

Deep Learning

Chapter 10: Introduction to Generative Models

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LECTURE OUTLINE

Supervised Learning vs Unsupervised Learning

Generative Model

Application of Generative Model

WHICH FACE IS FAKE?



Fake faces generated by ThisPersonDoesNotExist.com. | Image: The Verge

Supervised Learning vs Unsupervised Learning

SUPERVISED LEARNING VS UNSUPERVISED LEARNING

- **Supervised Learning**

Data: (x, y)

x is Data and y is corresponding label

Goal: learn function to map $x \rightarrow y$

Examples: Classification, Regression, Object Detection, Image Segmentation, etc.

- **Unsupervised Learning**

Data: x

x is Data and no labels!

Goal: learn hidden structure of data

Examples: Clustering, Dimensionality Reduction, etc.

DEEP UNSUPERVISED LEARNING

There are two main goals of **deep unsupervised learning**:

- **Representation Learning**

- Examples are: manifold learning, feature learning, etc.
- Can be done by an autoencoder
- Examples of applications:
 - dimensionality reduction / data compression
 - transfer learning / semi-supervised learning

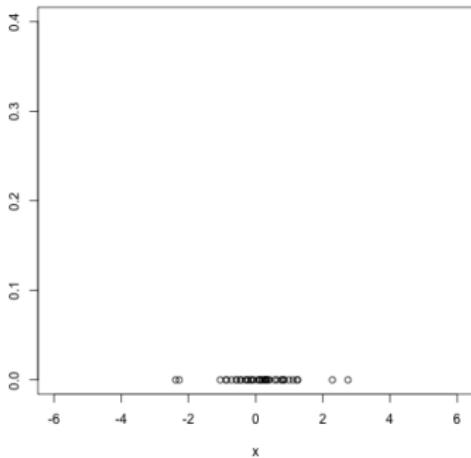
- **Generative Models**

- Given a training set $\mathcal{D} = (\mathbf{x}^{(1)}, \dots, \mathbf{x}^{(n)})$ where each $\mathbf{x}^{(i)} \sim \mathbb{P}_x$, the goal is to estimate \mathbb{P}_x .
- **Goal:** Take as input training samples from some distribution and learn a model that represents that distribution!
- Examples of applications:
 - generating music, videos, volumetric models for 3D printing, synthetic data for learning algorithms, outlier identification, images denoising, inpainting, etc.

Generative Model

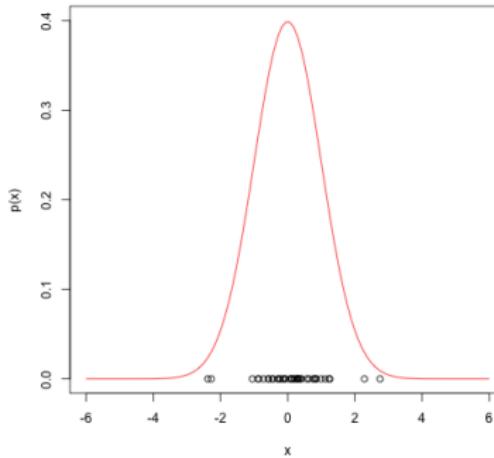
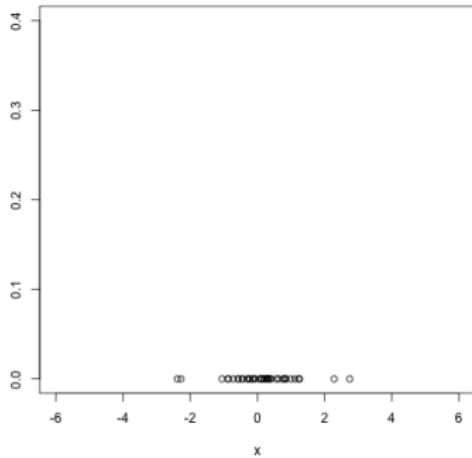
DENSITY FITTING / LEARNING A GENERATIVE MODEL

Given $\mathcal{D} = (\mathbf{x}^{(1)}, \mathbf{x}^{(2)}, \dots, \mathbf{x}^{(n)}) \sim \mathbb{P}_x$ learn a model of \mathbb{P}_x (for example, fitting a Gaussian distribution via Maximum Likelihood Estimation).



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Application of Generative Model

WHY GENERATIVE MODELS?

Generative model, Capable of uncovering underlying latent variables in a dataset and can be used for

- sampling / data generation
- outlier detection
- missing feature extraction
- image denoising / reconstruction
- representation learning
- planning in reinforcement learning
- ...

APPLICATION EXAMPLE: IMAGE GENERATION



Source: Karras et al. (2018)

Figure: Synthetic faces generated by a Generative Adversarial Network (more on this later).

APPLICATION EXAMPLE: NEURAL STYLE TRANSFER

A photograph is “redrawn” in the style of another image! (Gatys et al., 2015)



Figure: Examples generated on <https://deepart.io/>. The image on the left has been generated by translating the original image (middle) to the style of the image on the right.

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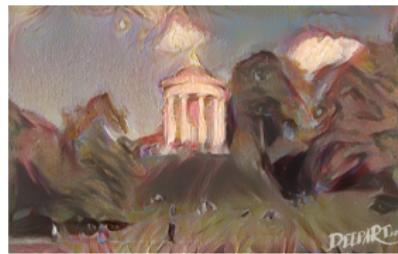
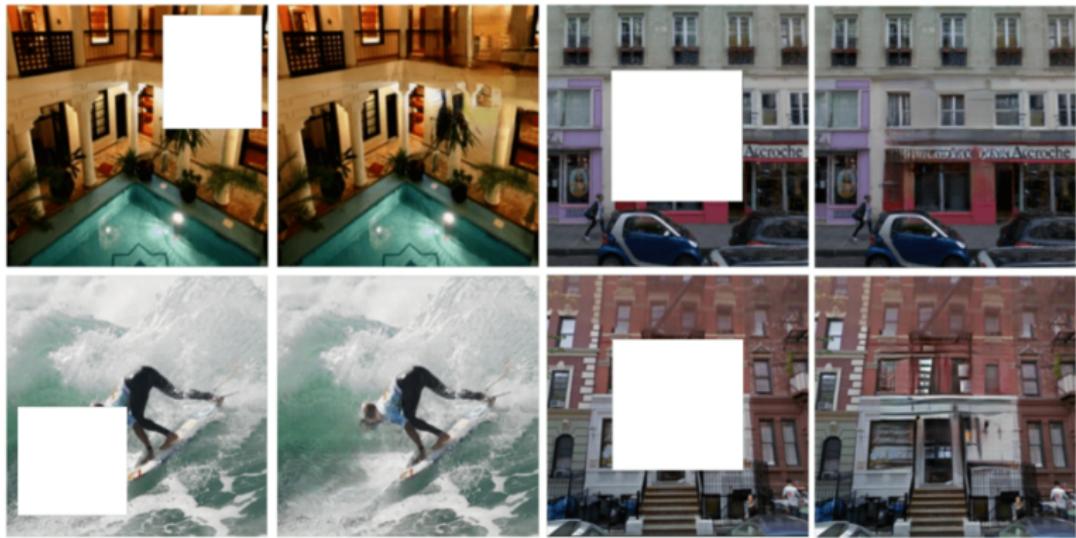


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APPLICATION EXAMPLE: IMAGE INPAINTING



Source: Demir et al (2018)

Figure: A generative model fills in the missing portion of the image based on the surrounding context.

APPLICATION EXAMPLE: SEMANTIC LABELS → IMAGES



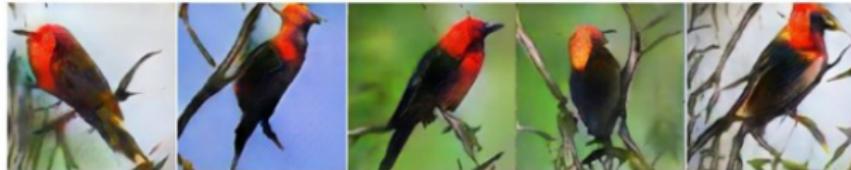
Source: Wang et al (2017)

APPLICATION EXAMPLE: GENERATING IMAGES FROM TEXT

This small blue bird has a short pointy beak and brown on its wings



This bird is completely red with black wings and pointy beak



A small sized bird that has a cream belly and a short pointed bill



A small bird with a black head and wings and features grey wings



Source: Zhang et al (2017)

REFERENCES

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<https://arxiv.org/abs/1803.07422>
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-  Leon A. Gatys et al. (2015)
Neural Algorithm of Artistic Style
<https://arxiv.org/abs/1508.06576>