Generative Models

Discriminative vs Generative

Understanding Machine Learning

Naïve Bayes

Generative vs Discriminative

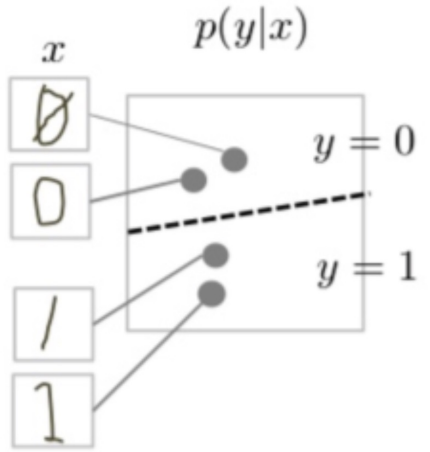
- P(Y, X) vs P(Y|X)

- generative-discriminative pair of algorithms: Naïve Bayes and Logistic Regression

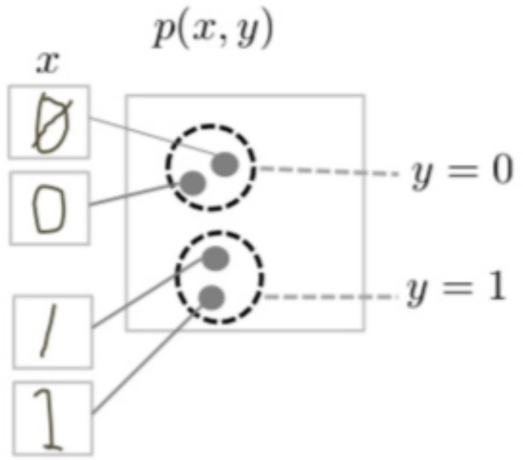
generative more difficult

… generate samples

discriminative model



generative model



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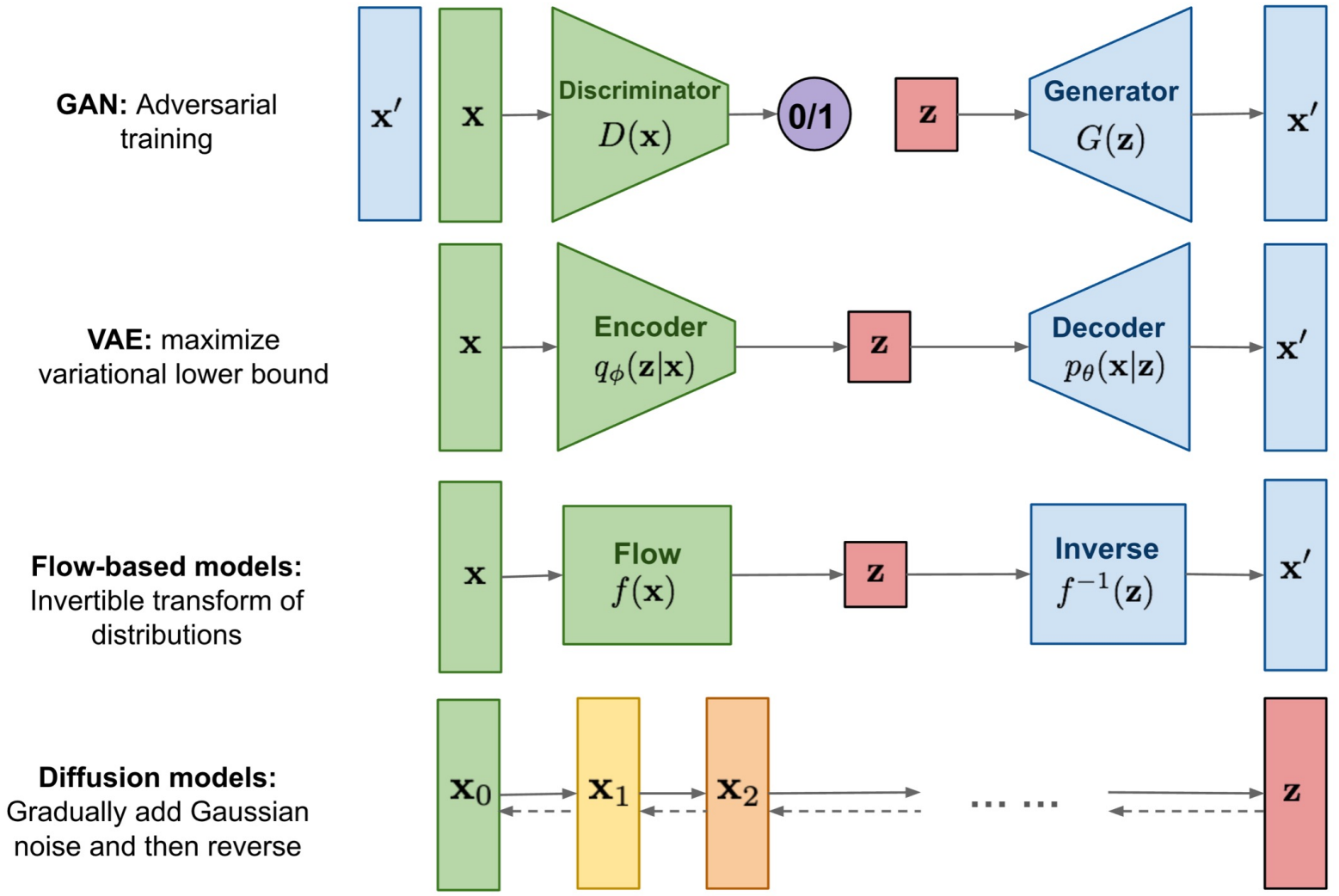
Example: Large Language Models

… auto-regressive models

Different Types of Generative Models



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Variational Inference

- Bayesian …

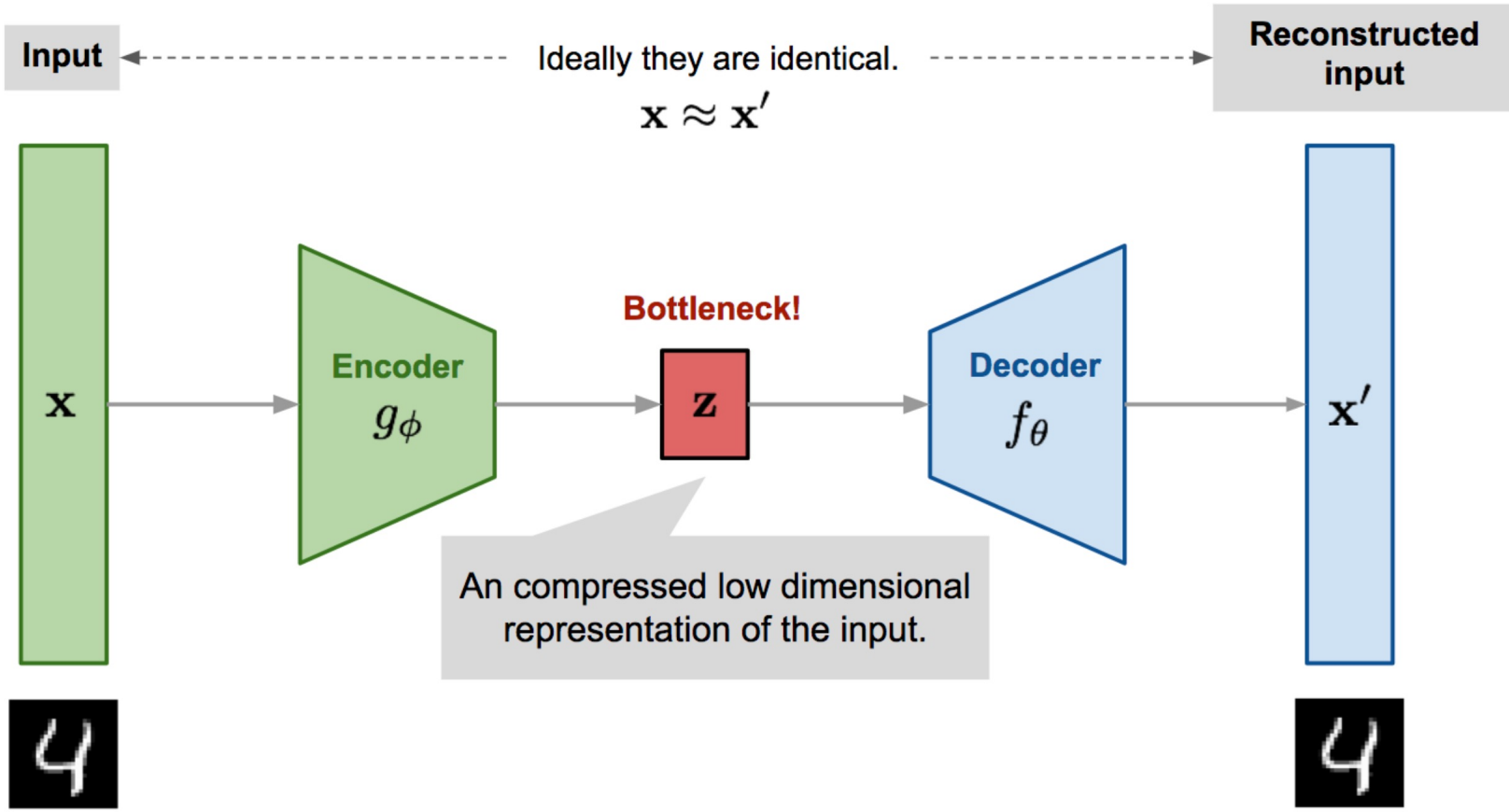
Recap: Autoencoder

(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



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Variational Autoencoder (VAE)

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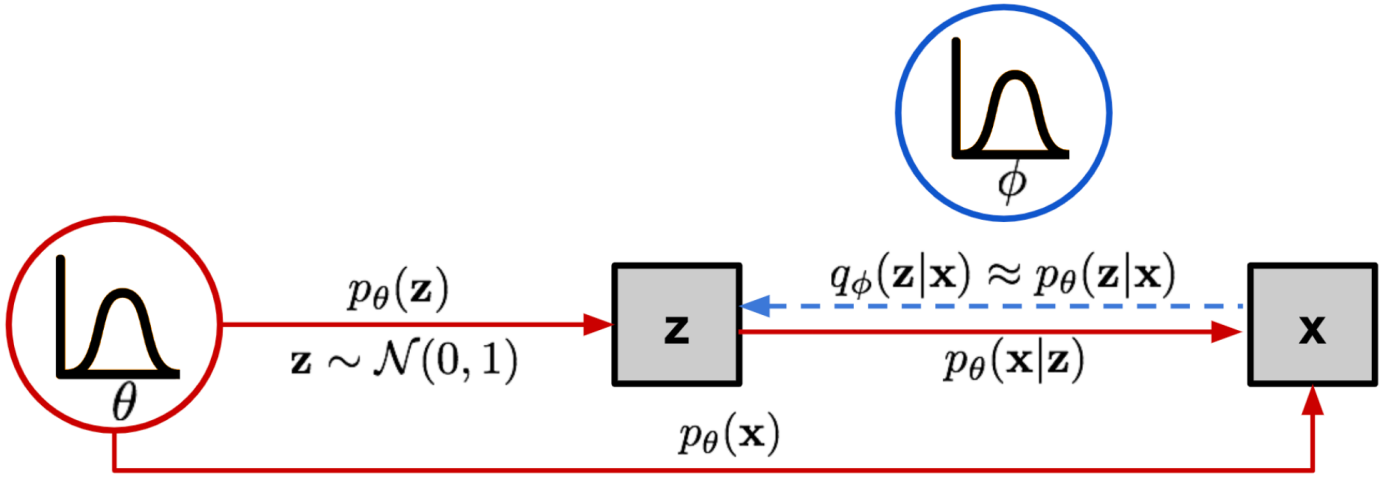
- VAE relies on a surrogate loss



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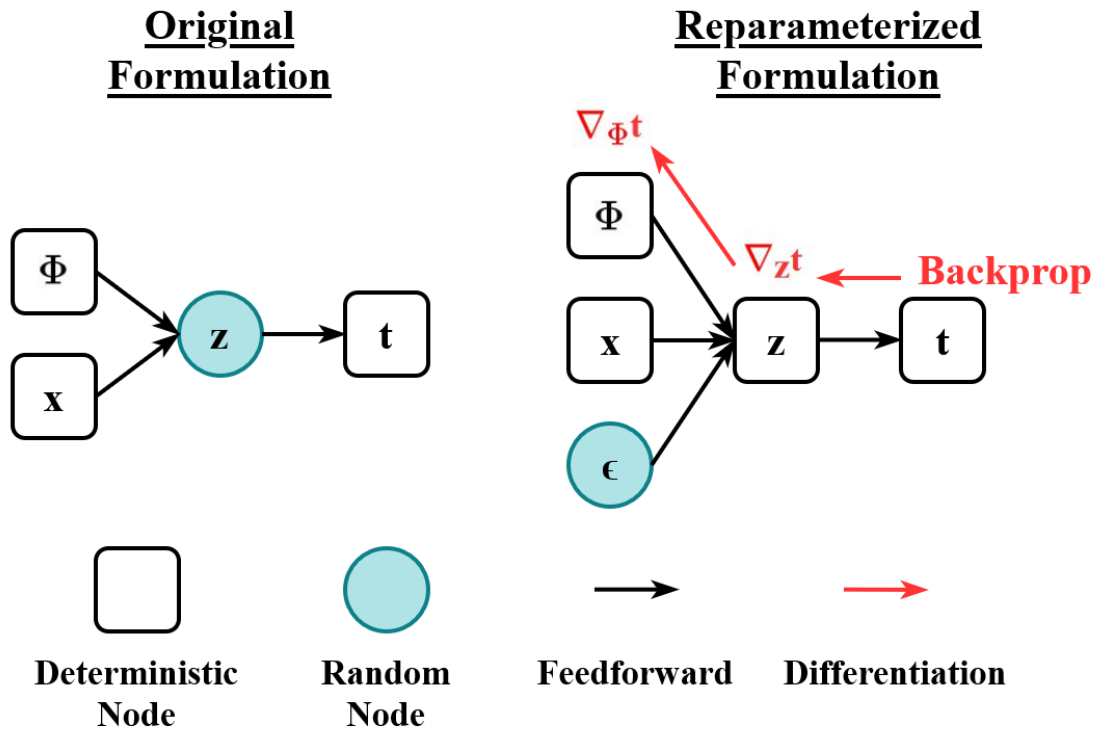
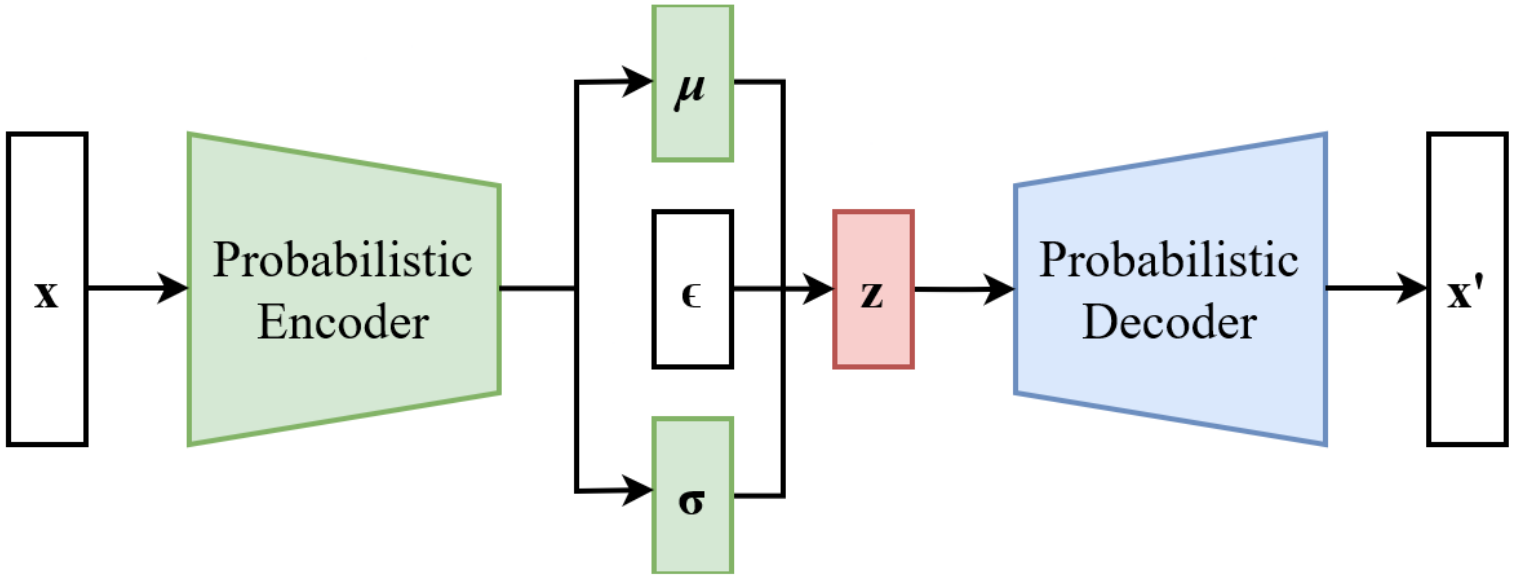
ELBO

- reparameterization trick



from wikipedia

- ...



from wikipedia

Generative Adversarial Networks (GAN)

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- 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).

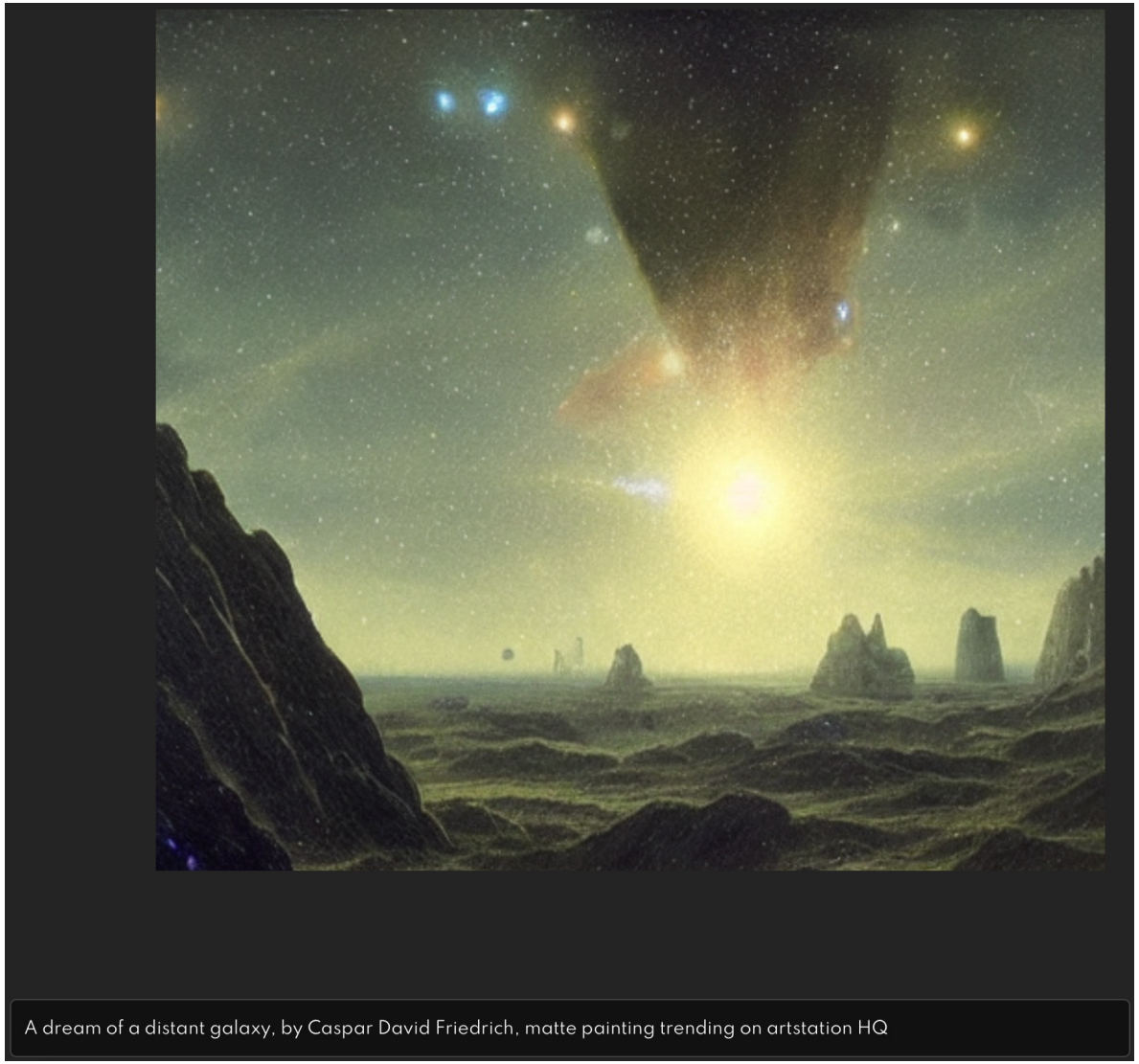
Image Generation

DALL-E 2

...

Stable Diffusion

DreamStudio



Literature

papers:

- variational autoencoder
- GAN
- normalizing flows
- latent diffusion

Movie-like Intelligence

emergent capabilities of complex systems almost impossible to foresee

mini examples in contemporary ML:

- large language models
- multi-agent reinforcement learning

one idea: reward is enough

philosophical: emotions or consciousness might also occur as emergent capabilities