

Machine Learning

CSC 461: Machine Learning

Fall 2020

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A (short) history of AI/ML

1940-1950: Early days

- ✓ 1943: McCulloch & Pitts: Boolean circuit model of brain
- ✓ 1950: Turing's "Computing Machinery and Intelligence"

1950—70: Excitement: Look, Ma, no hands!

- ✓ 1950s: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
- ✓ 1956: Dartmouth meeting: "Artificial Intelligence" adopted
- ✓ 1965: Robinson's complete algorithm for logical reasoning

1970—90: Knowledge-based approaches

- ✓ 1969—79: Early development of knowledge-based systems
- ✓ 1980—88: Expert systems industry booms
- ✓ 1988—93: Expert systems industry busts: "AI Winter"

1990—2012: Statistical approaches + subfield expertise

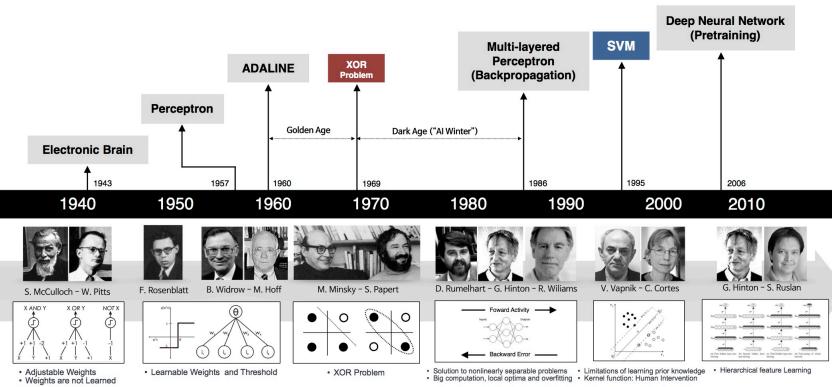
- ✓ Resurgence of probability, focus on uncertainty
- ✓ General increase in technical depth
- ✓ Agents and learning systems... "AI Spring"?

2012—...: Excitement: Look, Ma, no hands again?

- ✓ Big data, big compute, neural networks
- ✓ Some re-unification of sub-fields
- ✓ AI used in many industries

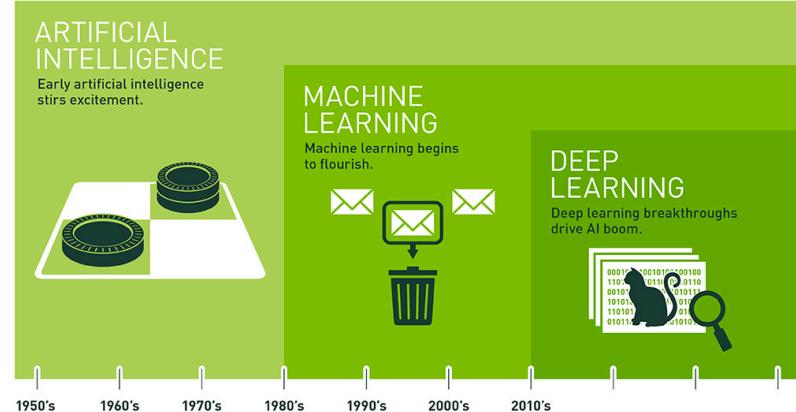
from: CS 188: Introduction to Artificial Intelligence, Berkeley

Milestones in AI/ML



http://beamandrew.github.io/deeplearning/2017/02/23/deep_learning_101_partI.html

AI vs ML vs DL



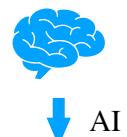
Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

<https://news.developer.nvidia.com/on-demand-webinar-deep-learning-demystified/>

AI vs ML

► ML: Bottom up

- ✓ make specific predictions
- ✓ smaller goals
- ✓ mostly based on Probability/Statistics and Optimization
- ✓ e.g. spam filtering

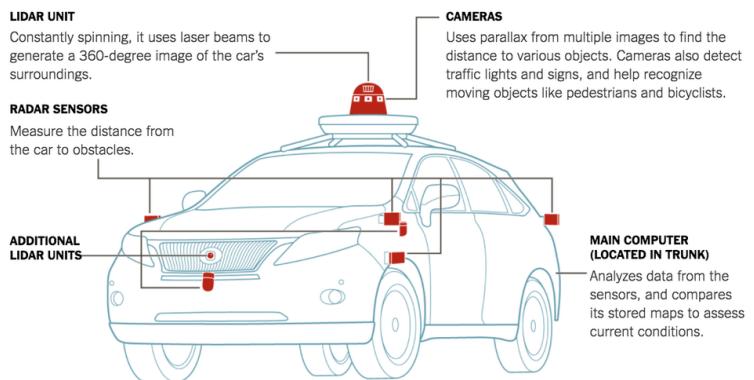


► AI: Top down

- ✓ focus on intelligent systems
- ✓ e.g. autonomous driving



Autonomous cars



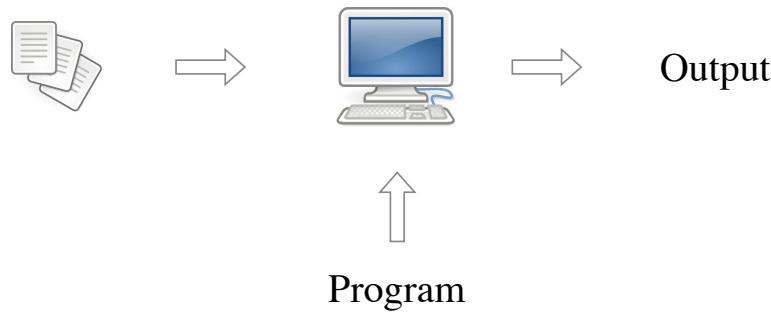
<https://www.nytimes.com/2018/03/19/technology/how-driverless-cars-work.html>

What is Machine Learning?

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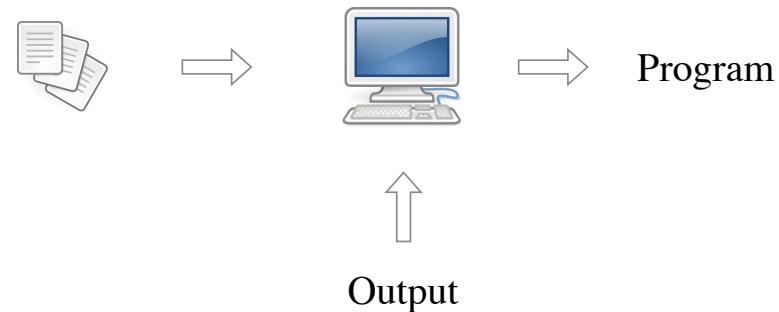
- Machine Learning is ... [Mitchell]
 - ✓ the study of computer algorithms that learn from experience **E** with respect to a particular task **T** and performance metric **P**
- Remember the badges problem?
 - ✓ can you identify **E**, **T** and **P**?

Traditional Programming



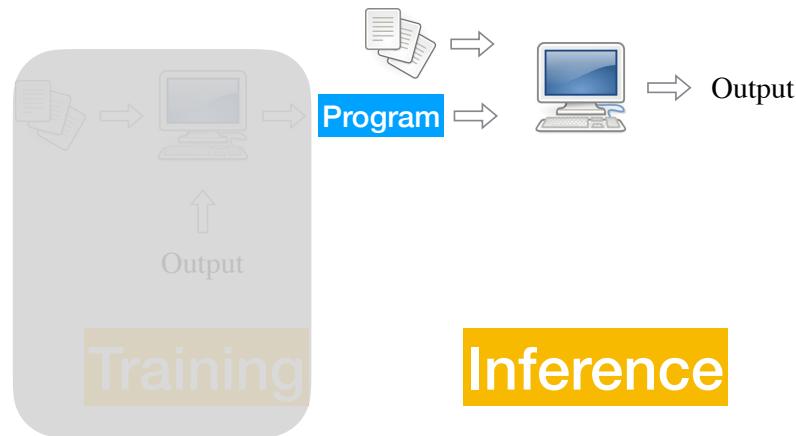
Machine Learning

(Supervised)



Machine Learning

(Supervised)



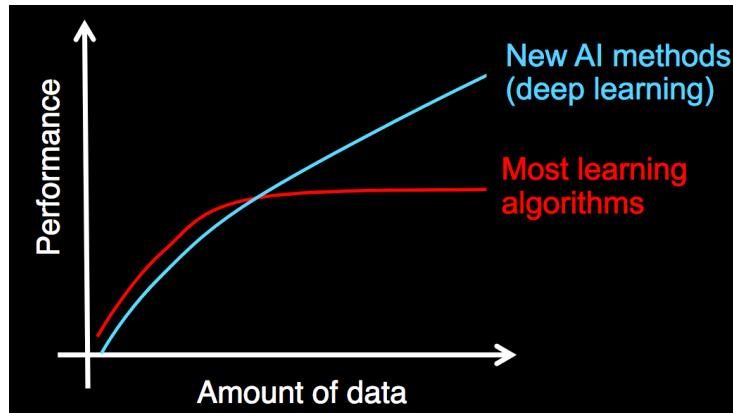
Applications ...



Data and Machine Learning

Data is the most important part

Quality &
Quantity



from: CS229: Machine Learning, Stanford

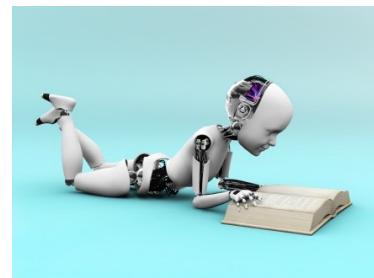
THE EXPANDING UNIVERSE OF MODERN AI



Intro to Deep Learning by NVIDIA, HPC AdminTech, 2017

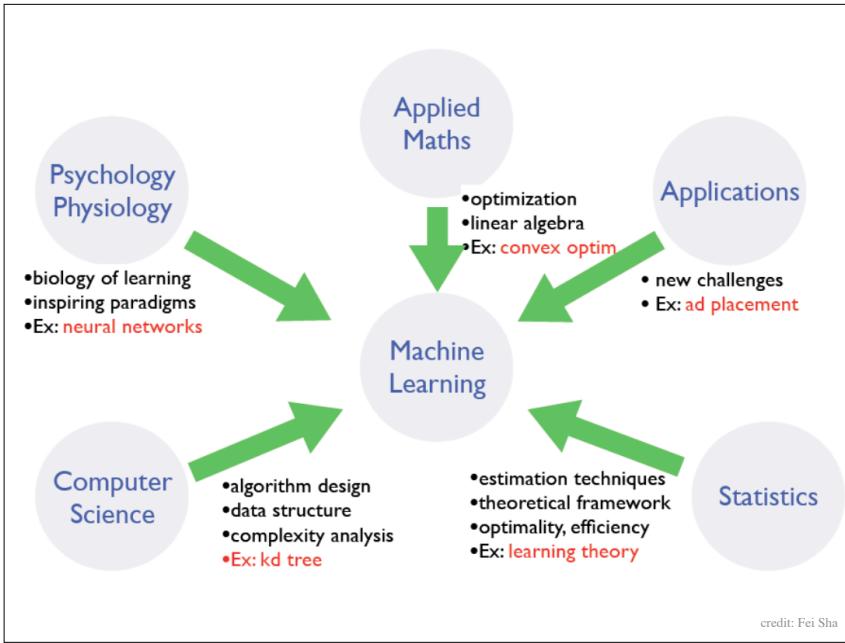
Why ML is so popular?

- Recent progress in algorithms and theory
- Growing amounts of data
- Computational power
- Industry investment
- Great applications



When to use Machine Learning?

- Need for automation
 - ✓ automate things humans can do (e.g. speech recognition)
 - ✓ difficult/expensive things for humans (e.g. process huge amounts of data)
- Need for custom models
 - ✓ e.g. personalized medicine, spam filters



Major Paradigms

Supervised learning

- ✓ training data and labels
- ✓ classification, regression

Unsupervised learning

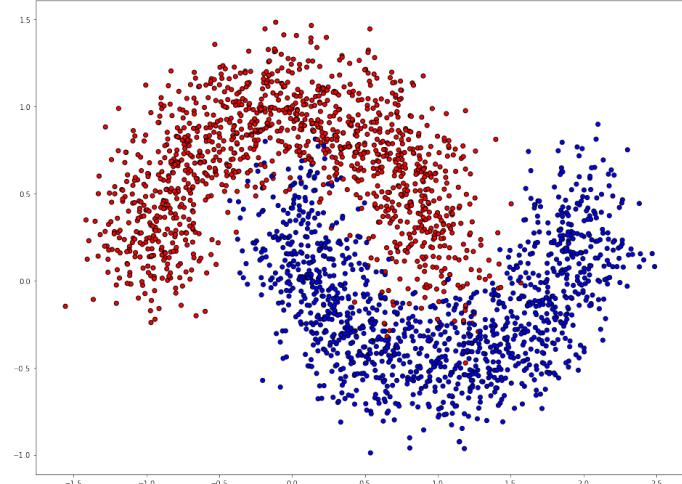
- ✓ training data (no labels)
- ✓ clustering, dimensionality reduction, density estimation

Reinforcement learning

- ✓ rewards from actions

Supervised Learning

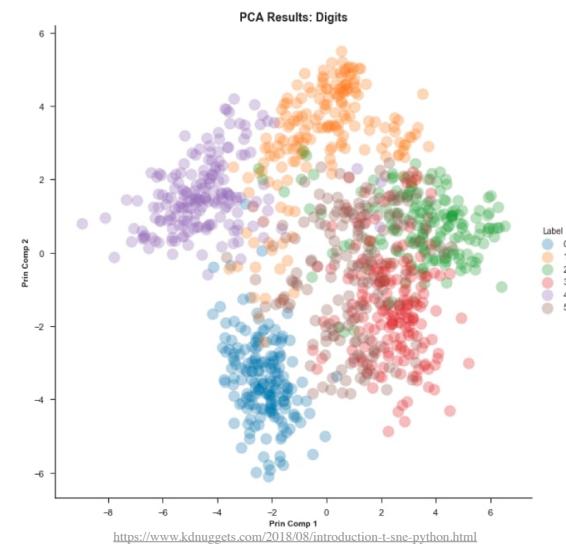
Binary classification



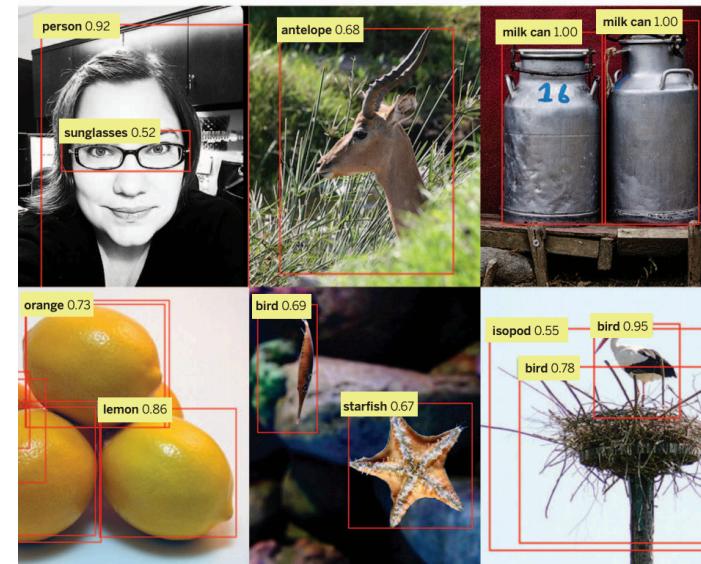
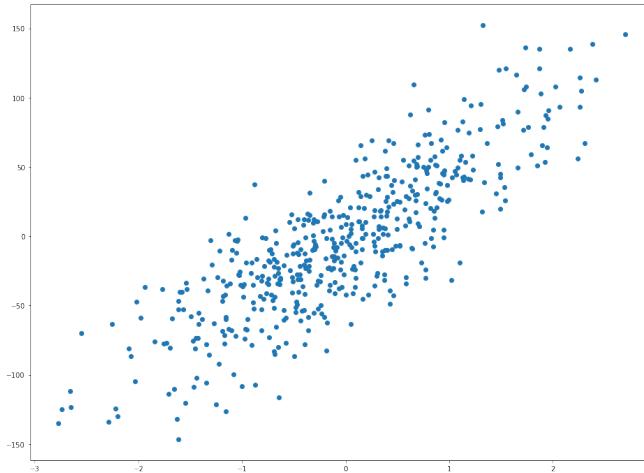
Data?

```
array([[ 0.24277092,  0.89098144],      array([[0],  
[-0.57961074,  0.50618765],      [1],  
[ 0.24259841,  0.12209649],      [1],  
[ 1.68348295, -0.10059047],      [1],  
[ 2.00696736, -0.79306007],      [1],  
[ 1.56891881,  0.30515286],      [0],  
[ 0.1314049 , -0.35704446],      [1],  
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[-1.03087047,  1.52609949],      [0],  
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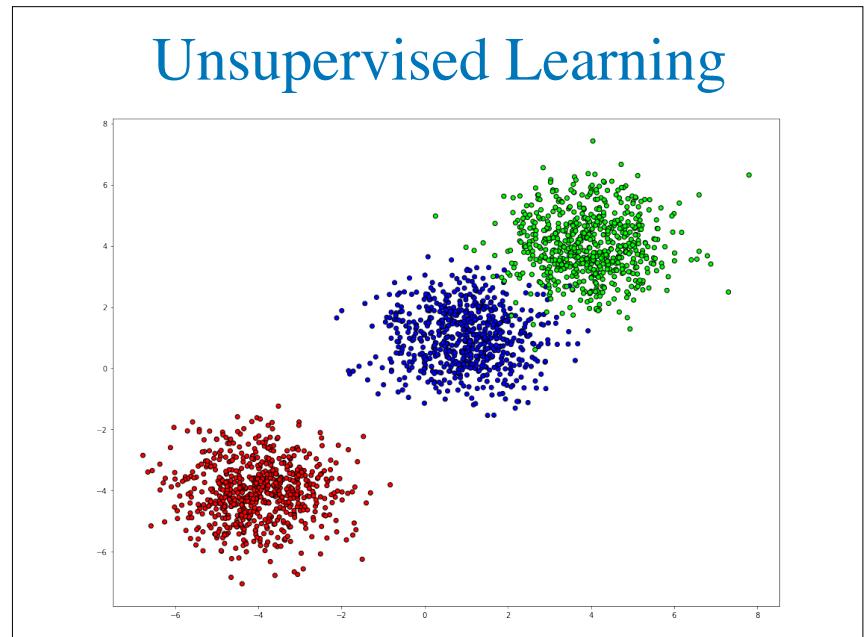
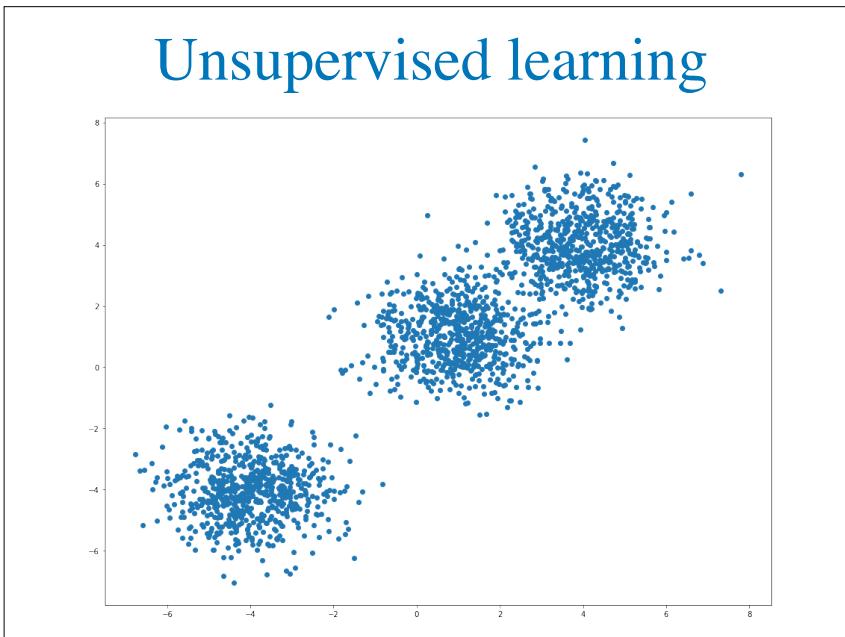
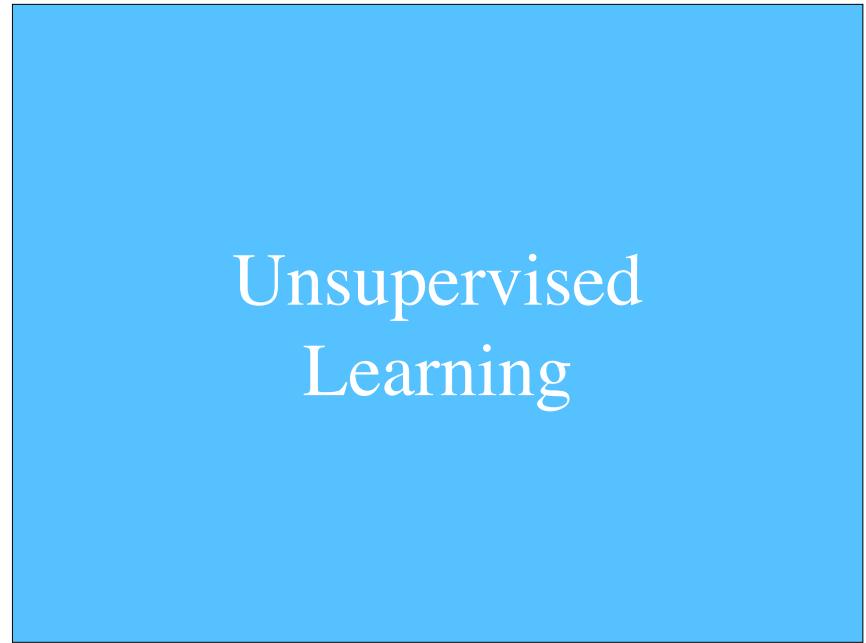
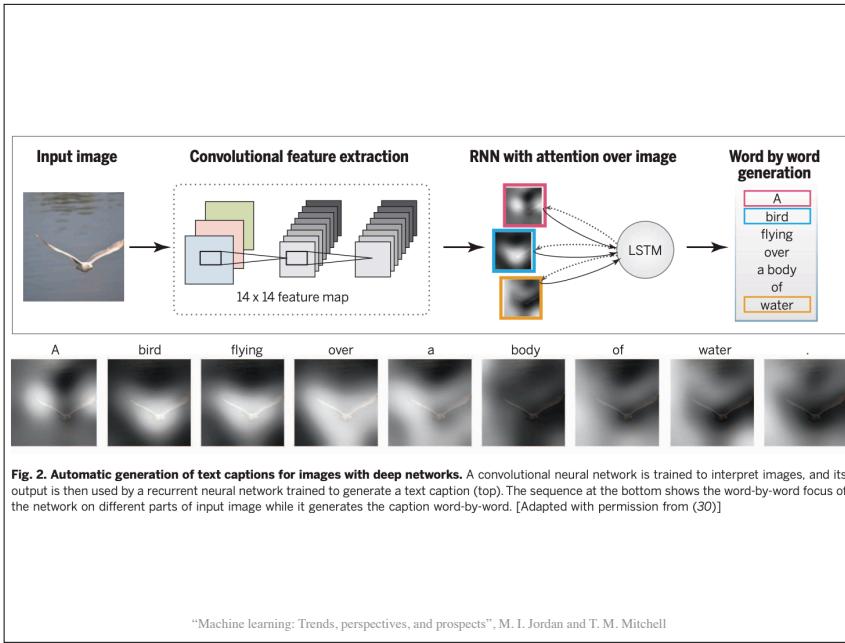
Multiclass classification



Regression



"Machine learning: Trends, perspectives, and prospects", M. I. Jordan and T. M. Mitchell



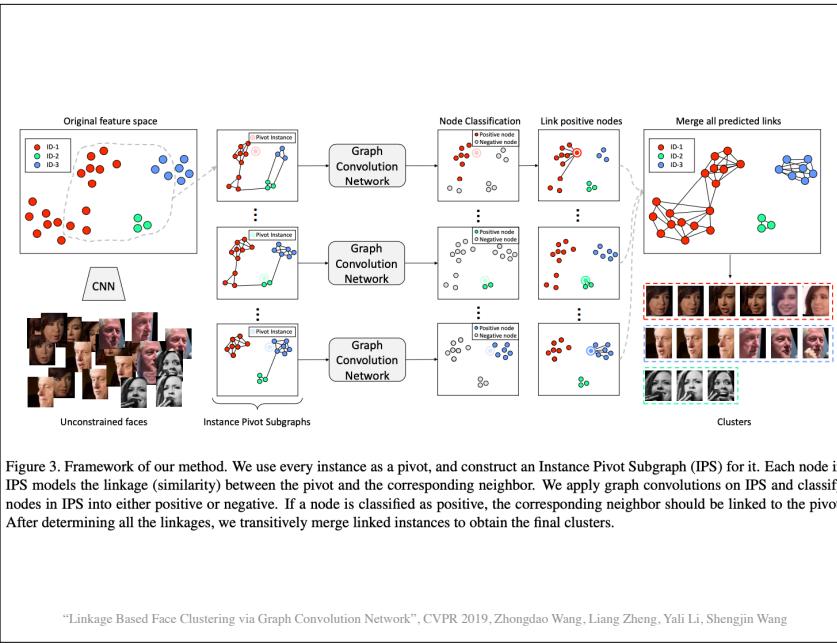


Figure 3. Framework of our method. We use every instance as a pivot, and construct an Instance Pivot Subgraph (IPS) for it. Each node in IPS models the linkage (similarity) between the pivot and the corresponding neighbor. We apply graph convolutions on IPS and classify nodes in IPS into either positive or negative. If a node is classified as positive, the corresponding neighbor should be linked to the pivot. After determining all the linkages, we transitively merge linked instances to obtain the final clusters.

"Linkage Based Face Clustering via Graph Convolution Network", CVPR 2019, Zhongdao Wang, Liang Zheng, Yali Li, Shengjin Wang

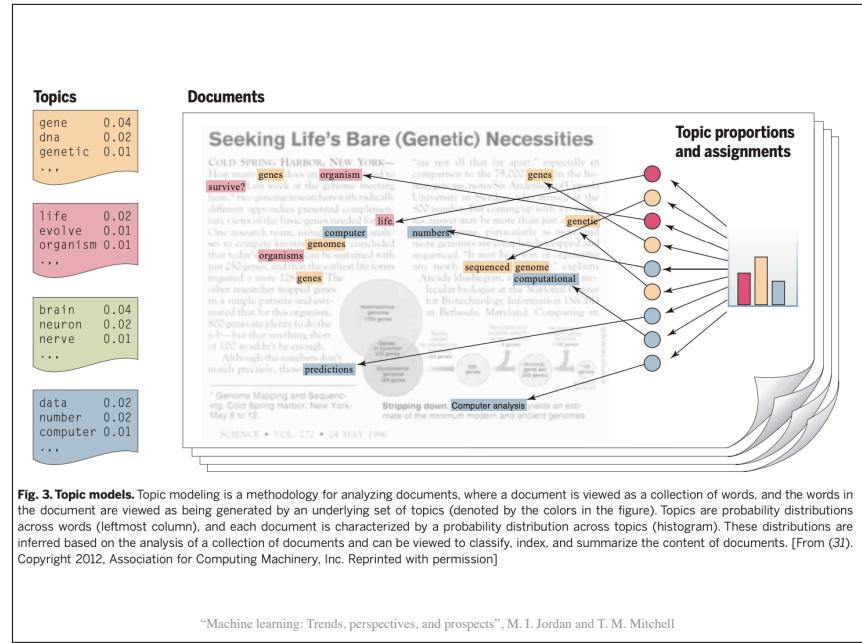
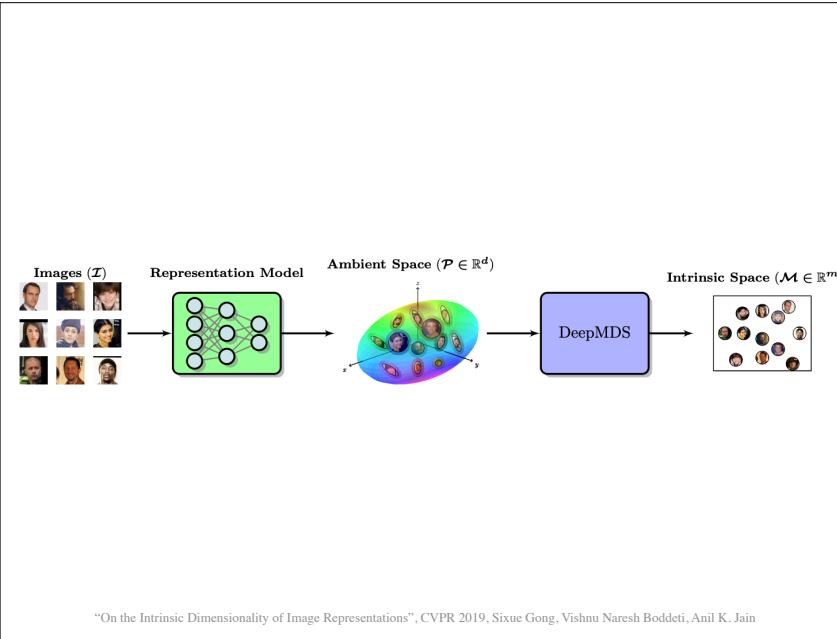


Fig. 3. Topic models. Topic modeling is a methodology for analyzing documents, where a document is viewed as a collection of words, and the words in the document are viewed as being generated by an underlying set of topics (denoted by the colors in the figure). Topics are probability distributions across words (leftmost column), and each document is characterized by a probability distribution across topics (histogram). These distributions are inferred based on the analysis of a collection of documents and can be viewed to classify, index, and summarize the content of documents. [From (31). Copyright 2012, Association for Computing Machinery, Inc. Reprinted with permission]

"Machine learning: Trends, perspectives, and prospects", M. I. Jordan and T. M. Mitchell



"On the Intrinsic Dimensionality of Image Representations", CVPR 2019, Sixue Gong, Vishnu Naresh Bodetti, Anil K. Jain

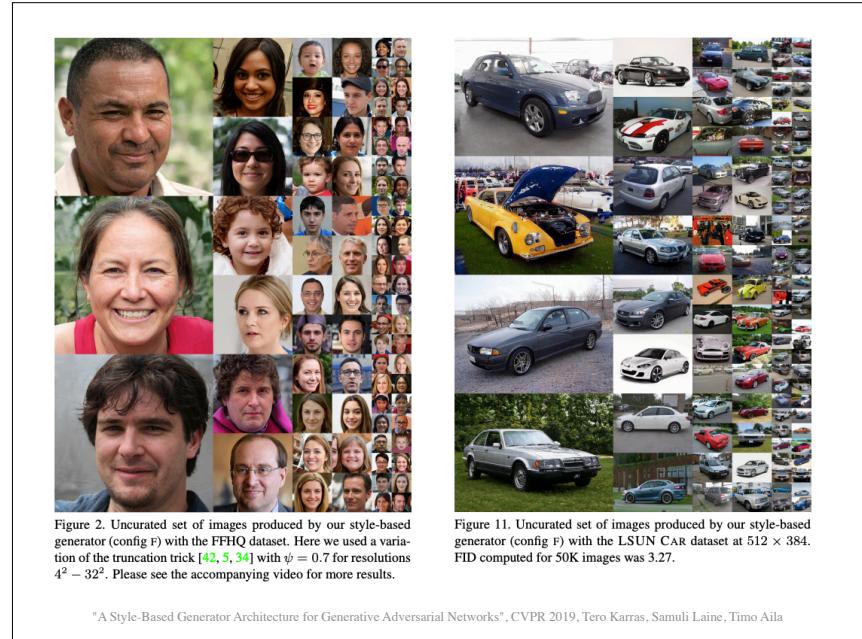
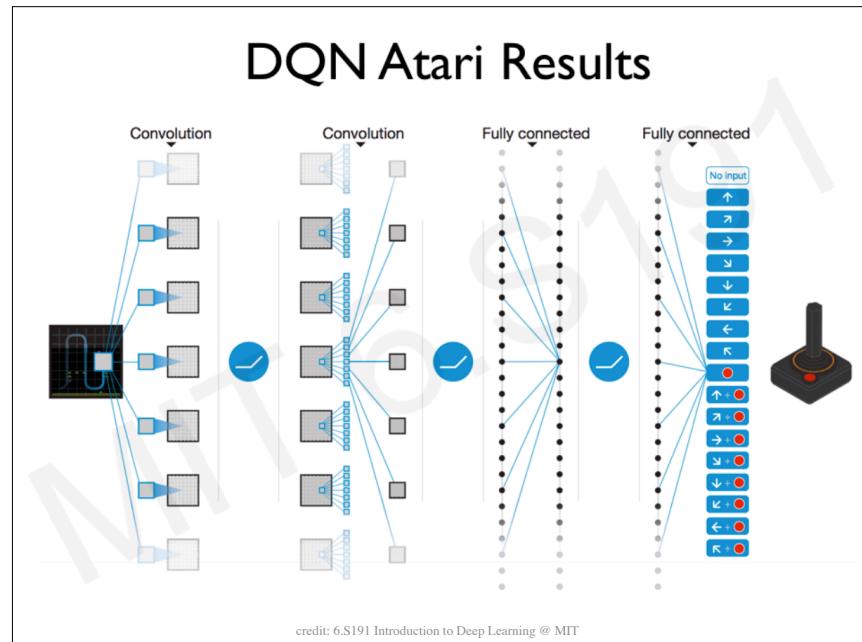
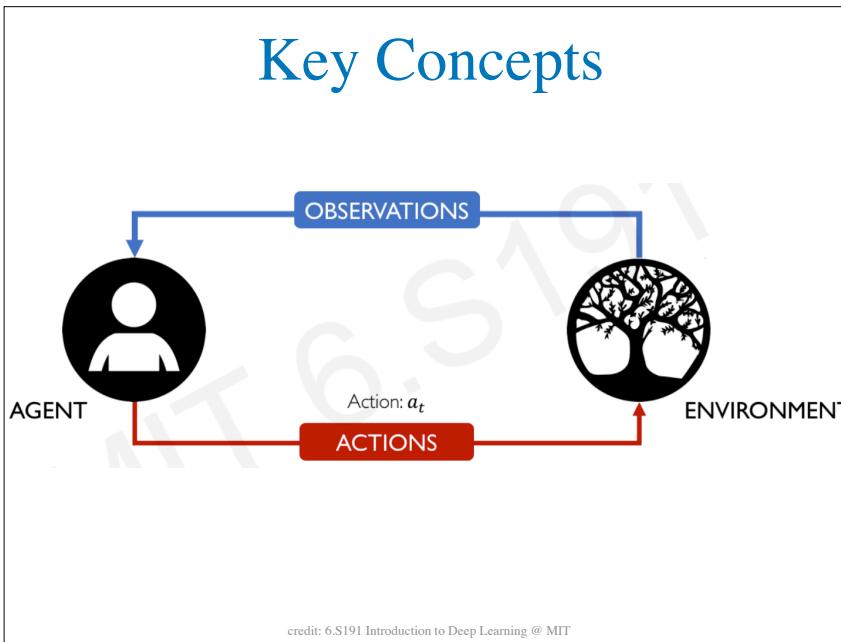
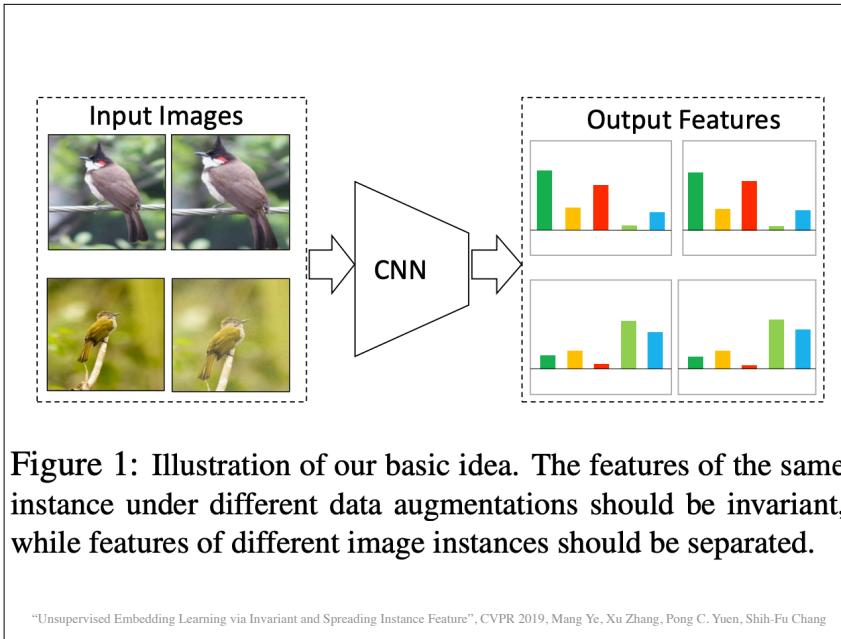
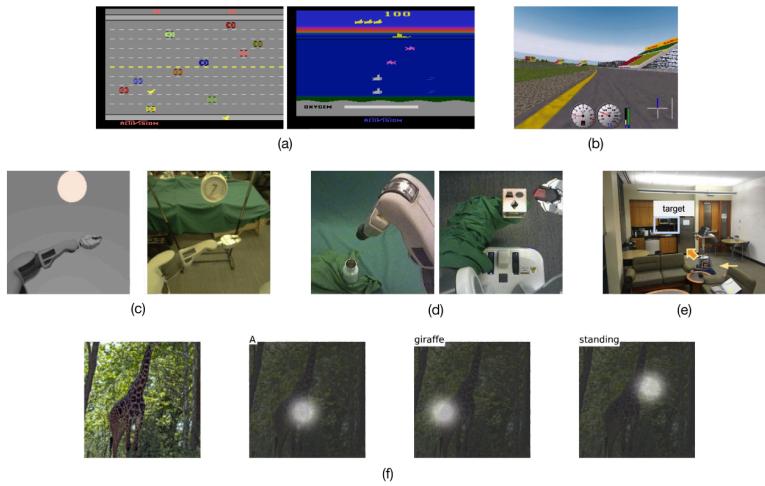


Figure 2. Uncurated set of images produced by our style-based generator (config F) with the FFHQ dataset. Here we used a variation of the truncation trick [42, 5, 34] with $\psi = 0.7$ for resolutions $4^2 - 32^2$. Please see the accompanying video for more results.

Figure 11. Uncurated set of images produced by our style-based generator (config F) with the LSUN CAR dataset at 512×384 . FID computed for 50K images was 3.27.

"A Style-Based Generator Architecture for Generative Adversarial Networks", CVPR 2019, Tero Karras, Samuli Laine, Timo Aila





Generating random data

<https://colab.research.google.com/drive/1Lk8VqVhmPsIdiZeJo57IWdNDbDyD8EYC>