

Défi 3 : Generative Artificial Intelligence (III/III) Diffusion Models

Défis en Intelligence Artificielle

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21 Décembre 2023

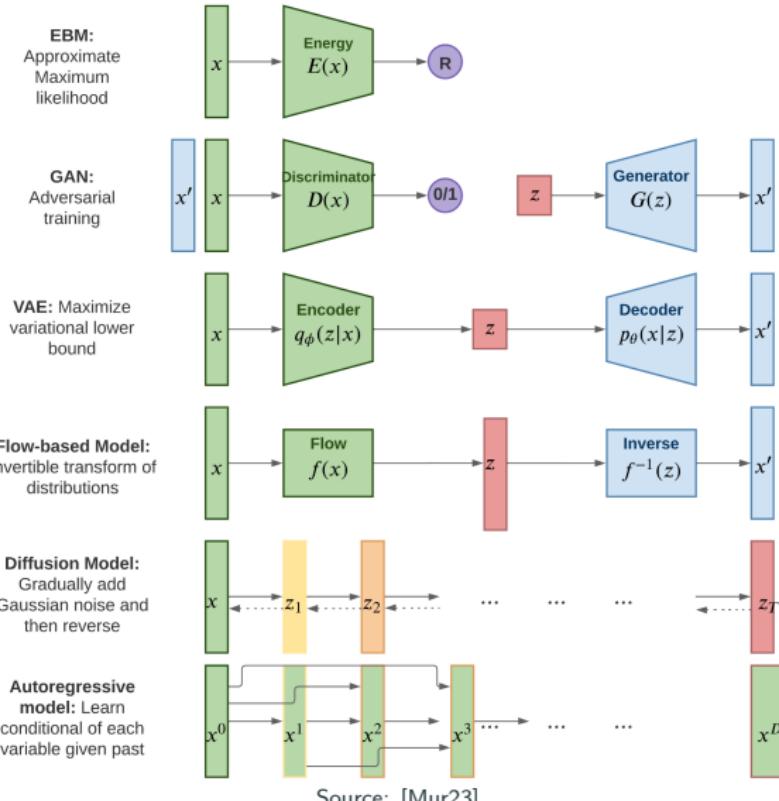
Université de Mons

Schedule

- *Week 1: 7 December 2023, 6-9 pm*
 - Introduction to generative modelling
- *Week 2: 14 December 2023, 6-9 pm*
 - Variational Autoencoders (VAEs)
- **Week 3: 21 December 2023, 6-9 pm**
 - Diffusion models
- *Project: 2 February 2024, 11:55 pm*
 - Project details¹

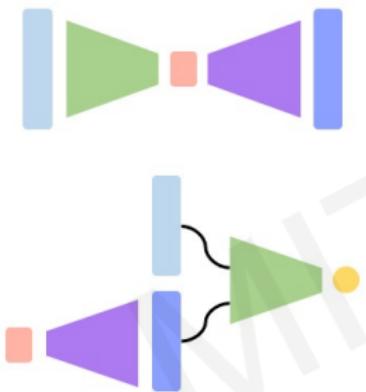
¹<https://github.com/bsouhaib/Hands-On-AI-2023-Challenge3/blob/3598ca1cc1bb3f81dc88f2ab6de6772fc16c9492/project/project.pdf>

Overview of deep generative models



The Landscape of Generative Modeling

Lecture 4: VAEs and GANs



Limitations

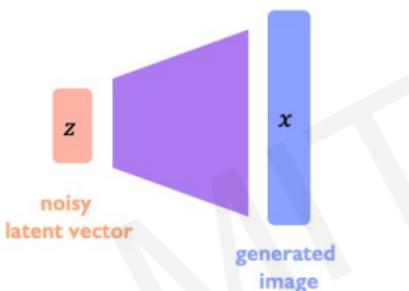
- ⚠ Mode collapse
- 💡 Generating OOD
- 💥 Hard to train

Challenges

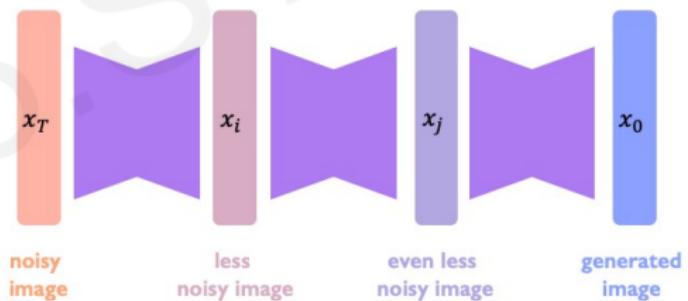
- 🕒 Stability
- ⚡ Efficiency
- 💪 Quality
- 🧠 Novelty

Diffusion Models

VAEs/GANs: Generating images in one-shot directly from low-dimensional latent variables

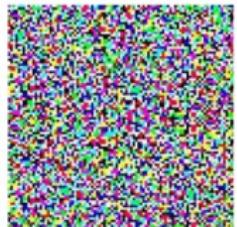
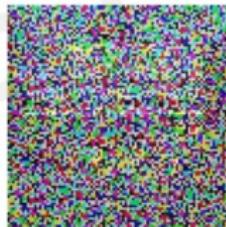
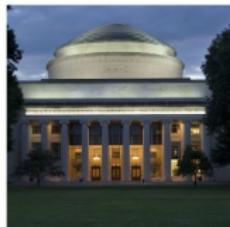


Diffusion: Generating images iteratively by repeatedly refining and removing noise



The Diffusion Process

Forward noising
(data-to-noise)

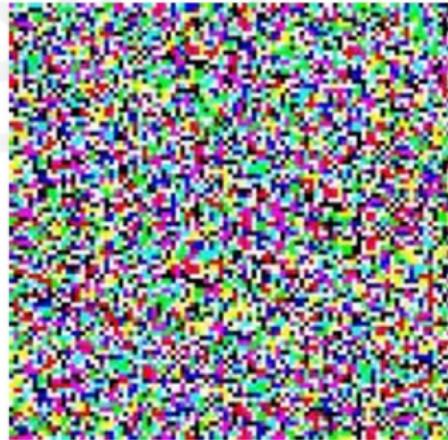
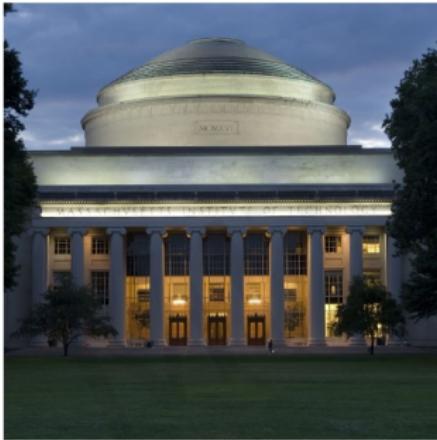


Reverse denoising
(noise-to-data)



Forward Noising

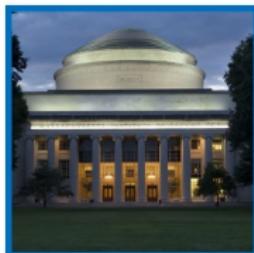
Step 1: Given an image (left), randomly sample a random noise pattern (right)



Forward Noising

Step 2: Progressively add more and more of the noise to your image

T = 0



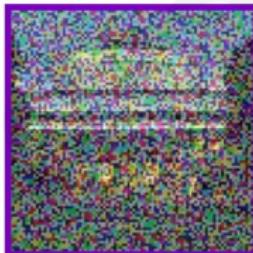
100% image
0% noise

T = 1



75% image
25% noise

T = 2



50% image
50% noise

T = 3



25% image
75% noise

T = 4



0% image
100% noise

Reverse Denoising



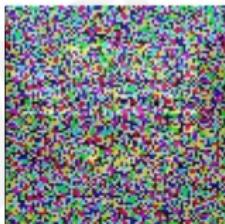
T = 0

...

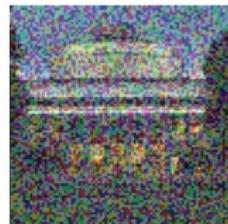
T = 4

Goal: Given image at **T**, can we learn to estimate image at **T-1**?

T = 3



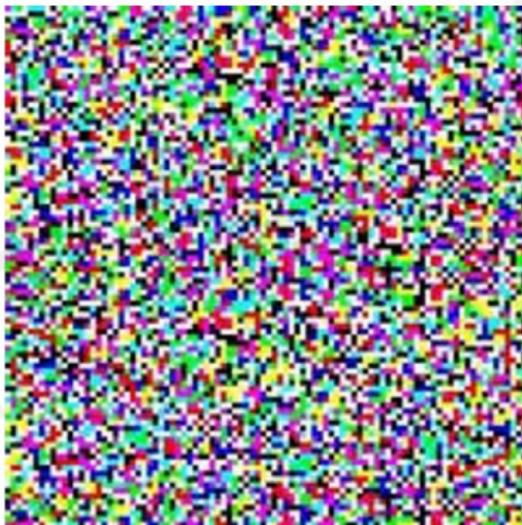
T = 2



How can we
train this
network?

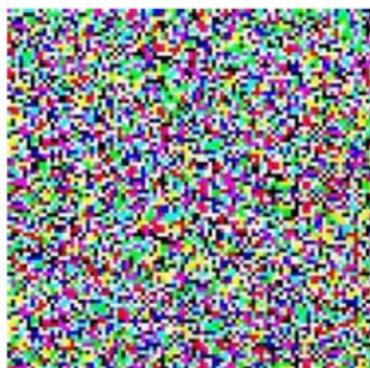
Sampling Brand New Generations

T



Sampling Brand New Generations

T



T-I

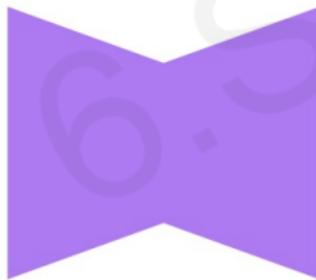


Sampling Brand New Generations

T-1



T-2

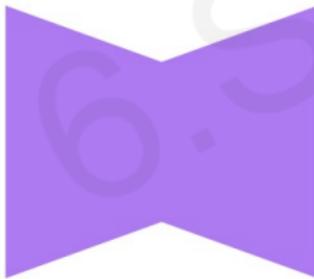


Sampling Brand New Generations

T-2



T-3



Sampling Brand New Generations

T-3



T-4

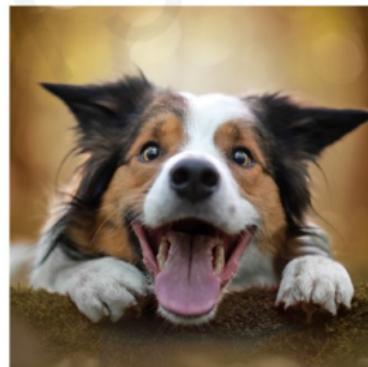


Sampling Brand New Generations

T-4



T-5 (end)

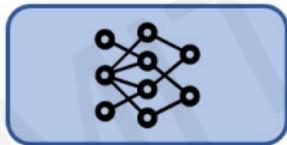


Sampling Brand New Generations



Generating Images from Natural Language

“A photo of an astronaut riding a horse.”



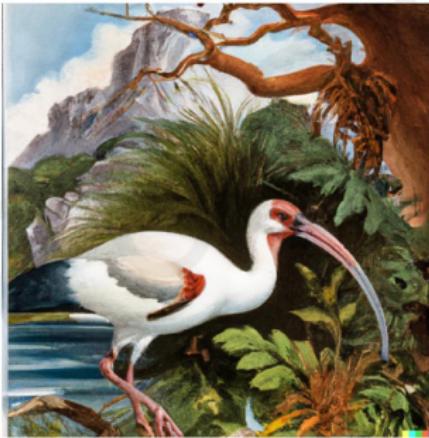
Ramesh+ arXiv 2022

Text-to-Image Generation

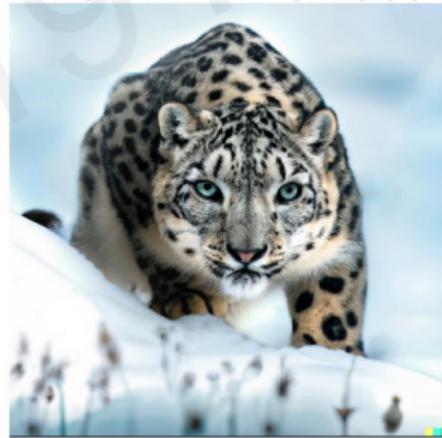
"a painting of a fox sitting in a field at sunrise in the style of Claude Monet"



"an ibis in the wild, painted in the style of John Audubon"

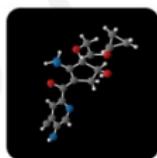
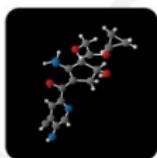
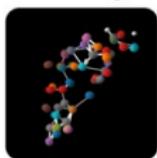
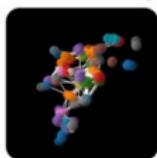
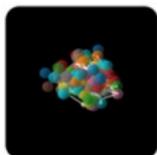


"close-up of a snow leopard in the snow hunting, rack focus, nature photography"



Beyond Images: Molecular Design

Chemistry: Generating Molecules in 3D

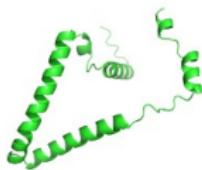
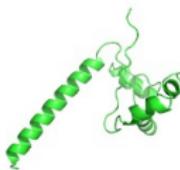


Noise

Hoogeboom+ ICML 2022

→ Molecule

Biology: Generating Novel Proteins



Wu+ arXiv 2022, Anand+ arXiv 2022, Trippe+ arXiv 2022



Generative AI Spawns a Powerful Idea

“What I cannot create, I cannot understand.”
Richard Feynman

- Images, language, biology, and more
- Design AI to improve and evolve AI itself
- Power and Caution of Generative AI – and AI at large

Connections and distinctions between artificial and human intelligence