

# Generative vs Discriminative Models

Understanding Machine Learning

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# PDF Predictions

... pdf assumption and estimation of moments

... quantile regression

... generative method and sampling

# Generative-Discriminative Pairs of Learning Methods

# Naïve Bayes

# Generative vs Discriminative

- $P(Y, X)$  vs  $P(Y|X)$
- generative example: Naïve Bayes
- discriminative example: Generalized Additive Models

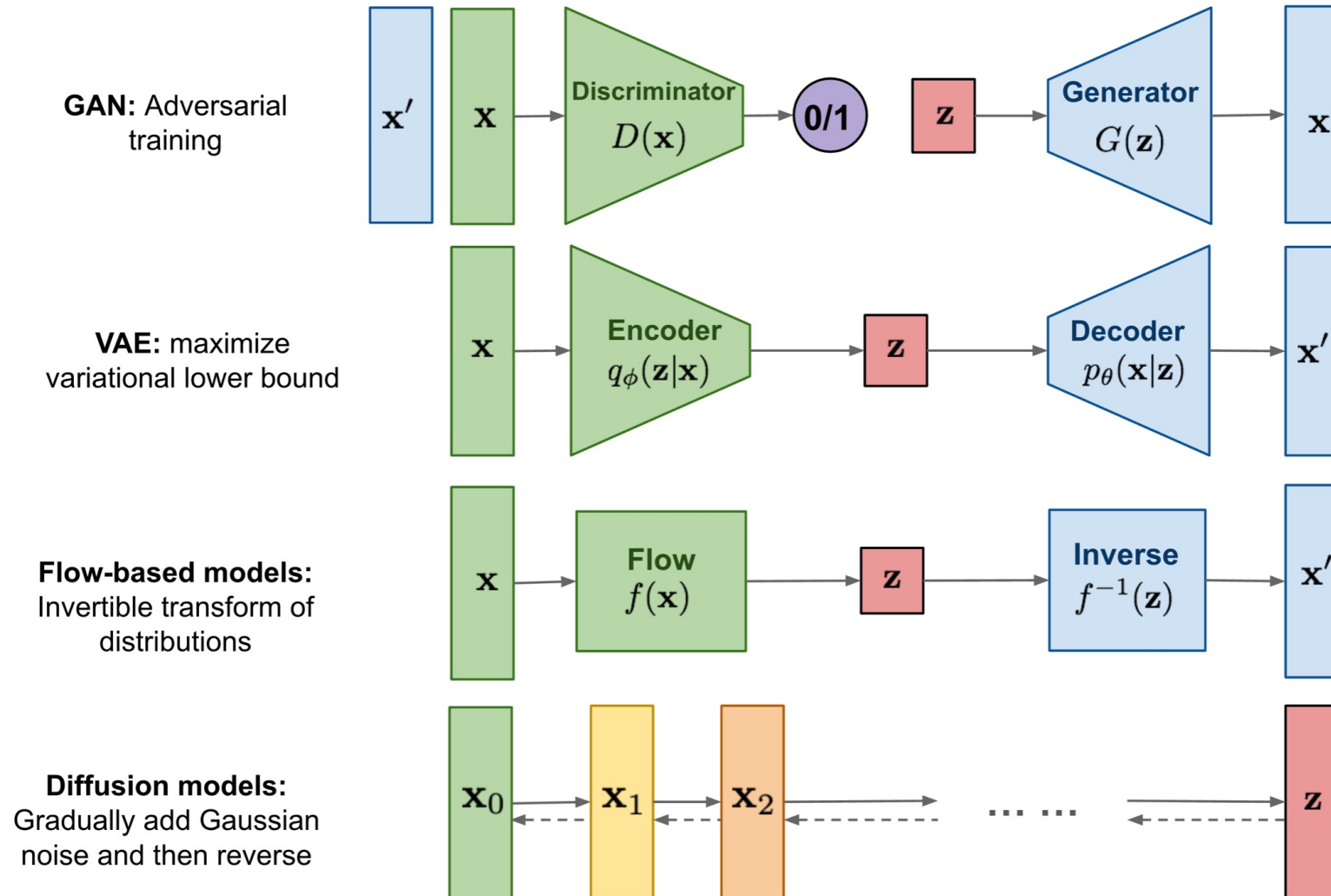


generative-discriminative pair of algorithms:

Naïve Bayes and Logistic Regression

Hidden Markov Models and Conditional Random Fields (sequential data)

# Different Types of Generative Models



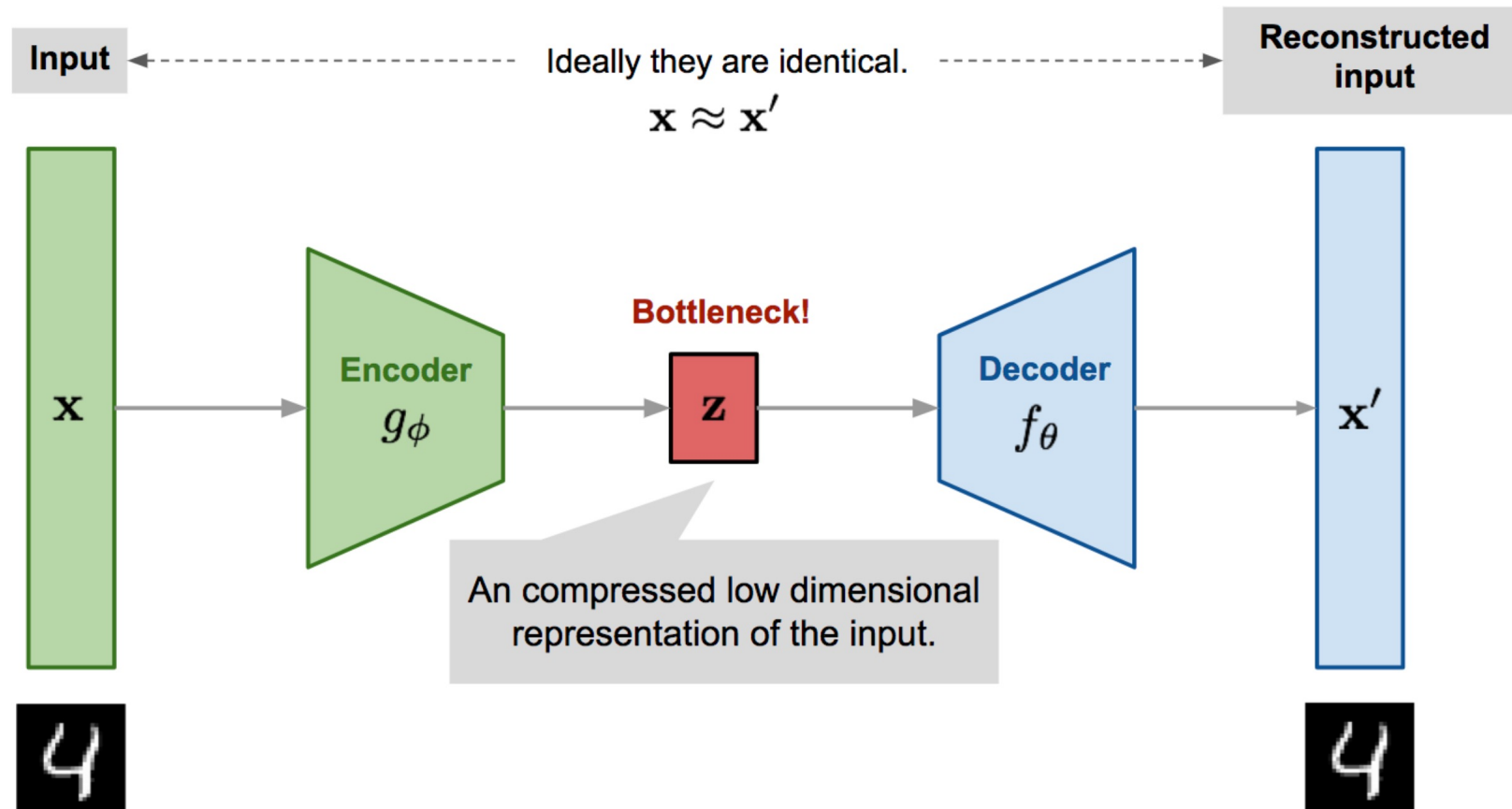
# Variational Inference

- Bayesian ...

# Recap: Autoencoder

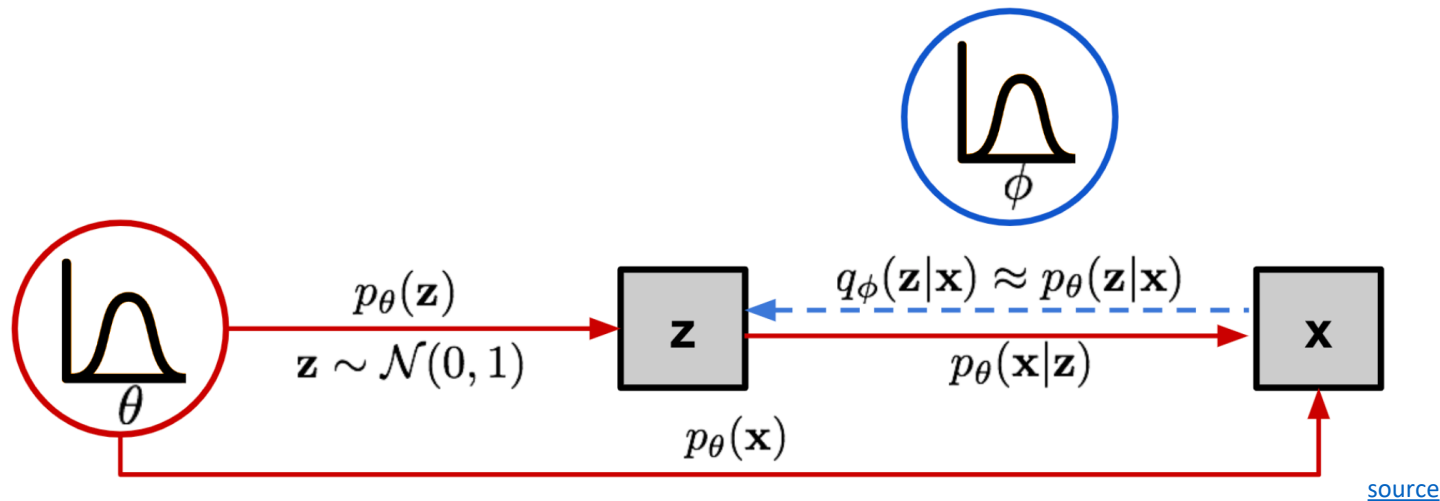
(deep) encoder network  
(deep) decoder network  
learned together by  
minimizing differences  
between original input and  
reconstructed input  
(expressed as losses)

compressed intermediate  
representation:  
dimensionality reduction



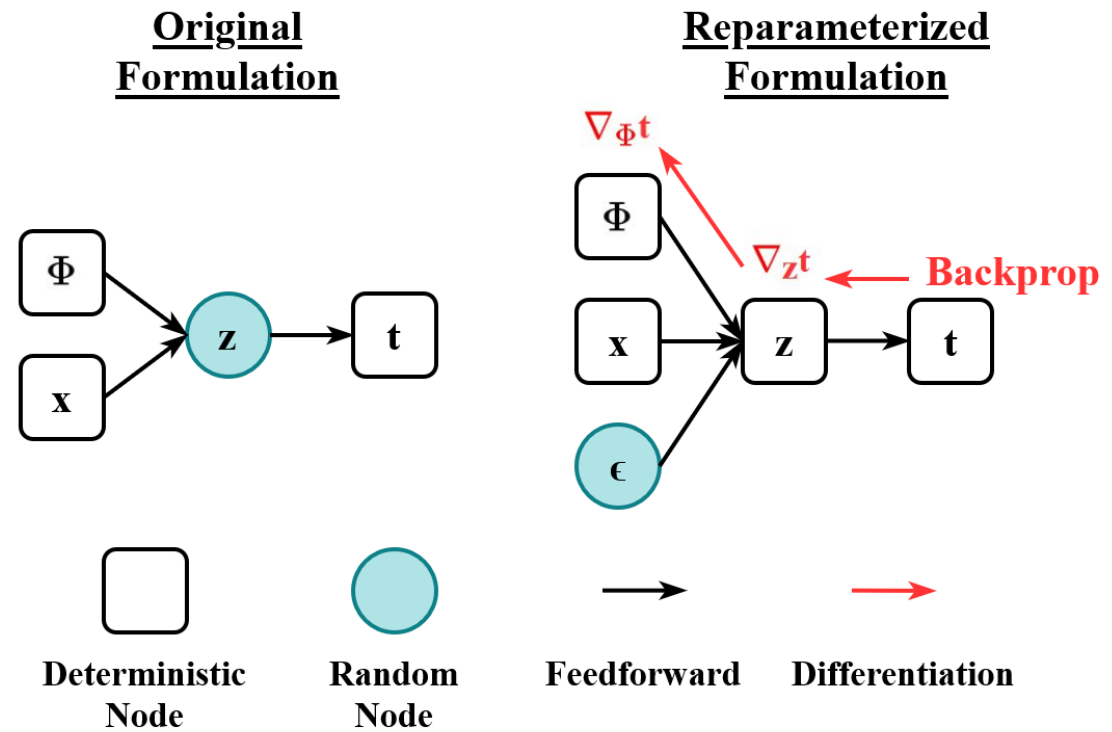
# Variational Autoencoder (VAE)

- ...
- VAE relies on a surrogate loss



# ELBO

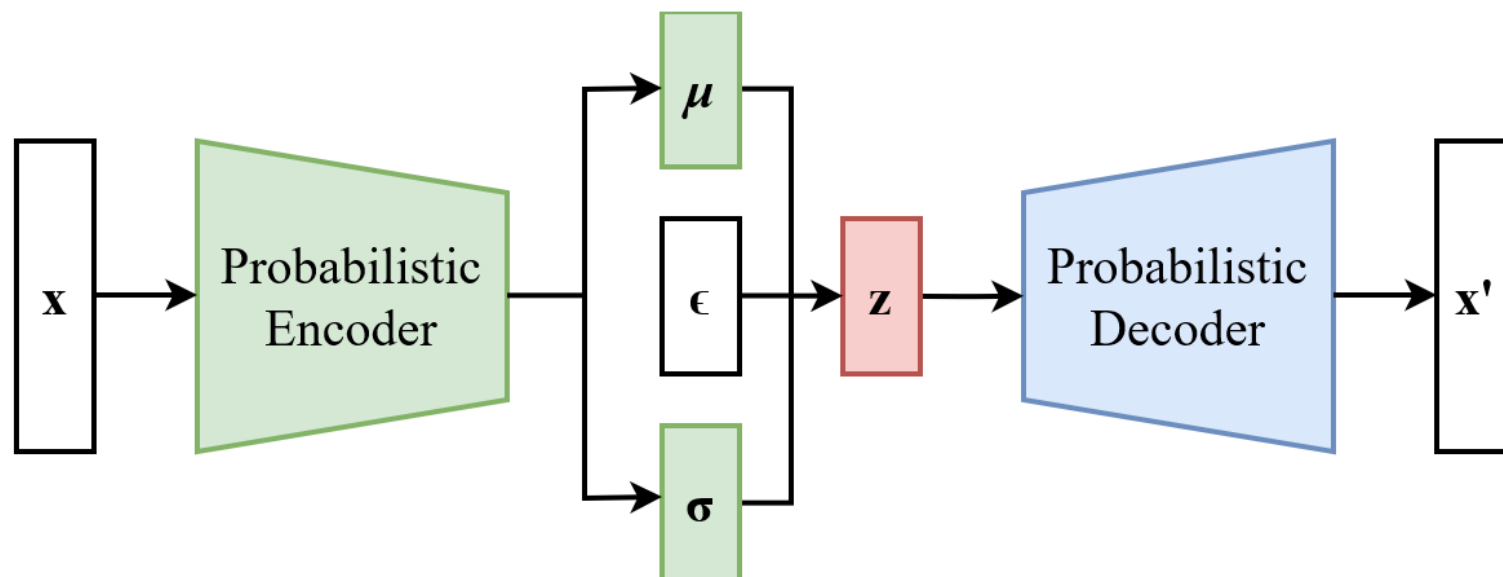
- reparameterization trick



from wikipedia



• ...



from wikipedia

# Generative Adversarial Networks (GAN)

● ...

- GAN models are known for potentially unstable training and less diversity in generation due to their adversarial training nature.

# Flow-Based Methods

● ...

- Flow models have to use specialized architectures to construct reversible transform.

# Energy-Based Methods



● ...

# Diffusion Models

● ...

- Diffusion models are inspired by non-equilibrium thermodynamics. They define a Markov chain of diffusion steps to slowly add random noise to data and then learn to reverse the diffusion process to construct desired data samples from the noise. Unlike VAE or flow models, diffusion models are learned with a fixed procedure and the latent variable has high dimensionality (same as the original data).

# Image Generation

[DALL-E 2](#)

...

## Stable Diffusion DreamStudio



A dream of a distant galaxy, by Caspar David Friedrich, matte painting trending on artstation HQ

# Literature

papers:

- [variational autoencoder](#)
- [GAN](#)
- [normalizing flows](#)
- [latent diffusion](#)





# Movie-like Intelligence

emergent capabilities of complex  
systems almost impossible to foresee

examples for (potential) emergence  
in ML: large language models, multi-  
agent reinforcement learning,  
reward is enough

philosophical: emotions or  
consciousness might also occur as  
emergent capabilities

