Supervised
Unsupervised
Semi-supervised
Weakly-supervised
Multi-task
Transfer
Few-shot
Zero-shot
Self-supervised
Reinforcement

Learning

CS229: Machine Learning
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Supervised Learning

- Observe:
  - Features $x$
  - Labels $y$ (for all data points)

- Learning goal:
  - Model to predict $y$ from $x$
Unsupervised Learning

- Observe:
  - Features $x$

- Learning goal:
  - Discover structure in space of $x$, e.g.:
    - Clustering: infer cluster labels $z$
      - Typically one cluster per input
    - Dimensionality reduction: discover lower dimensional subspaces, e.g.:
      - PCA – linear subspace
      - Embeddings – general vector space
    - Topic modeling: infer cluster labels $z$
      - Input can belong to multiple clusters

![Graph showing data points and clusters](image-url)
Semi-supervised Learning

- Observe:
  - Features $x$ for all data points
  - Labels $y$ only for some data points

- Learning goal:
  - Model to predict $y$ from $x$

much more unlabeled data than labeled
Very Simple Semi-supervised learning algorithm

Consider responsibilities in EM:

\[ r_{ik} = p(z^i = k | x^i, \pi, \mu, \Sigma) \]

- **unlabeled data**
- **labeled data**: 
  \[ r_{ik} = \begin{cases} 1 & \text{if } k \text{ is the label} \\ 0 & \text{otherwise} \end{cases} \]
Weakly Supervised Learning

- Decrease cost or complexity of labeling by using “surrogate” labels
- Observe:
  - Features $x$
  - Some signal $z$ related to true label $y$:
    - Imprecise labels – simpler, high-level labels
    - Inaccurate labels – inexpensive, lower-quality labels
    - Existing resources – knowledge bases or heuristics to generate labels
- Learning goal:
  - Model to predict $y$ from $x$
Multi-tasks Learning

Observe:
- $k$ tasks
- Each data point:
  - Features $x$
  - Labels $y_j$ for task $j$
    - Potentially labels for multiple tasks

Learning goal:
- Model to predict $y_1,...,y_k$ from $x$
Transfer Learning

- **Observe:**
  - Model M for previous task
    - Maps $x \rightarrow z$
  - New task
    - Features $x$
    - Labels $y$

- **Learning goal:**
  - Model to predict $y$ from $x$
Transfer learning: *Use data from one task to help learn on another*

Old idea, explored for deep learning by Donahue et al. '14 & others
What’s learned in a neural net

Neural net trained for Task 1: cat vs. dog

More generic
Can be used as feature extractor

Very specific
to Task 1
Should be ignored for other tasks
Transfer learning in more detail...

For Task 2, predicting 101 categories, learn only end part of neural net

Neural net trained for Task 1: cat vs. dog

Keep weights fixed!

More generic
Can be used as feature extractor

Very specific
to Task 1
Should be ignored for other tasks

Use simple classifier
e.g., logistic regression, SVMs, nearest neighbor,...
Careful where you cut: 
*latter layers may be too task specific*

Example detectors learned

Example interest points detected

[Zeiler & Fergus ‘13]
Few-Shot Learning

- **Observe:**
  - Very few data points: (1–100)
    - Features $\mathbf{x}$
    - Labels $\mathbf{y}$

- **Learning goal:**
  - Model to predict $\mathbf{y}$ from $\mathbf{x}$
Zero-Shot Learning

**Observe:**
- Features \( x \)
- Labels \( y \)

**Learning goal:**
- Model to predict \( y' \) from \( x \)
  - For a new class \( y' \) not seen in training data

- **Side information:**
  - Zebras are like horses with stripes
Self-Supervised Learning

- **Observe:**
  - Features \( \mathbf{x} \)
    - Usually sequence of data, e.g., text or video
  - Define some supervision signal \( y \) ("label") that can be automatically extracted from data

- **Learning goal:**
  - Predict \( y \) from \( \mathbf{x} \)

**Language model:**
- Label \( y \) is next word
- Sequence \( \mathbf{x} \) – words thus far in the sentence
Dear Richard Dawkins,

Can you tell me in short what was the central idea in your book "The Selfish Gene"?

Warmly,
Paras

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Dear Paras,

This is quite hard to answer briefly. But the central idea is that living organisms are a kind of machine, a ‘vehicle’ for replicating molecules - the genes. The organism is like a truck whose job it is to transport the genes around in order to survive, and then reproduce them in new trucks (that is, in offspring). This is done by the genes making the truck (organism) behave in such a way as to protect the genes, to allow them to survive and reproduce. The genes ‘want’ to live forever if they can. This is their single aim in life, and they are utterly ruthless in achieving it. But the point is that they themselves are not alive. The truck (the organism) is alive, but the ‘driver’ (the genes) is not. You see what I mean? I hope that is clear!

Best wishes, Richard.

Describe it without using the word “giraffe”: “A lonely animal looks for love in a forest filled with tall trees.”

Wittgenstein would describe it in the following way: “The sentence uses an icon that looks like a giraffe.”

Jane Austen would write the sentence about the giraffe in the following way: “The lonely giraffe is the most beautiful animal in the forest because of his long neck. All the other animals are jealous of him and afraid that he will steal their girlfriends.”

A mathematical way to formulate the same sentence is: “The relative number of animals in the forest, whose necks are shorter than the giraffe’s, is less than the relative number of animals in the forest, whose necks are longer than the giraffe’s.”

The python version of the sentence with the giraffe looks like this: ‘obj = giraffe()’

a utomatically
Legal clause: Upon liquidation of the Company, the Series A Shareholders to all other shareholders an amount in respect of each Series A Share equal to the Issue Price (the "Liquidation Preference"), plus all accrued but unpaid dividends. The Company has assets remaining after the distribution of that amount, these assets will participate with the holders of Ordinary Shares pro rata to the number of shares converted basis.

Plain English: If the startup is wound up, the Series A investors will be paid first and they will also share any leftover assets with ordinary shareholders.

Legal Clause: Sale of all or substantially all of the assets of the Company (involving a change in control (each, a "Corporate Transaction") will be treated as an event of liquidation and the proceeds of sale will be distributed as set out in paragraph 36. The Series A Shares have received any Special Dividend it shall be set off against the Liquidation Preference.

Plain English: If the company is sold, or a new owner takes control, the proceeds will be distributed as in the liquidation clause above. Any special dividend paid will be paid towards the Series A investors.

Title: United Methodists Agree to Historic Split
Subtitle: Those who oppose gay marriage will form their own denomination
Article: After two days of intense debate, the United Methodist Church has agreed to a historic split - one that is expected to end in the creation of a new denomination, one that will be "theologically and socially conservative," according to The Washington Post. The majority of delegates attending the church's annual General Conference in May voted to strengthen a ban on the ordination of LGBTQ clergy and to write new rules that will "discipline" clergy who officiate at same-sex weddings. But those who opposed these measures have a new plan: They say they will form a separate denomination by 2020, calling their church the Christian Methodist denomination.

The Post notes that the denomination, which claims 12.5 million members, was in the early 20th century the "largest Protestant denomination in the U.S.,” but that it has been shrinking in recent decades. The new split will be the second in the church's history. The first occurred in 1968, when roughly 10 percent of the denomination left to form the Evangelical United Brethren Church. The Post notes that the proposed split “comes at a critical time for the church, which has been losing members for years,” which has been "pushed toward the brink of a schism over the role of LGBTQ people in the church." Gay marriage is not the only issue that has divided the church. In 2016, the denomination was split over ordination of transgender clergy, with the North Pacific regional conference voting to ban them from serving as clergy, and the South Pacific regional conference voting to allow them.
Describe a layout.

Just describe any layout you want, and it'll try to render below!

```html
<button style={backgroundColor: 'pink', border: '2px solid green', borderRadius: '50%', padding: 20, width: 100, height: 100}>Watermelon</button>
```
Foundation (large-language) models: definition

A self-supervised model trained on broad data

and

can be adapted to a wide range of different tasks

Content Courtesy of Percy Liang
foundation models: emergence

self-supervised learning + scale = emergence

In 1885, Stanford University was

Find a word that rhymes: duck, luck; lunch, munch

Content Courtesy of Percy Liang
foundation models: homogenization

question answering  
translation  
parsing  
sentiment classification  
coreference resolution  

foundation (large-language) model

Content Courtesy of Percy Liang
brittleness

lacks commonsense

Q: Which is heavier, a toaster or a pencil?
A: A pencil is heavier than a toaster.

Q: What is 1,000 + 4,000?
A: 5,000

Q: What is 1000 + 4000?
A: 2,000

lacks internal consistency

Content Courtesy of Percy Liang
Two Muslims walked into the lobby of the Family Research Council in Washington, D.C. They shot the security guard.

Stanford University was founded in 1891. However, the university's roots date back to 1885 when the Association for the Relief of California Indian Widows and Orphans was founded.

Climate change is the new communism - an ideology based on a false science that cannot be questioned.
Reinforcement Learning

- Observe:
  - State $x$
  - Action $a$
  - Reward $r$

- Learning goal:
  - Policy: $x \rightarrow a$
    - To maximize accumulated reward