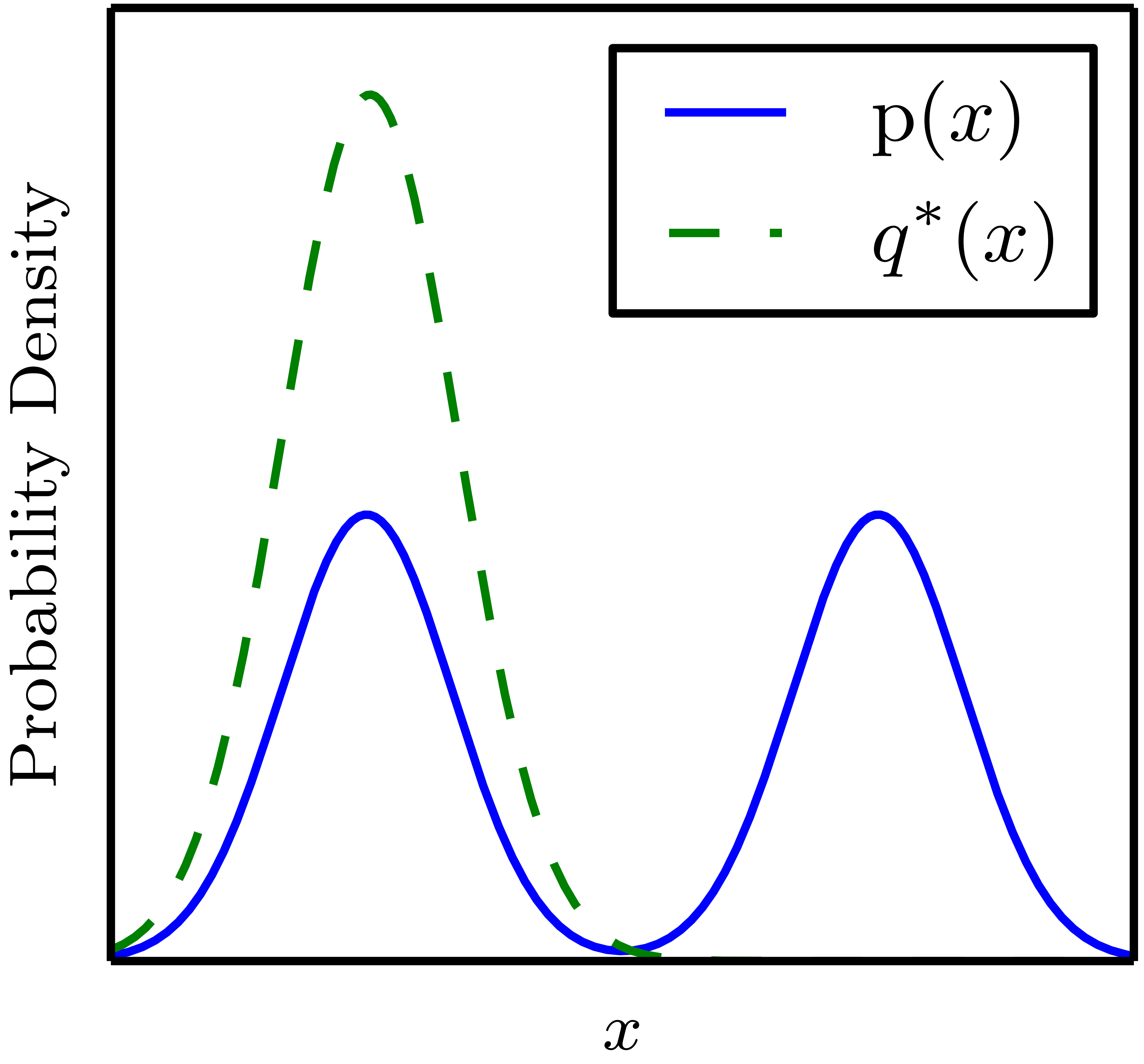
Modeling Priorities

$q^* = \text{argmin}_q D_{\text{KL}}(p\|q)$



Put high probability where there should be high probability

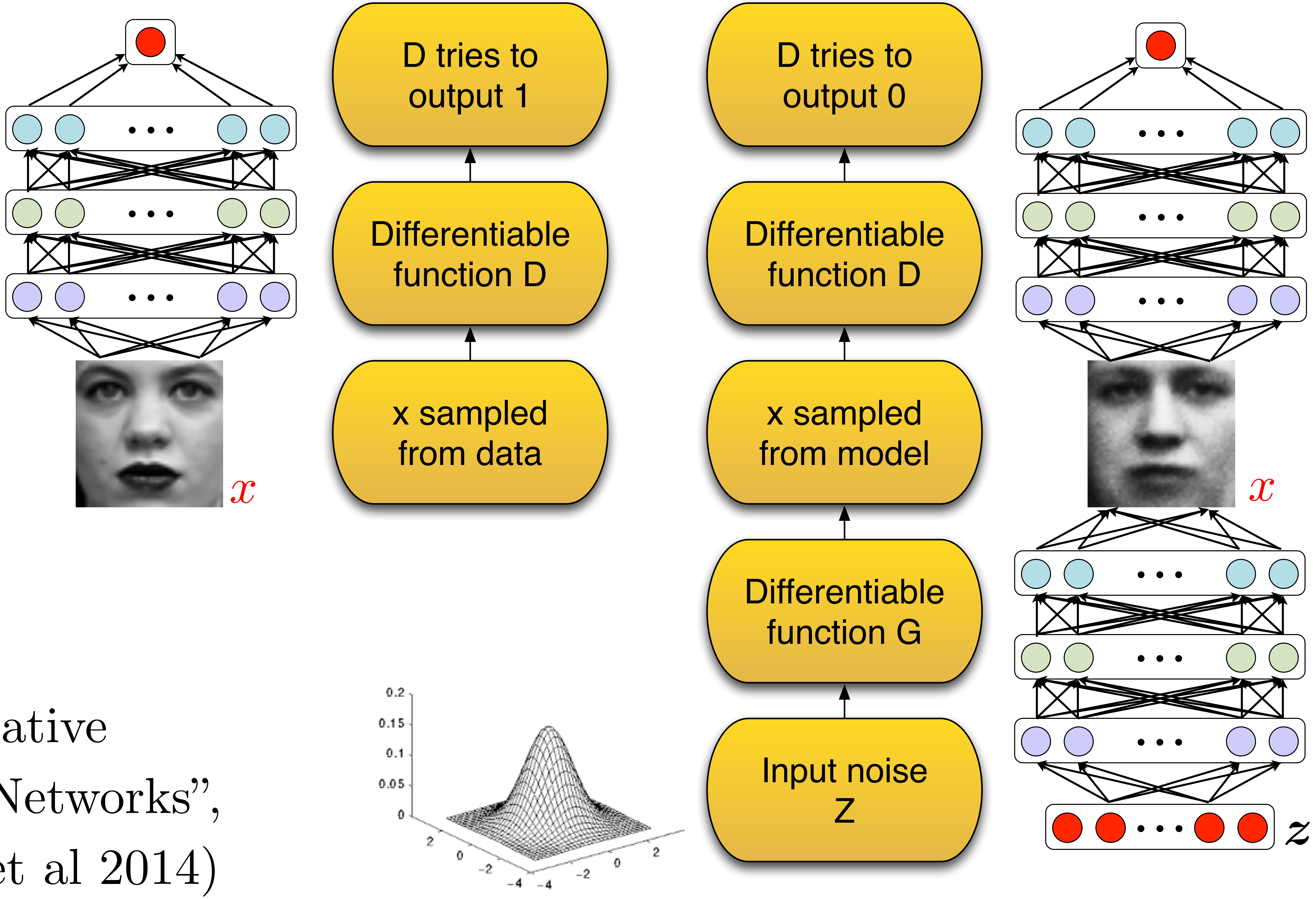
$q^* = \text{argmin}_q D_{\text{KL}}(q\|p)$



Put low probability where there should be low probability

(*Deep Learning*, Goodfellow, Bengio, and Courville 2016)

Generative Adversarial Networks

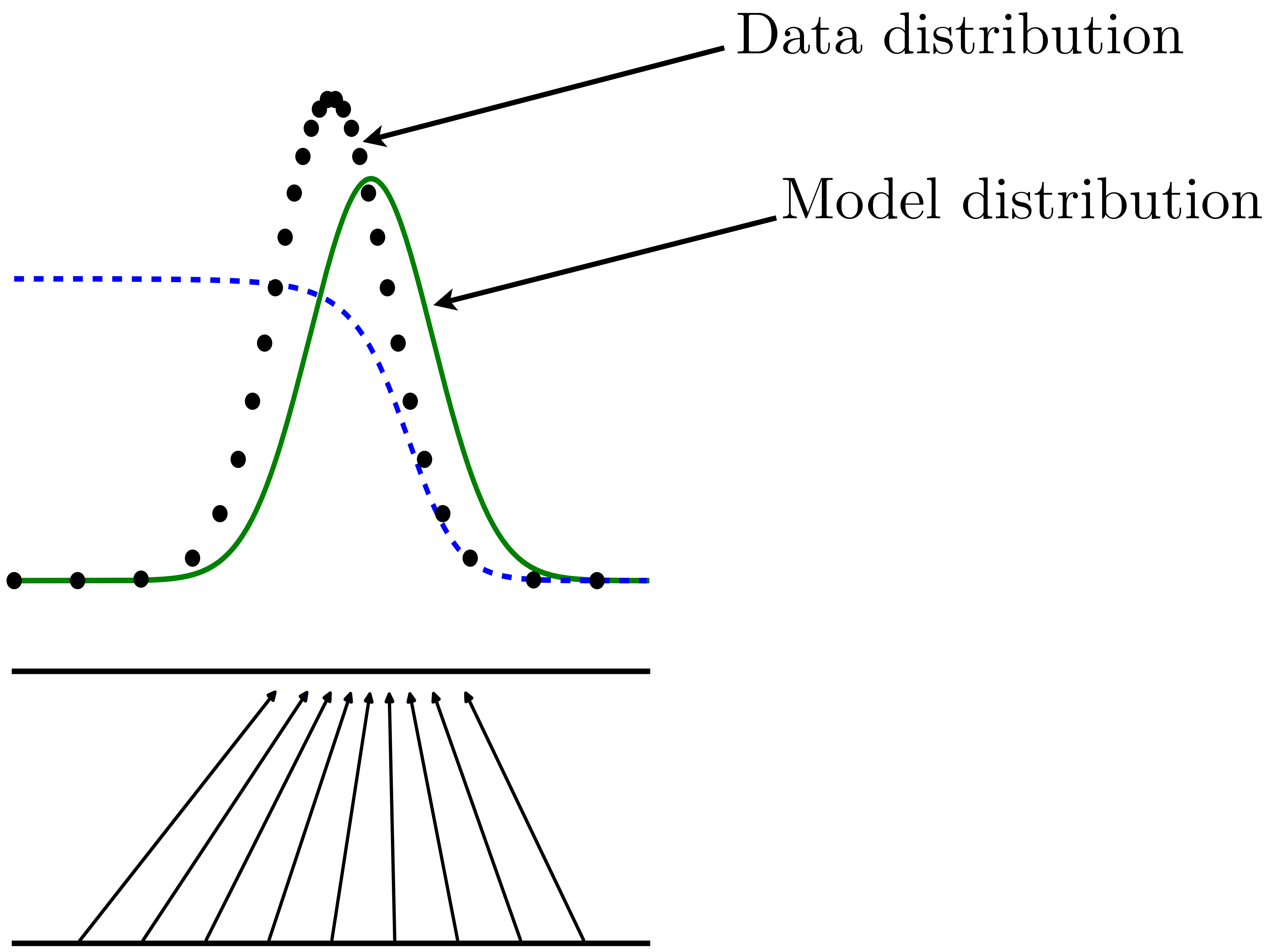


("Generative Adversarial Networks", Goodfellow et al 2014)

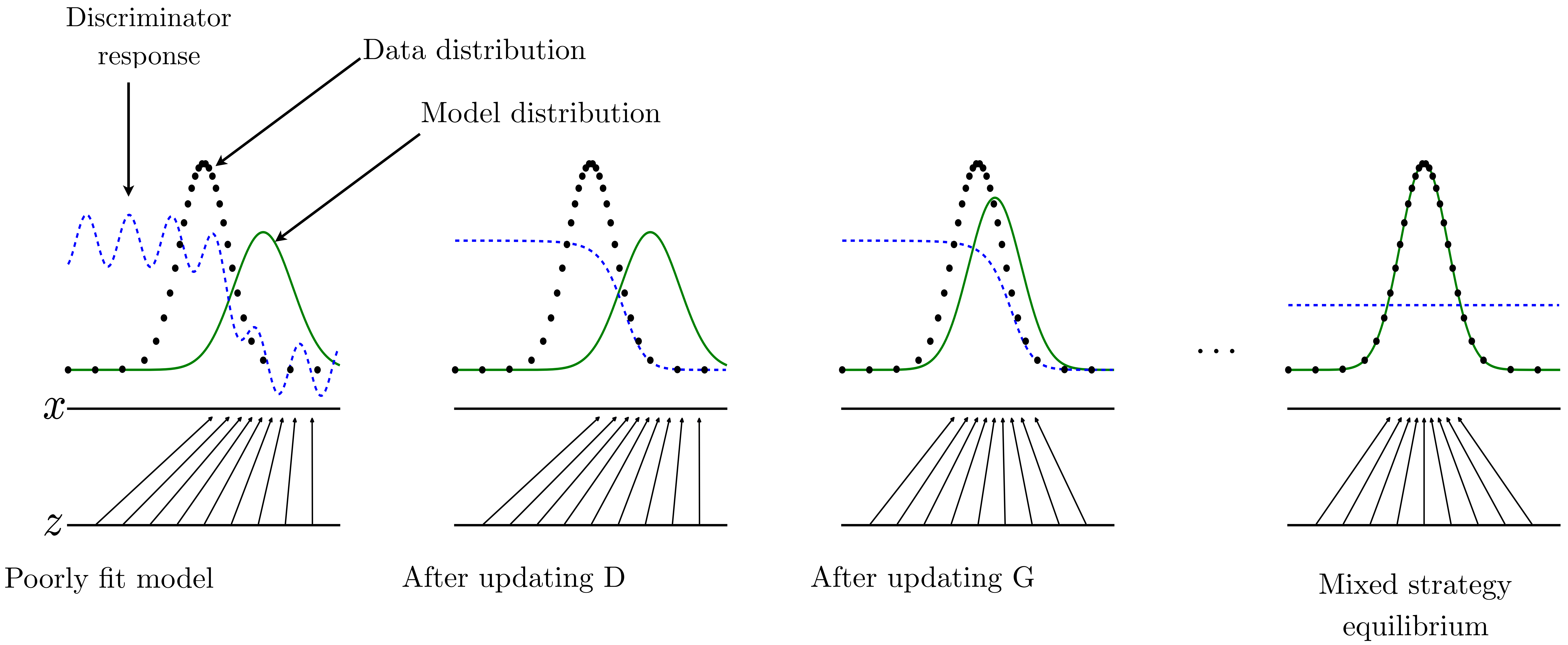
Discriminator Strategy

Optimal $D(\boldsymbol{x})$ for any $p_{\text{data}}(\boldsymbol{x})$ and $p_{\text{model}}(\boldsymbol{x})$ is always

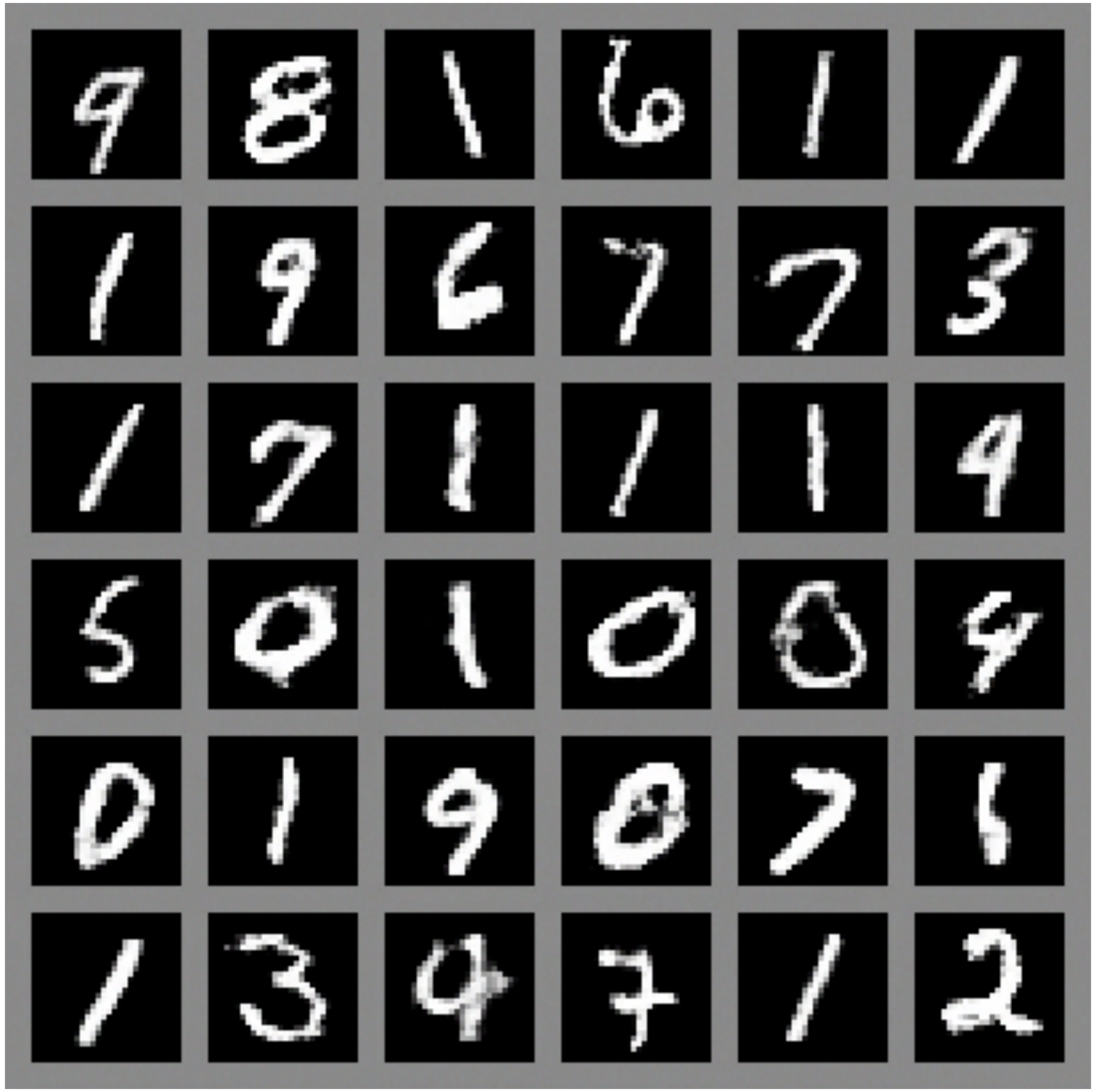
$$D(x) = \frac{p_{\text{data}}(x)}{p_{\text{data}}(x) + p_{\text{model}}(x)}$$



Learning Process



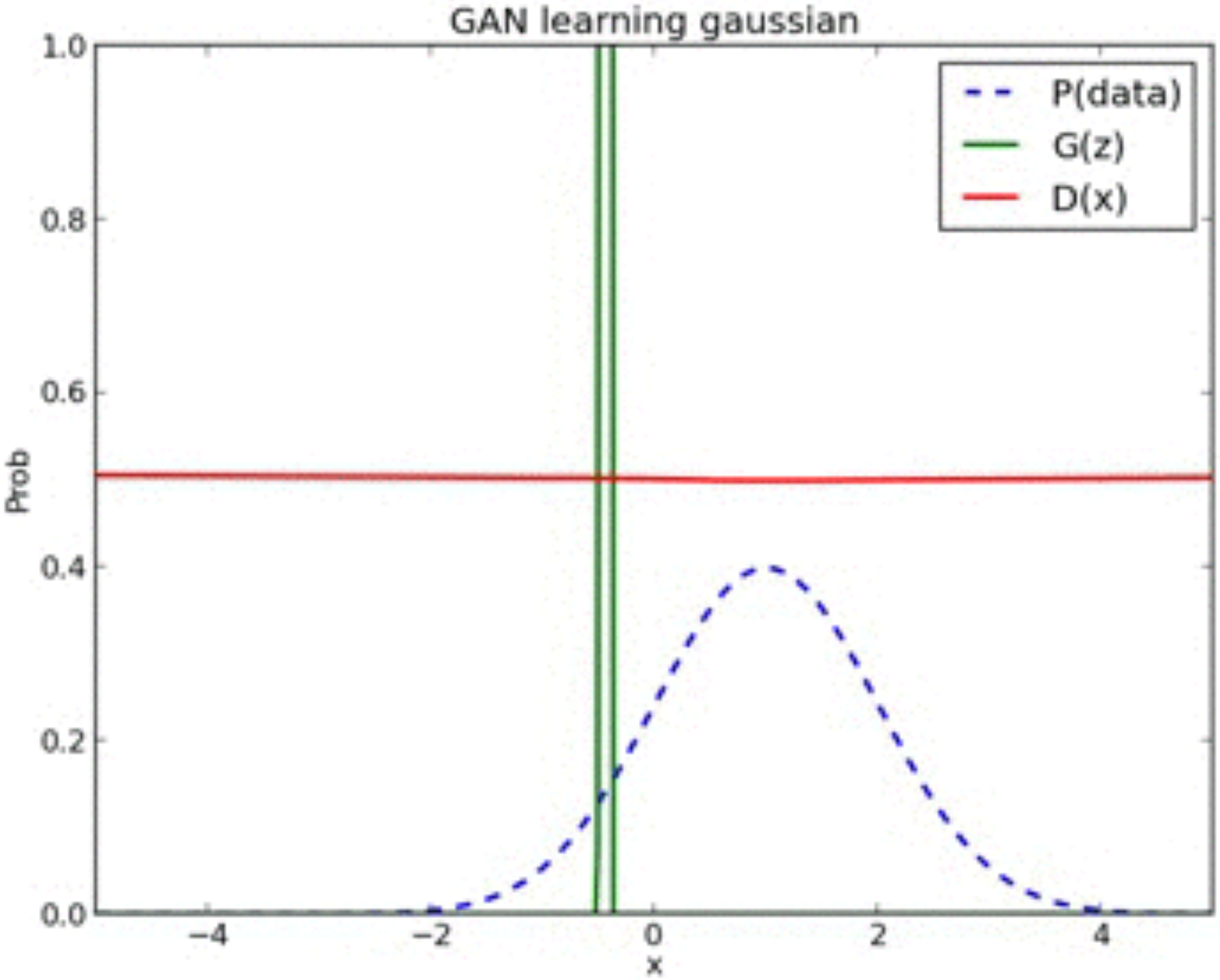
Generator Transformation Videos



MNIST digit dataset

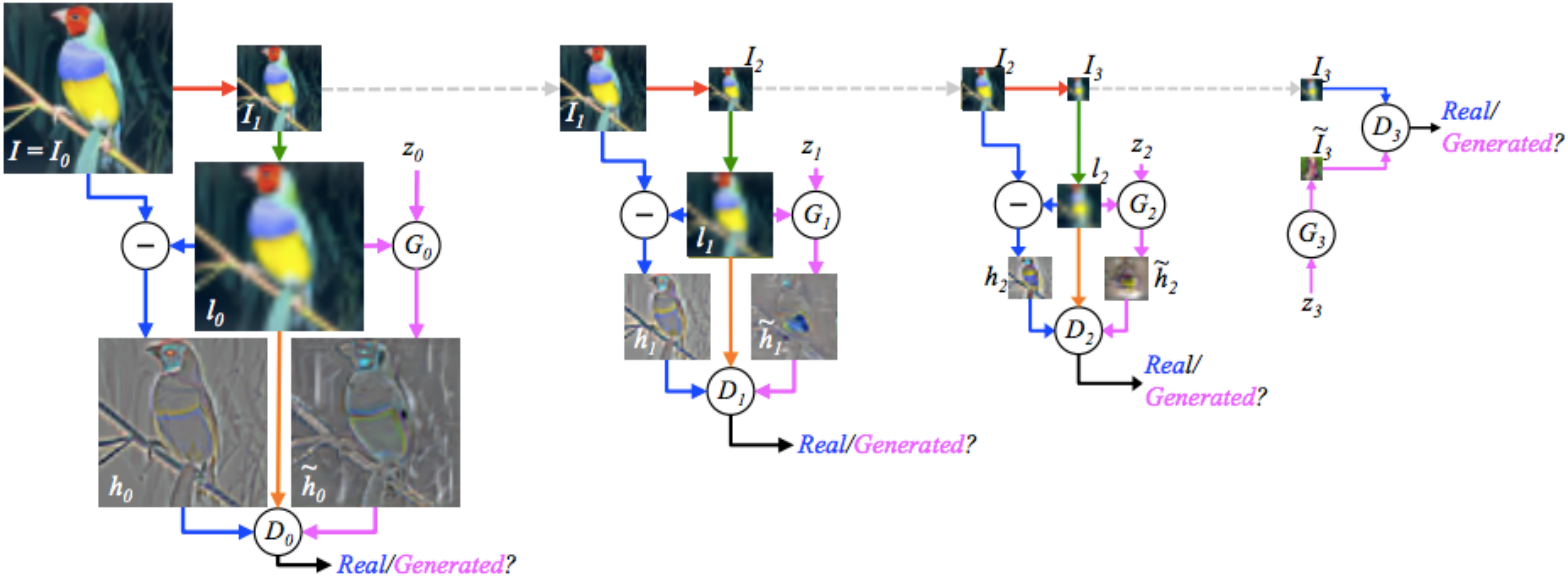
Toronto Face Dataset (TFD)

Non-Convergence



(Alec Radford)

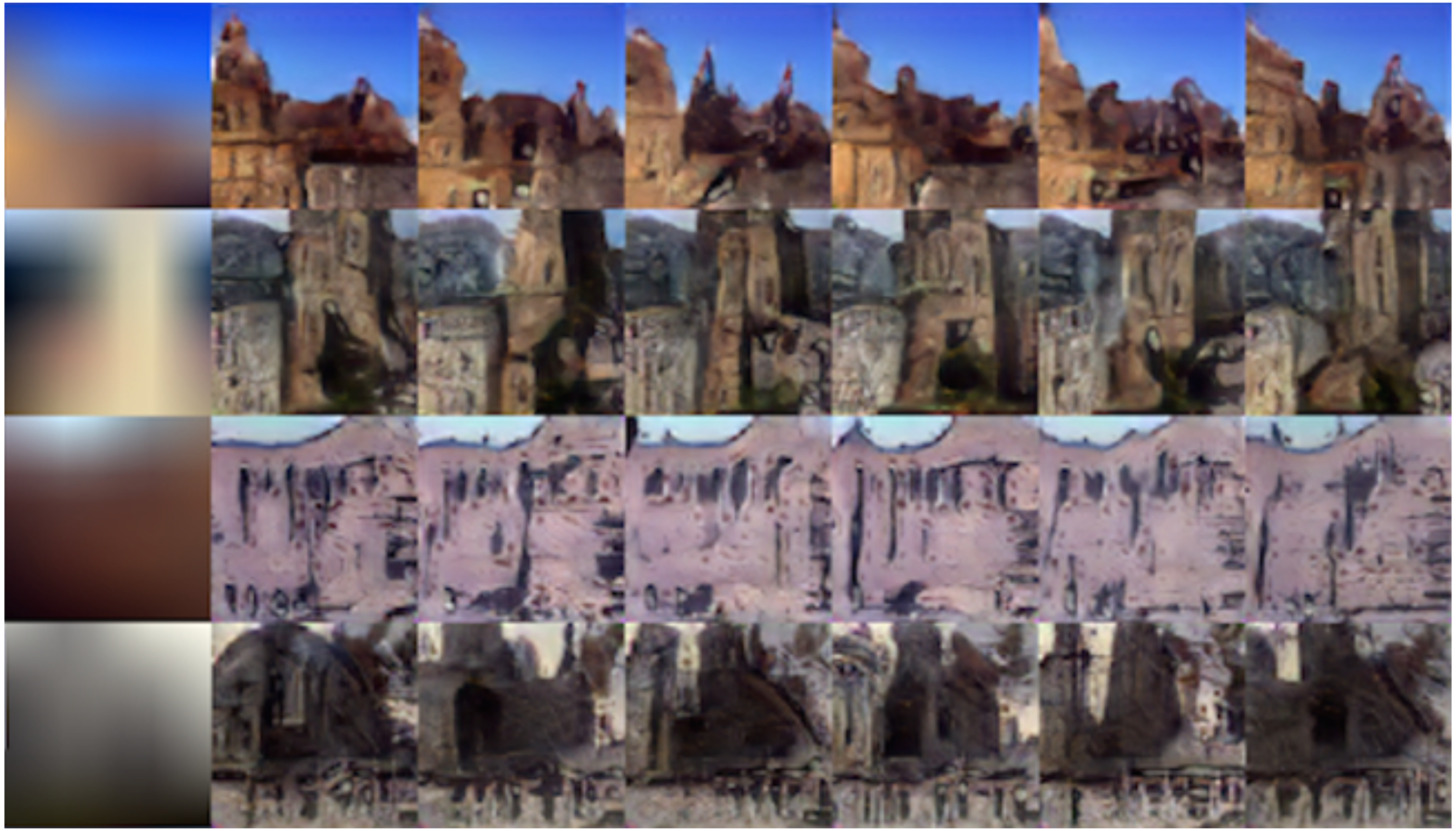
Laplacian Pyramid



(Denton+Chintala et al 2015)

LAPGAN Results

- 40% of samples mistaken *by humans* for real photographs

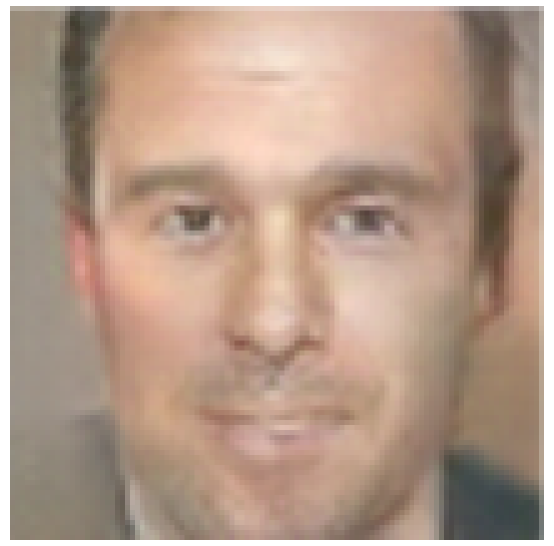
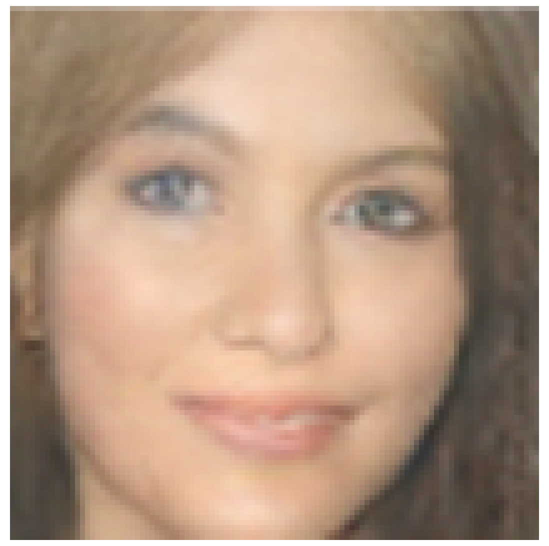
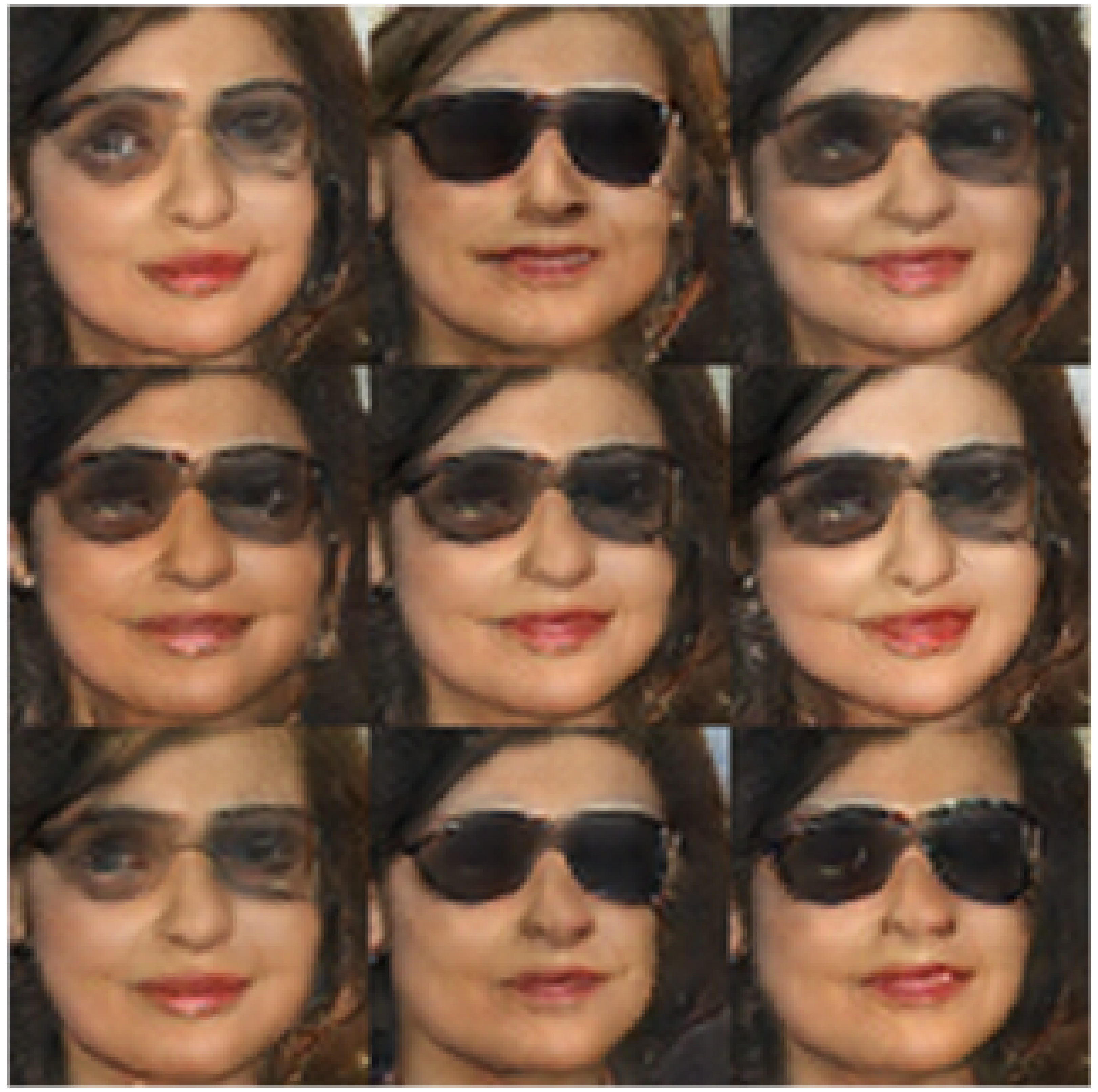


(Denton+Chintala et al 2015)

DCGAN Results

(Radford et al 2015)

Arithmetic on Face Semantics

 -  +  = 

Man wearing glasses

Man

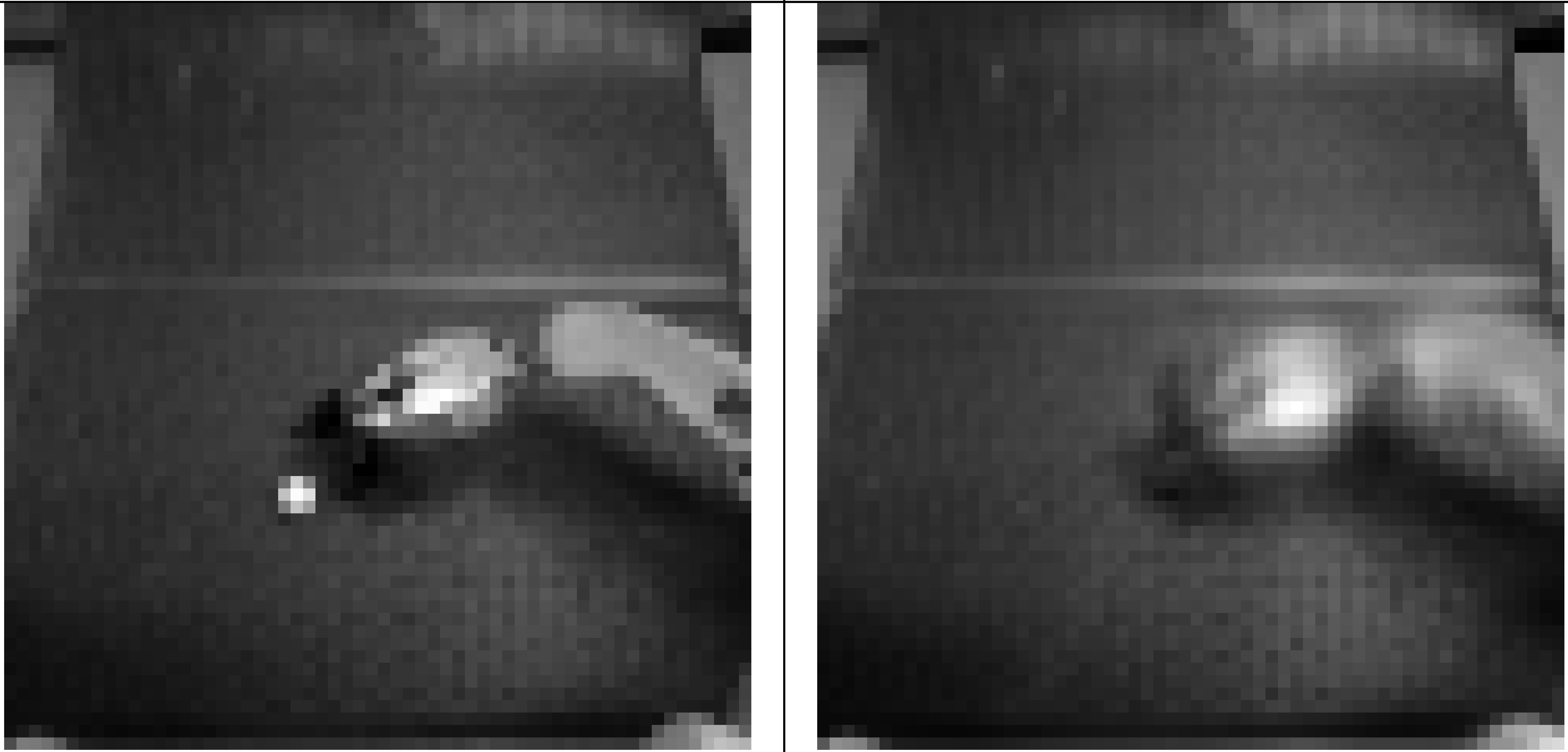
Woman

Woman wearing glasses

(Radford et al 2015)

Mean Squared Error Ignores Small Details

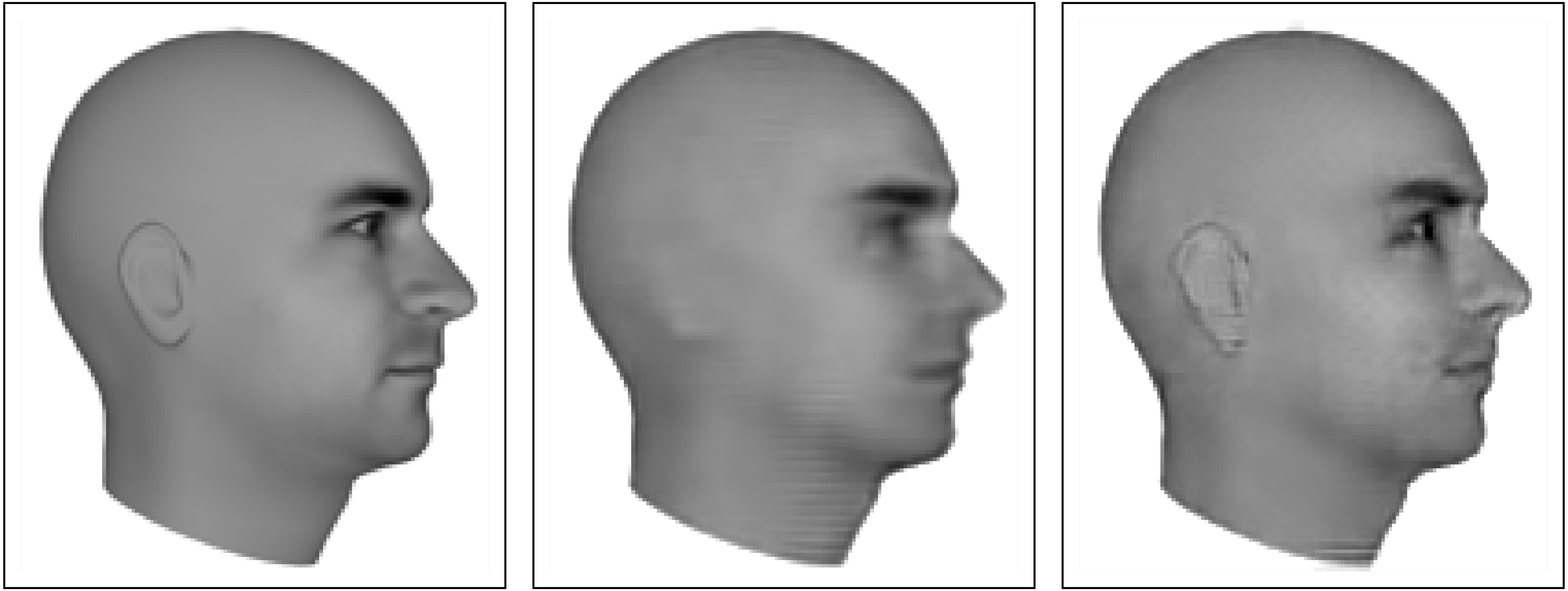
Input | Reconstruction



(Chelsea Finn)

GANs Learn a Cost Function

Ground Truth MSE Adversarial



Capture *predictable* details regardless of scale

(Lotter et al, 2015)

Conclusion

- Generative adversarial nets
  - Prioritize generating realistic samples over assigning high probability to all samples
  - Learn a cost function instead of using a fixed cost function
  - Learn that all predictable structures are important, even if they are small or faint