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Generative Adversarial Networks (GANs) and Its Applications

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Lecture 1
06 August, 2024

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Outline about the course:

- Problems tackled by the Deep Generative Models
- Concept of Generative Adversarial Networks (GANs) and its elements
- Challenges while using GANs
- Advancements in GANs
- GAN evaluation protocols
- Applications of GAN

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Detailed course structure:

- Introduction
- Basic tools
    - Overview on deep learning (architecture design, training, optimization, evaluation)
- Introduction to deep generative models
- GAN architectures, training, evaluation
- Applications of GANs

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Marking scheme:

- Assignments/Quiz (20)
    - **Paper reading** (related to GANs) and publishing the same on **blogs** (in 1-2 pages)
    - Class presentation (team of 2-4 members)
- Mid-term (15)
- End-term (25)
- Projects (40)
    - Implementing papers related to GANs and its applications
    - Discussion on the practical challenges

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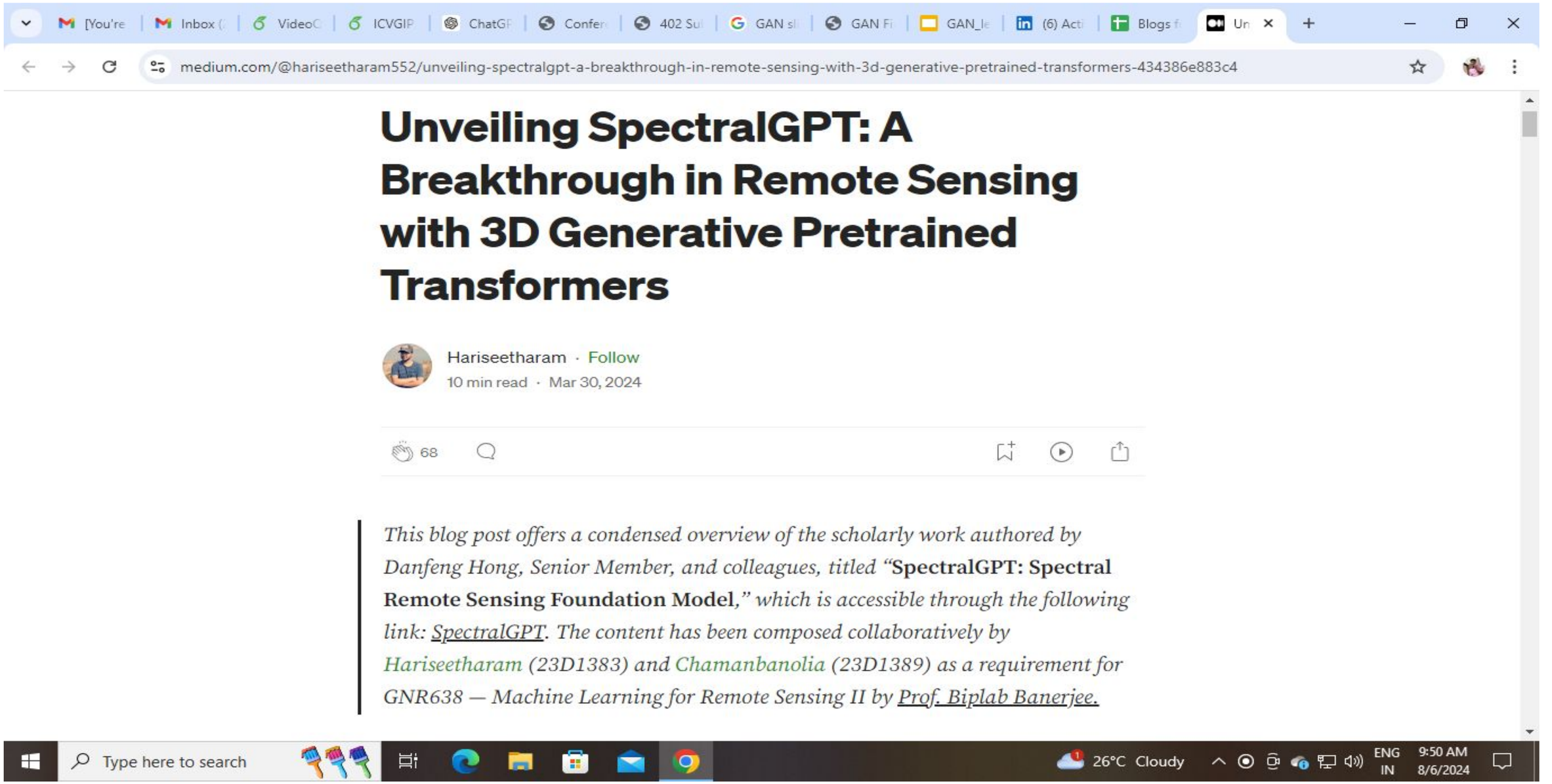
Programming Tools:

- Pytorch (I'll be using)
- TensorFlow/Keras


medium.com/@hariseetharam552/unveiling-spectralgpt-a-breakthrough-in-remote-sensing-with-3d-generative-pretrained-transformers-434386e883c4
Unveiling SpectralGPT: A Breakthrough in Remote Sensing with 3D Generative Pretrained Transformers
Hariseetharam · Follow
10 min read · Mar 30, 2024
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This blog post offers a condensed overview of the scholarly work authored by Danfeng Hong, Senior Member, and colleagues, titled "SpectralGPT: Spectral Remote Sensing Foundation Model," which is accessible through the following link: SpectralGPT. The content has been composed collaboratively by Hariseetharam (23D1383) and Chamanbanolia (23D1389) as a requirement for GNR638 — Machine Learning for Remote Sensing II by Prof. Biplab Banerjee.
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Motivation for the generative models:

Generative

Adversarial

Networks

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Overview of GANs:

- Belongs to class of Machine Learning (Proposed by Ian Goodfellow in 2014)
- Consists of two neural networks
    - Generator (create data that is indistinguishable from real data)
        - Generates fake data samples, attempting to mimic the real data distribution
    - Discriminator (aims to differentiate between real and generated data)
        - Evaluates the authenticity of the data, distinguishing between real and fake samples
- These two networks playing a zero-sum game (Game theory)
    - The gain of one player is exactly balanced by the loss of another player
    - The total payoff for all players in the game adds up to zero

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Overview of GANs:

- Generator’s objective:
    - Maximize the probability that the Discriminator classifies its outputs as real
    - Or minimize the Discriminator's ability to distinguish real from fake
- Discriminator’s objective:
    - Maximize its accuracy in distinguishing real samples from fake ones
    - Minimize the Generator's success in fooling the Discriminator

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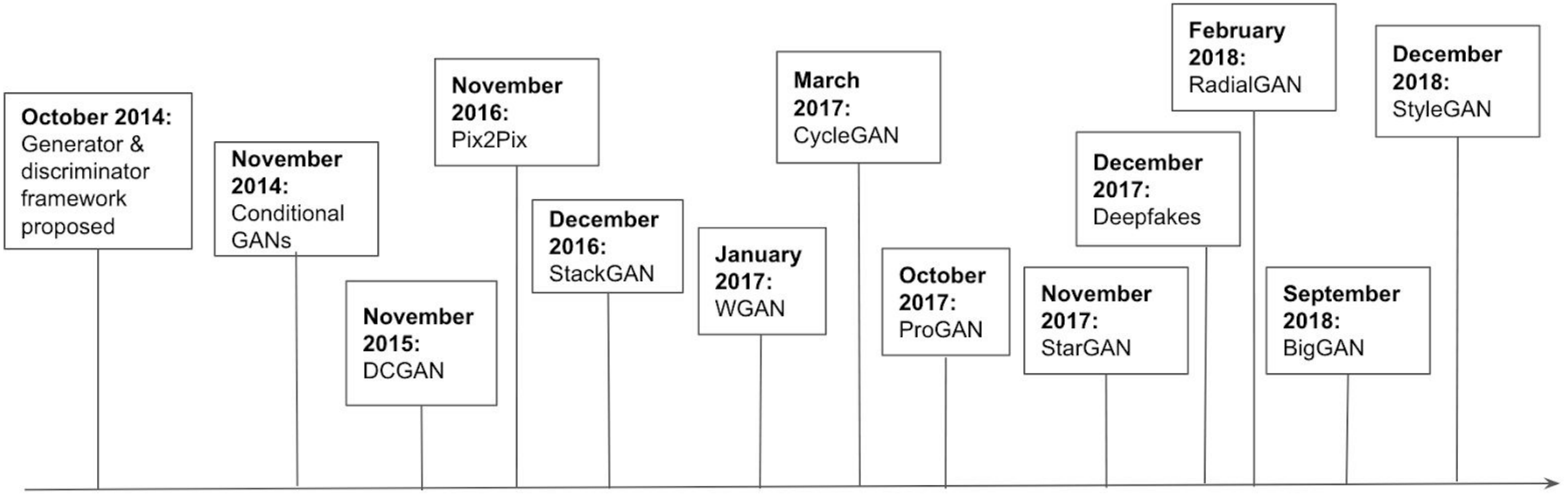
Timeline of GANs:



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Motivation for the generative models:

Generative

Adversarial

Networks

Learn generative model

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Motivation for the generative models:

Generative

Adversarial

Networks

Trained in an adversarial mode
competitive relationship

Competitive relationship between two components of the network: the Generator and the Discriminator.

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Motivation for the generative models:

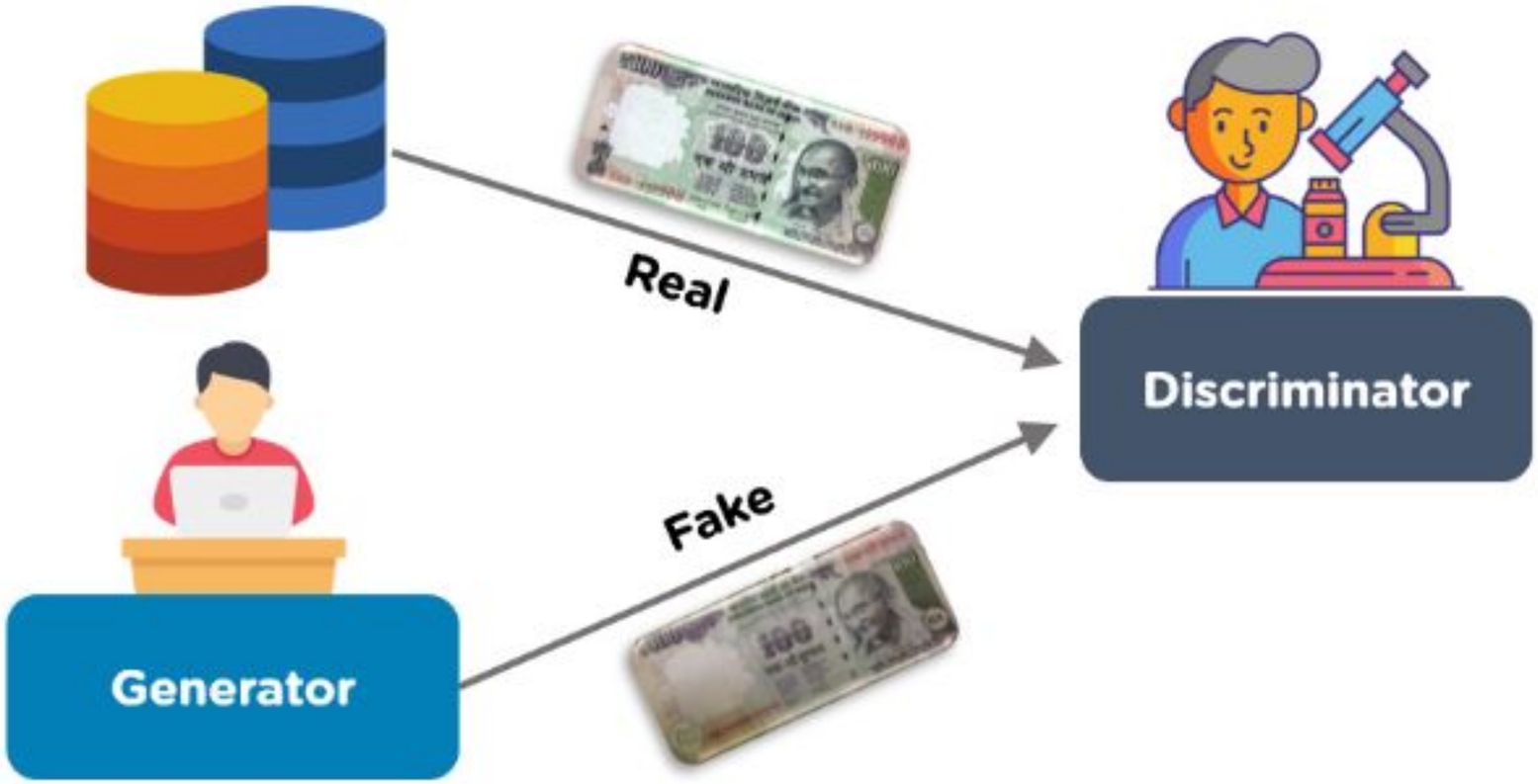
Generative

Adversarial

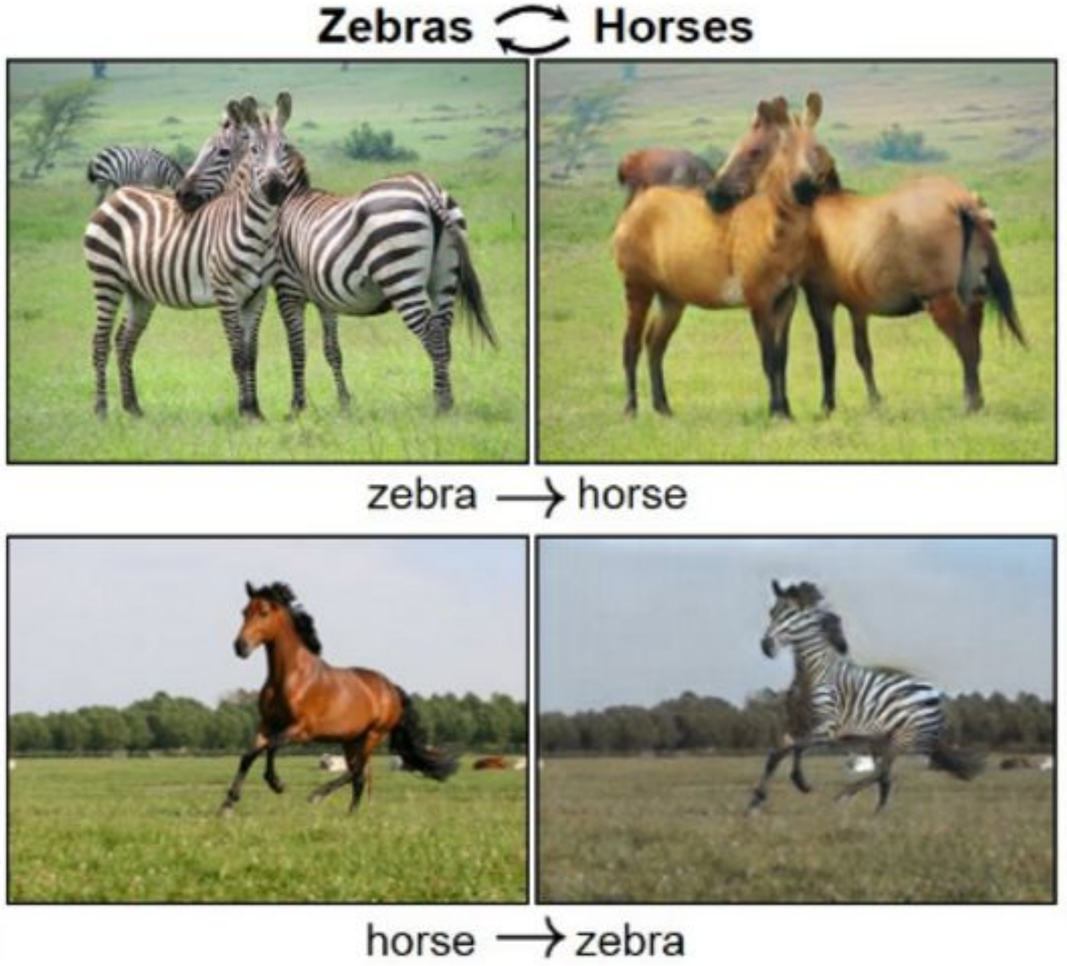
Networks

Using Deep Neural Networks

Motivation for the generative models:

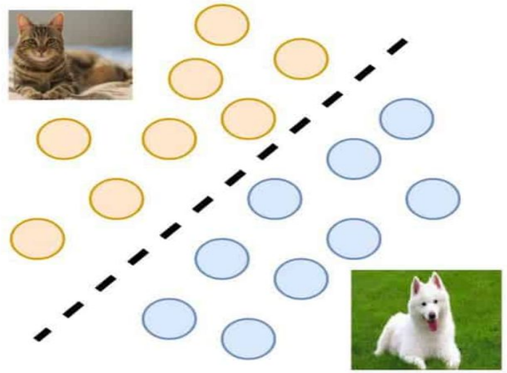


Motivation for the generative models:



Why generative model?

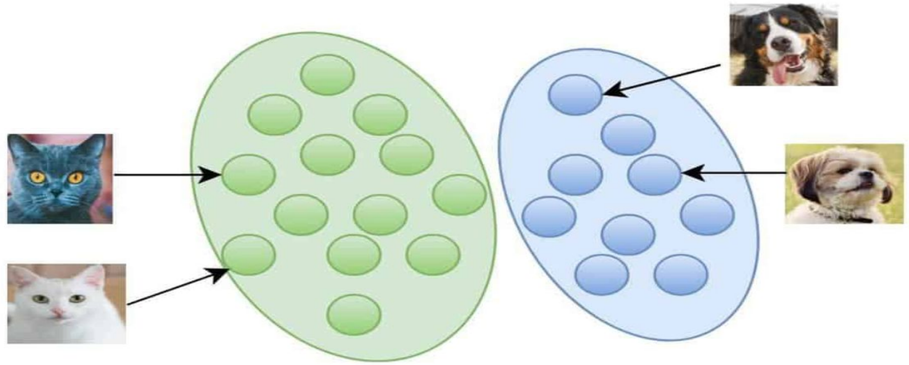
- Discriminative Models:
  - Learn the conditional probability distribution P(Y | X)
  - Focus on drawing boundaries between different classes in the data, making them well-suited for classification tasks
  - Mapping from input features X to output labels Y
  - Do not model the underlying data distribution explicitly
  - Examples:
    - SVM, Logistic Regression, Neural Network (classification or regression tasks)



Discriminative

Why generative model?

- Discriminative Models:
  - Learn the joint probability distribution P(X,Y) of the input data X and the corresponding labels Y
  - Generate new data instances that are similar to the training data
    - Model the distribution of the data, providing insights into the data structure
  - They model how the data is generated in terms of a probabilistic model
  - For instance, given a label Y, a generative model can generate a sample X from the distribution P(X|Y)
  - Examples:
    - Gaussian Mixture Models (GMMs)
    - Variational Autoencoders (VAEs)
    - GANs, etc.



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Applications of GANs:

- Image-to-Image Translation (pix2pix)
- Denoising
- Super-resolution
- Inpainting
- Neural Style Transfer
- Text-to-Image Synthesis

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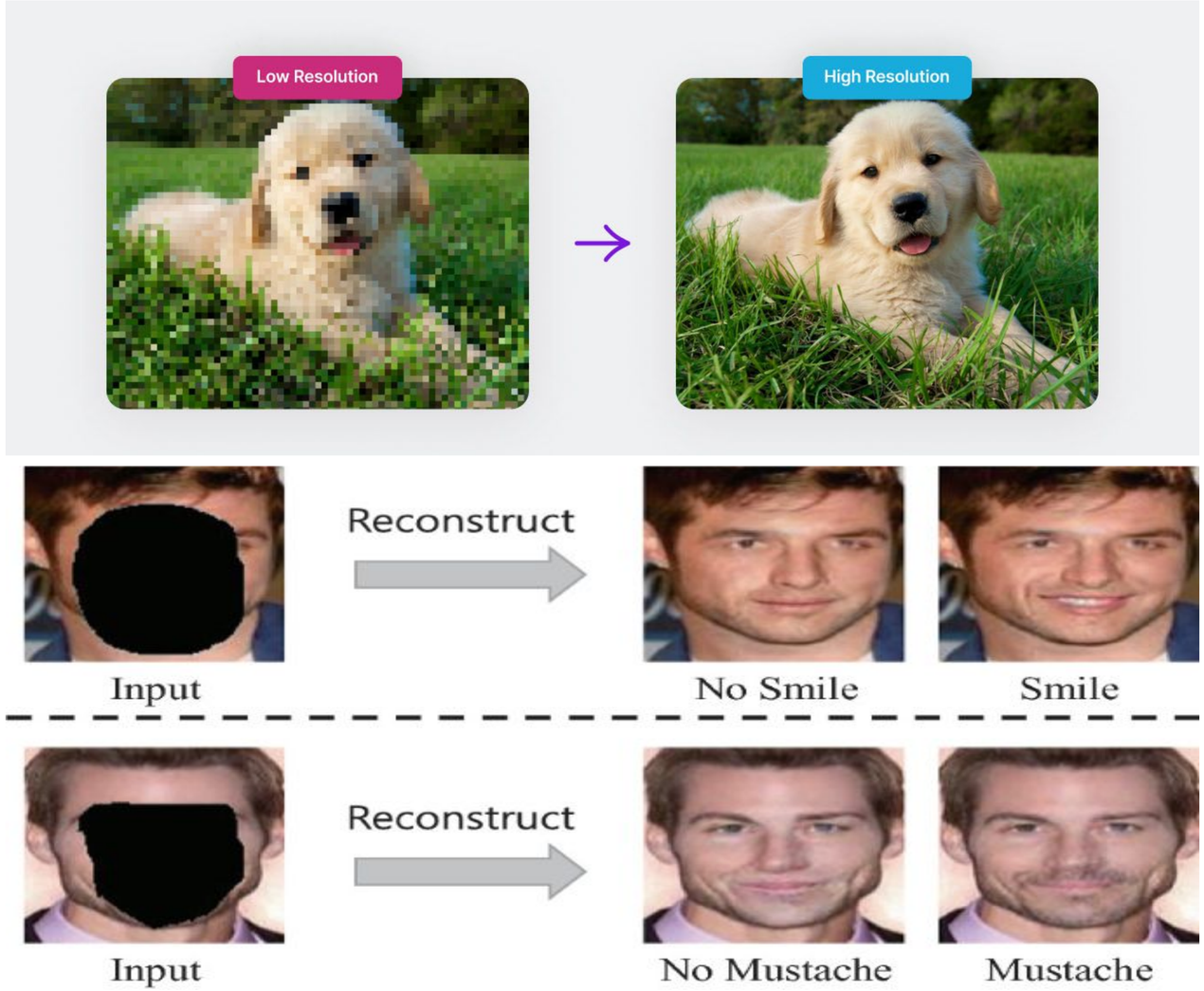
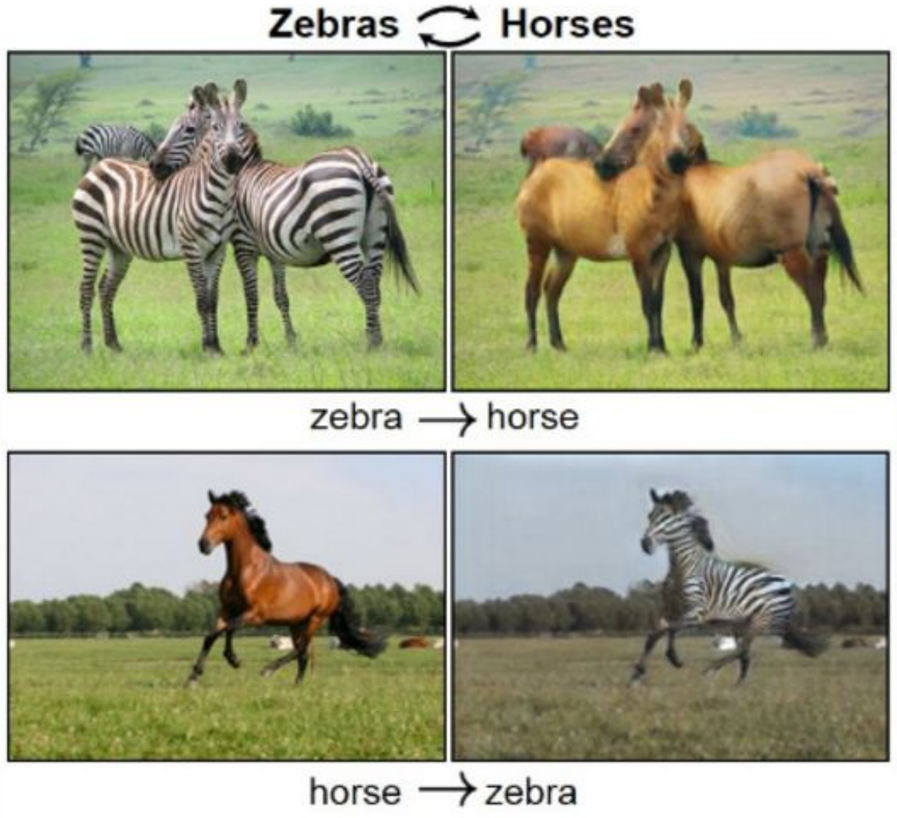
Applications of GANs:





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Applications of GANs:

(a) Denoised (b) Original (c) Noisy

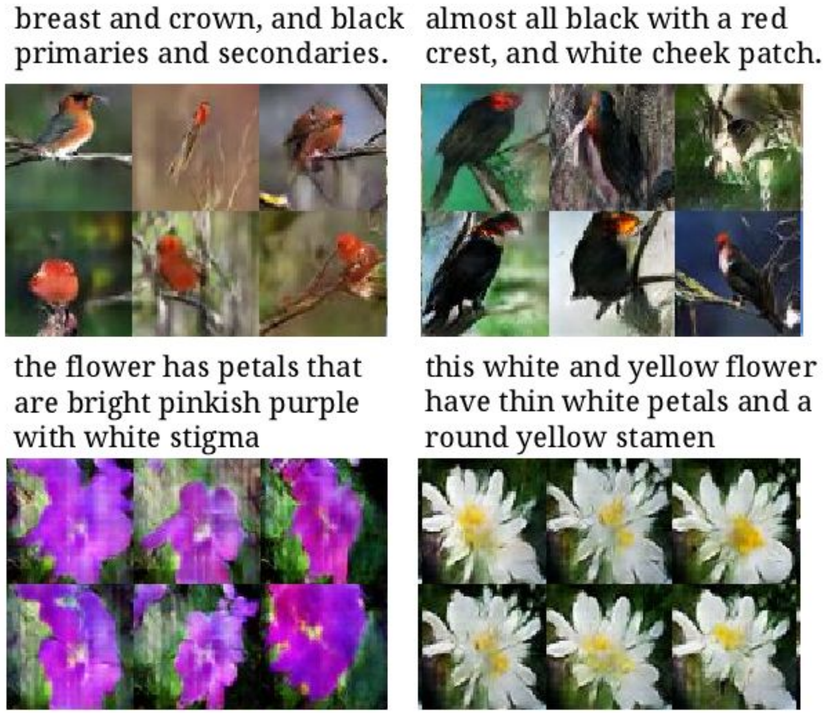

Figure 1. Examples of generated images from text descriptions

Applications of GANs: