



UNIVERSIDADE
CATÓLICA
PORTUGUESA

BRAGA

Deep Learning

Session 1

Course Introduction

Applied Data Science

2024/2025

Course Objectives

- **Learn the theoretical foundations of deep learning**
 - Explore key concepts such as neural networks, backpropagation, and optimization techniques.
- **Understand the mathematical models behind deep learning**
 - Understand the mathematical principles, including linear algebra, calculus, and probability, that support neural networks.
- **Implement advanced deep learning algorithms using Python**
 - Design, code, and optimize algorithms using Python and libraries like PyTorch.
- **Apply deep learning techniques to real-world problems**
 - Solve complex challenges in domains like computer vision, natural language processing, and predictive analytics.

Classes

- **Thursdays | 16:30 - 18:30**
- **Fridays | 11:00 - 13:00**
- **Theory Session**
 - **Focus:** Foundations of deep learning
- **Hands-On Session**
 - **Focus:** Practical implementation using Python

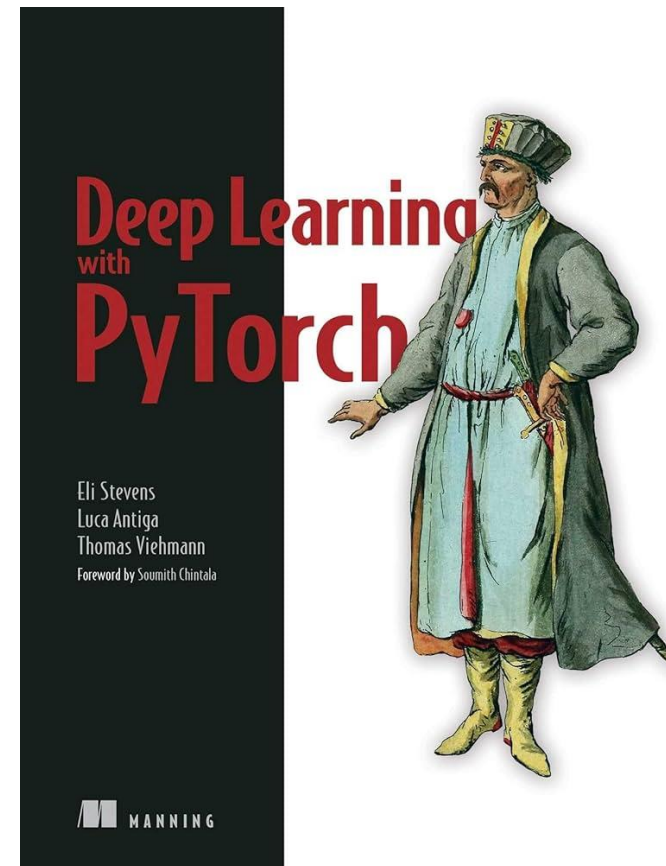
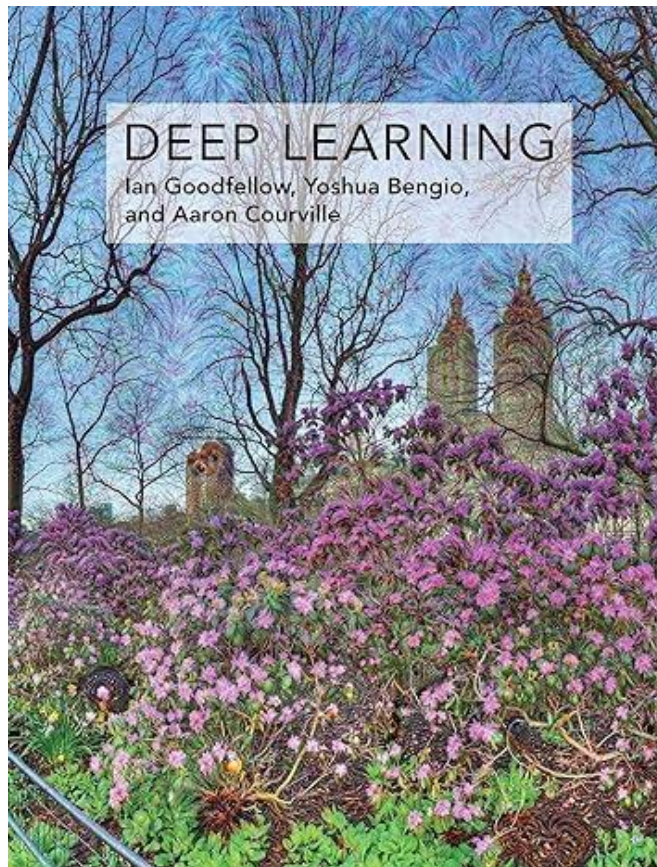
Evaluation



	% of Final Course Grade
Exam	30%
Lab Assignments	30%
Final Project	40%

Resources

- Both books are available online for free!

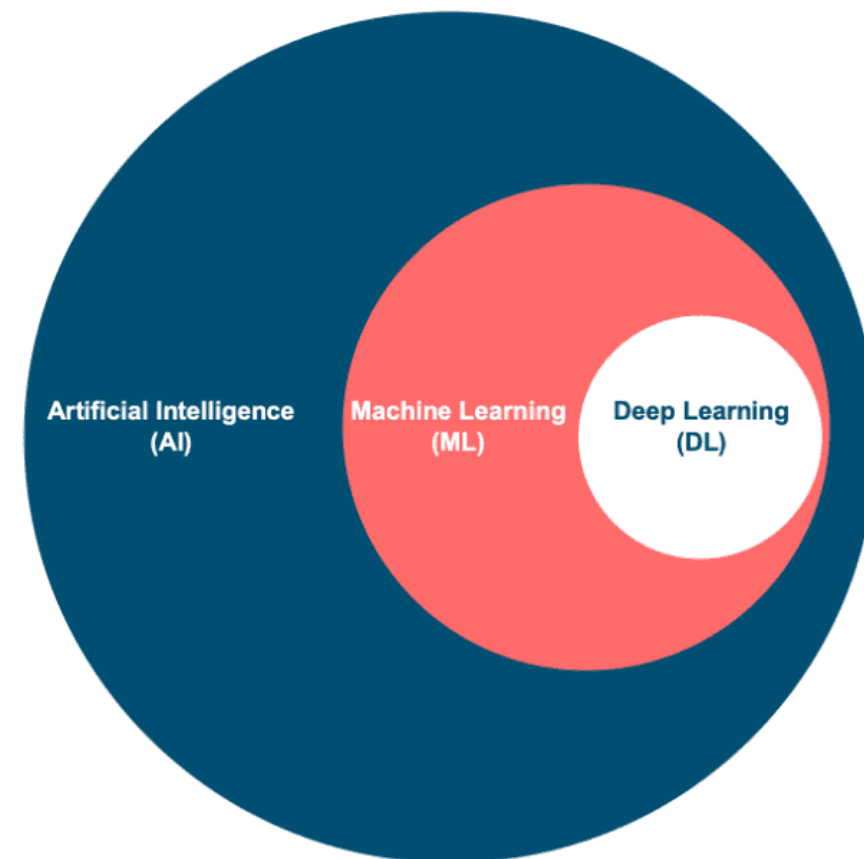


Contact

- For all course-related matters you can contact me:
 - joacorreia@ucp.pt
 - OR
 - Jfscorreia95@gmail.com

Deep Learning

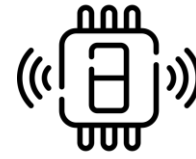
- **Artificial Intelligence (AI):** The broadest field focusing on creating machines capable of performing tasks that typically require human intelligence.
- **Machine Learning (ML):** A branch of AI that enables systems to learn and improve from experience without explicit programming.
- **Deep Learning (DL):** A specialized ML technique using neural networks with many layers to model complex patterns in data.



Deep Learning: Why now?

1. Big Data

- Larger Datasets
- Easier Collection and Storage



Sensor Data



Public Web



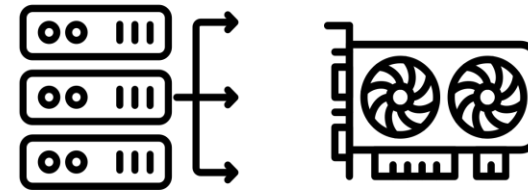
Social Media



Documents

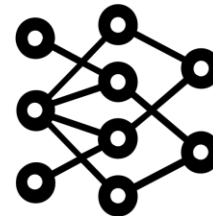
2. Hardware

- Graphics Processing Units (GPUs)
- Massively Parallelizable

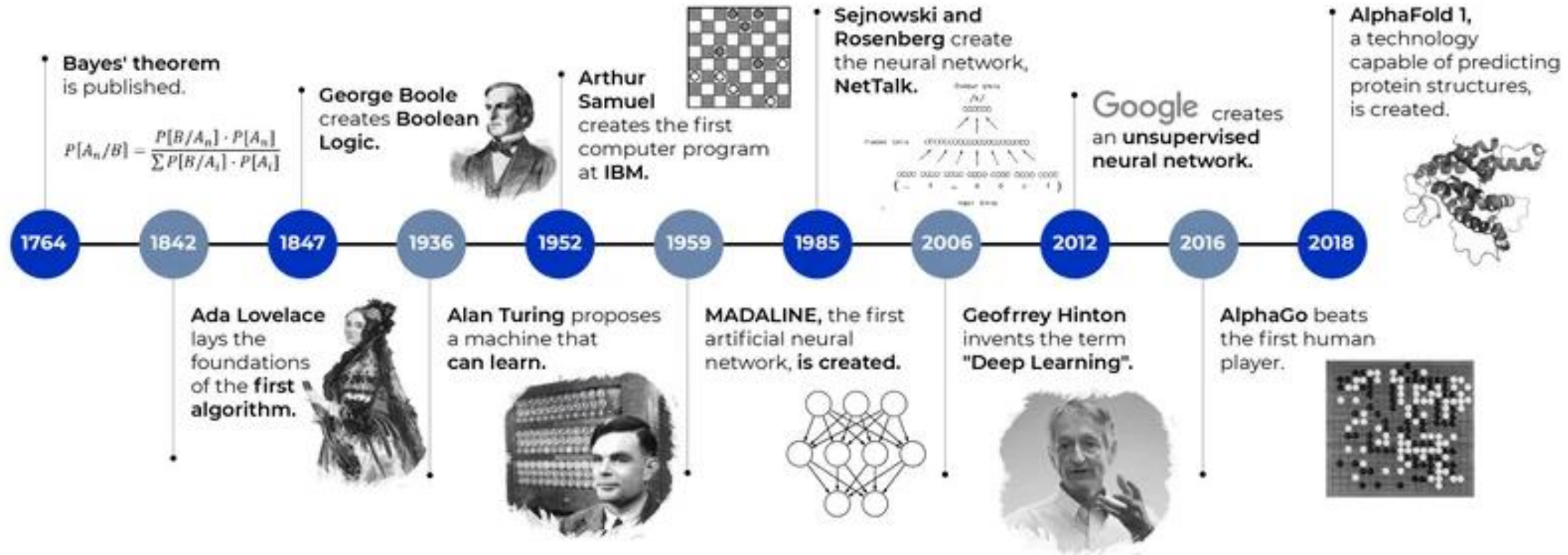


3. Software

- Improved Techniques
- New Models
- Toolboxes

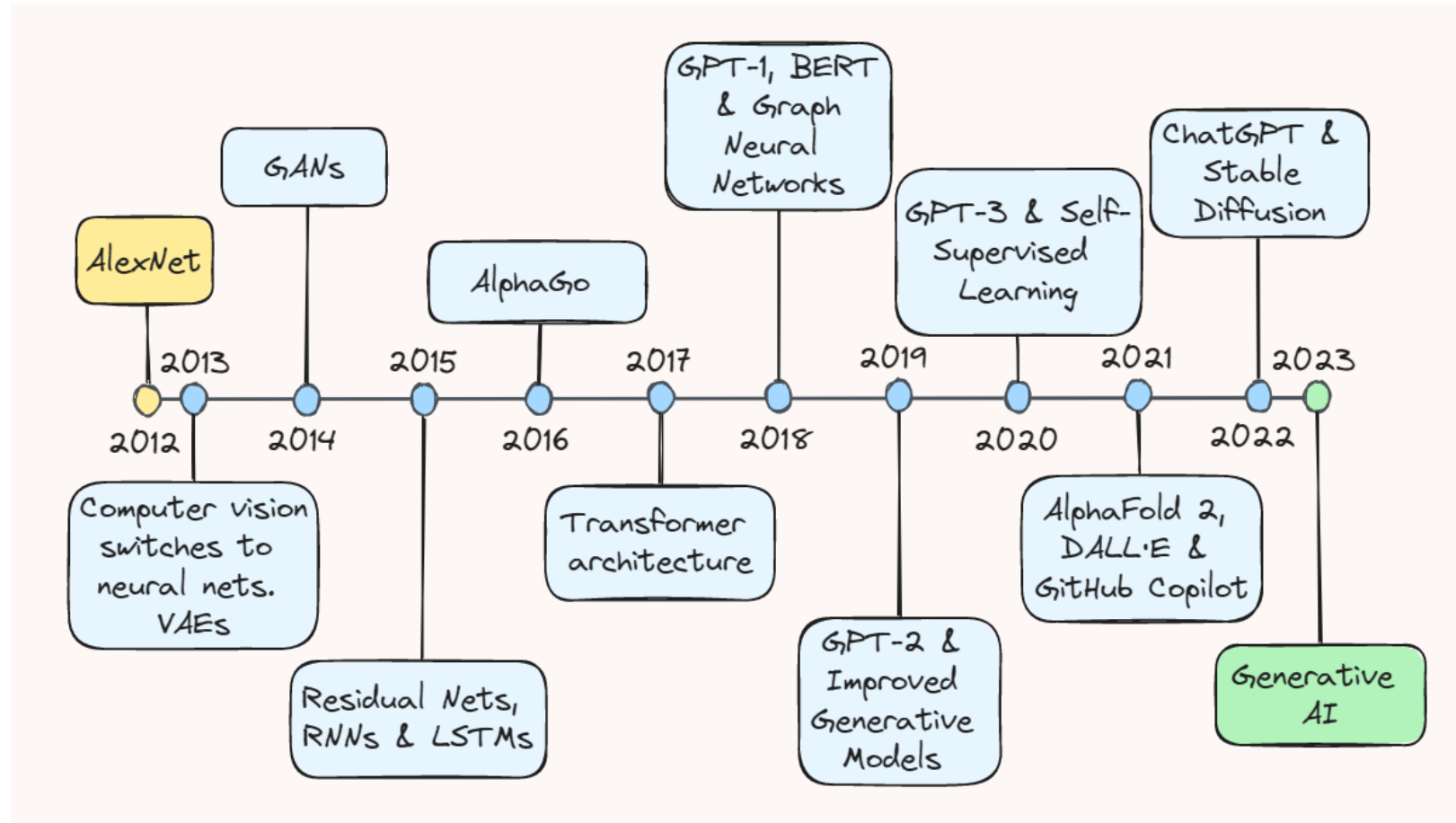


Deep Learning: Timeline



<https://www.algotive.ai/blog/machine-learning-what-is-ml-and-how-does-it-work>

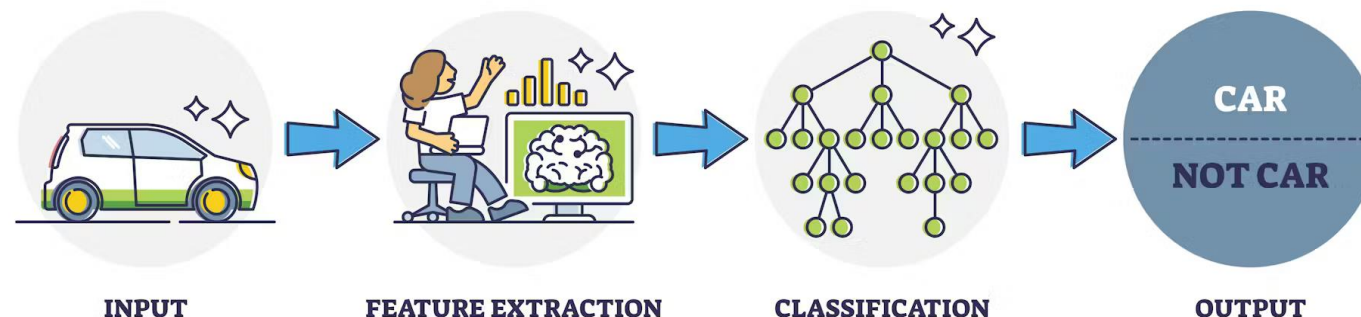
Deep Learning: The Last Decade



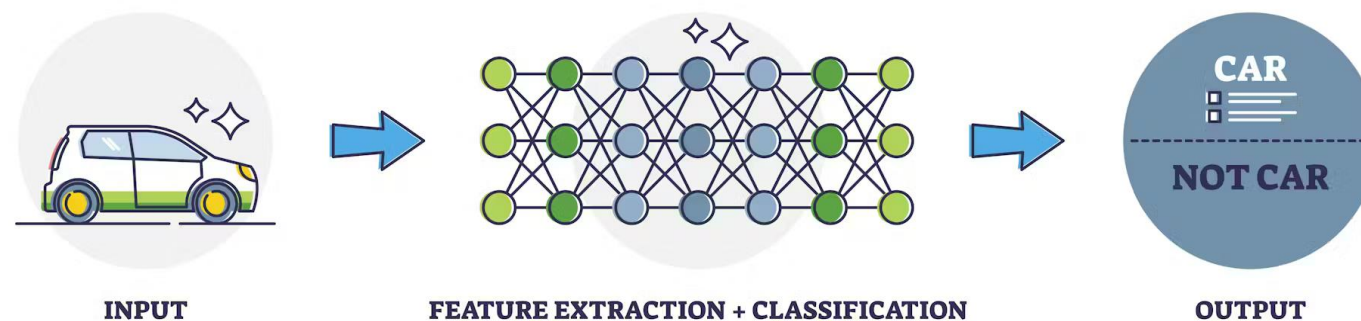
<https://towardsdatascience.com/ten-years-of-ai-in-review-85decdb2a540>

Why Deep Learning over Machine Learning?

MACHINE LEARNING



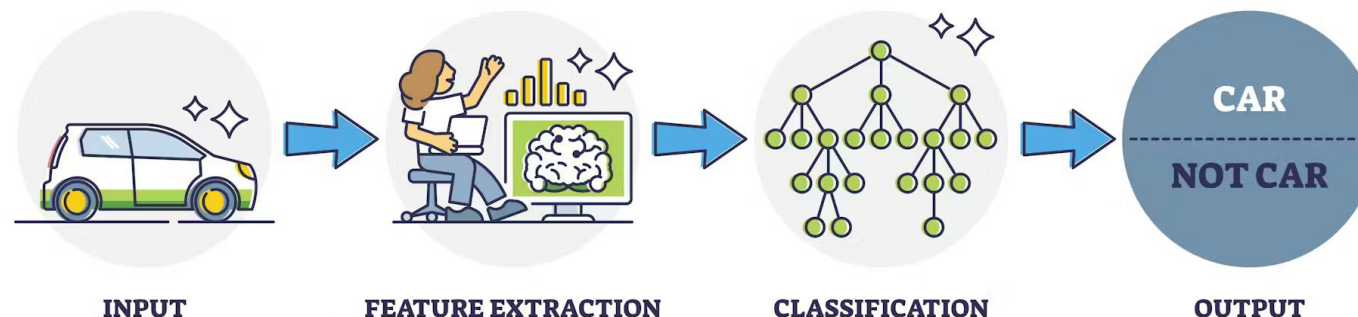
DEEP LEARNING



<https://www.turing.com/kb/ultimate-battle-between-deep-learning-and-machine-learning>

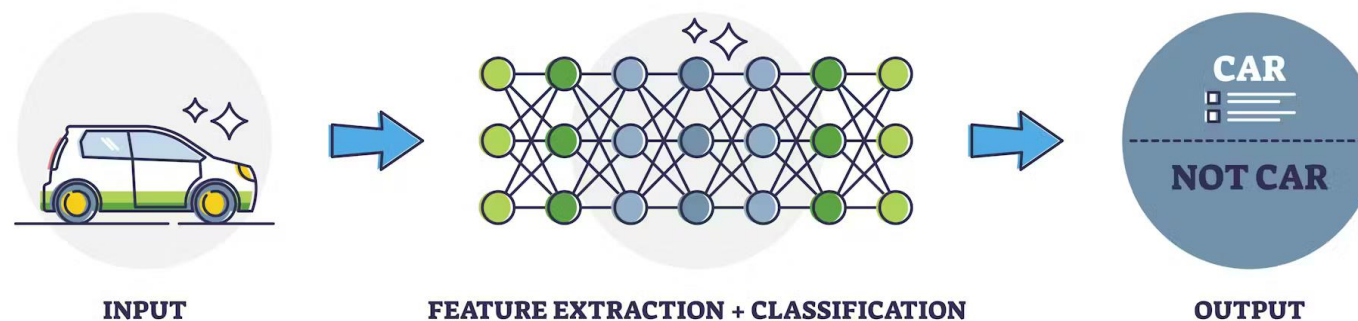
Why Deep Learning over Machine Learning?

MACHINE LEARNING



Challenging to
hand-craft features!

DEEP LEARNING



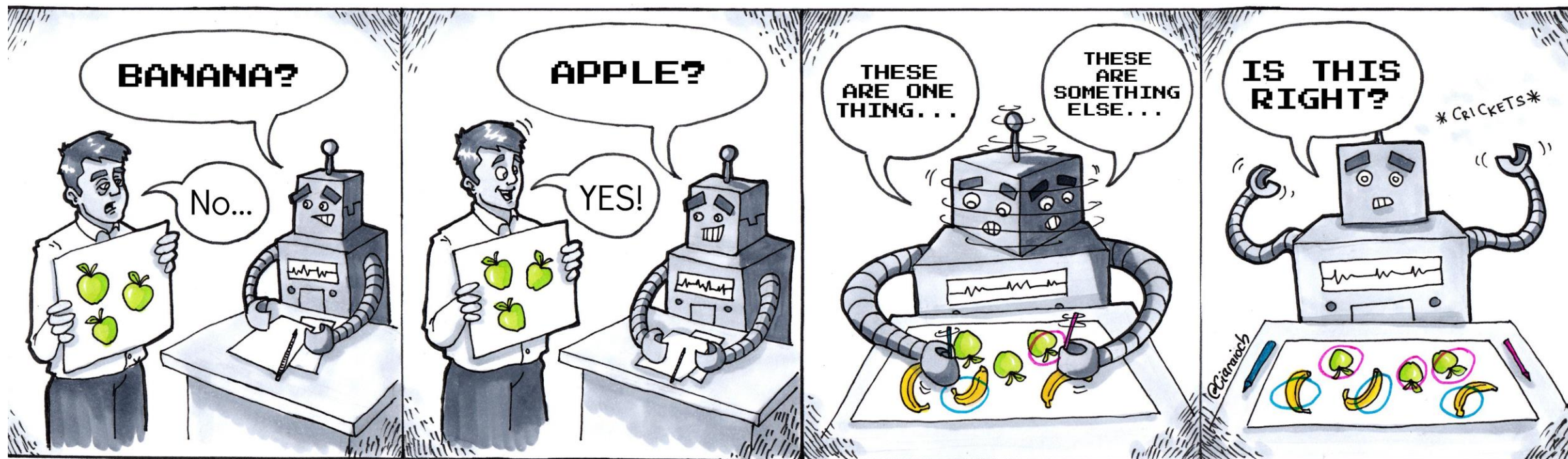
<https://www.turing.com/kb/ultimate-battle-between-deep-learning-and-machine-learning>

Machine Learning Recap

- General Idea:

Machine Learning is about turning data into useful insights and predictions with minimal human intervention.

Unsupervised vs Supervised Learning

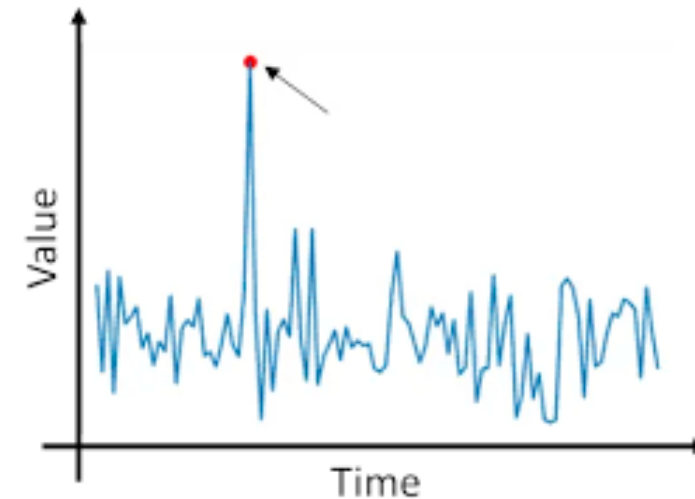
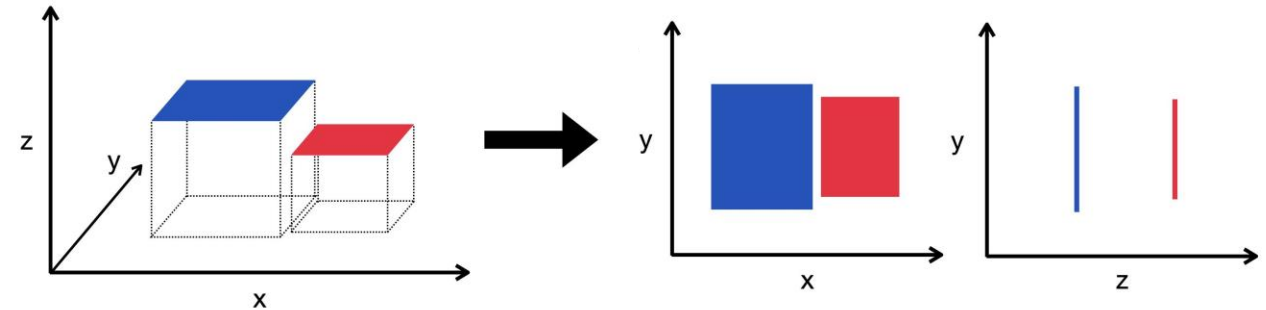
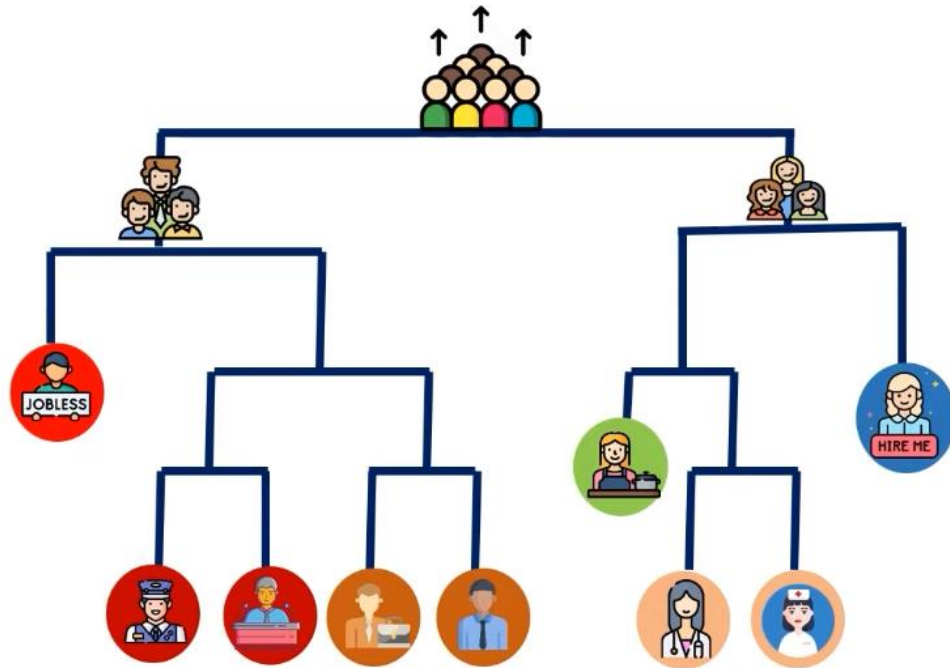


Supervised Learning

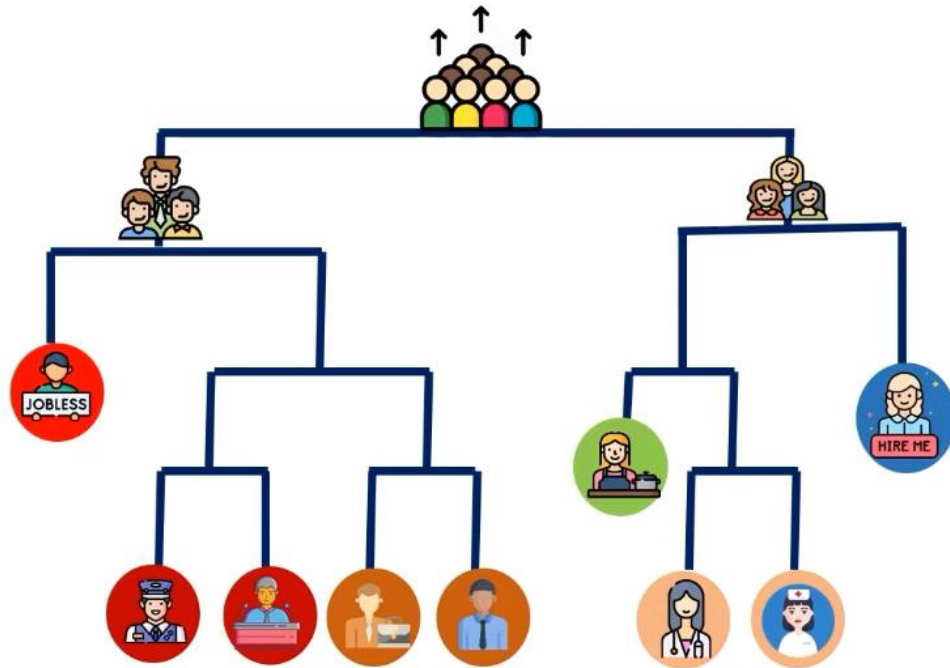
Unsupervised Learning

Illustration by [@Ciaraioch](#)

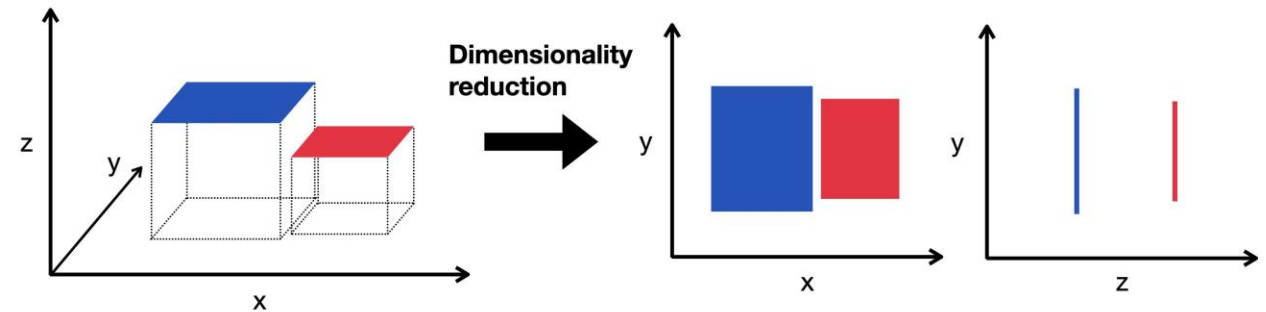
Types of Unsupervised Learning Tasks



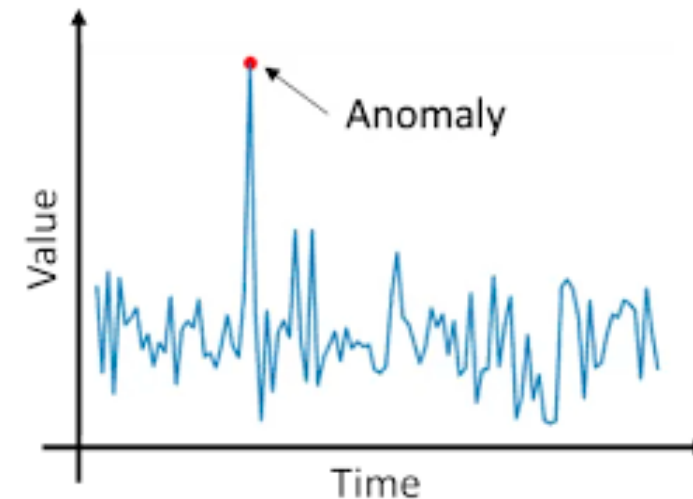
Types of Unsupervised Learning Tasks



Clustering



Dimensionality Reduction

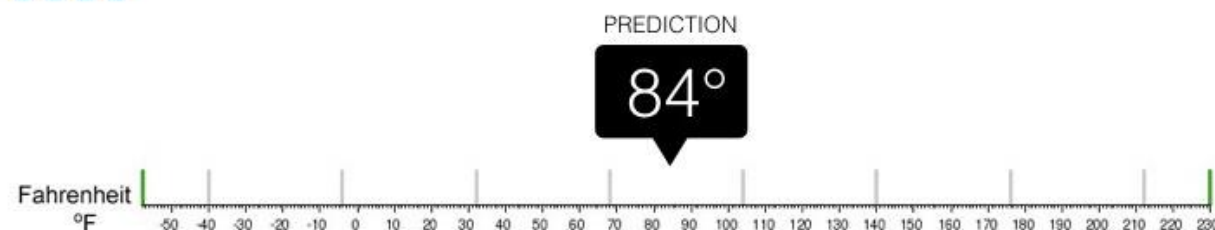


Anomaly Detection

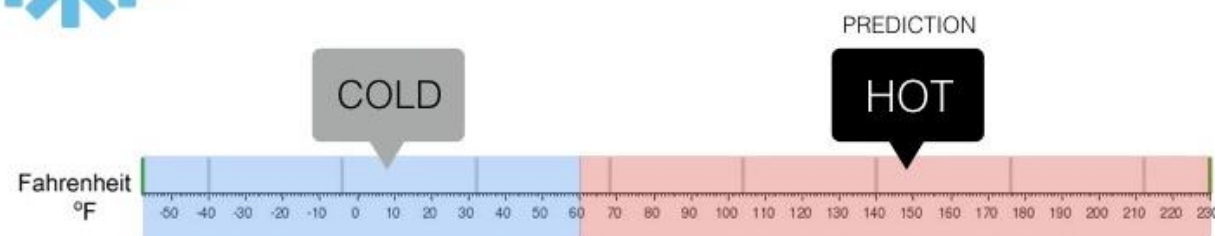
Types of Supervised Learning



What is the temperature going to be tomorrow?



Will it be Cold or Hot tomorrow?

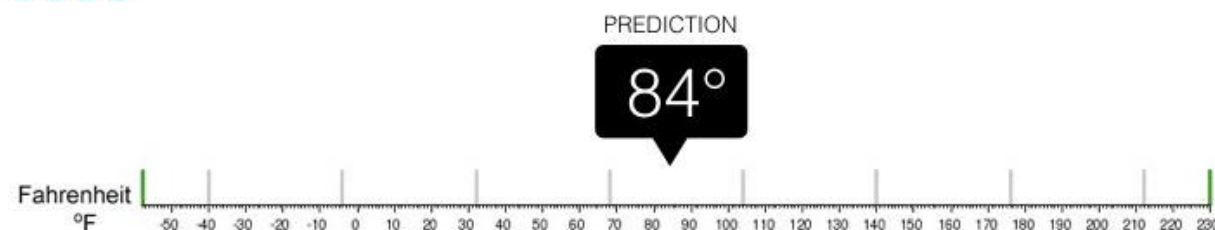


Types of Supervised Learning



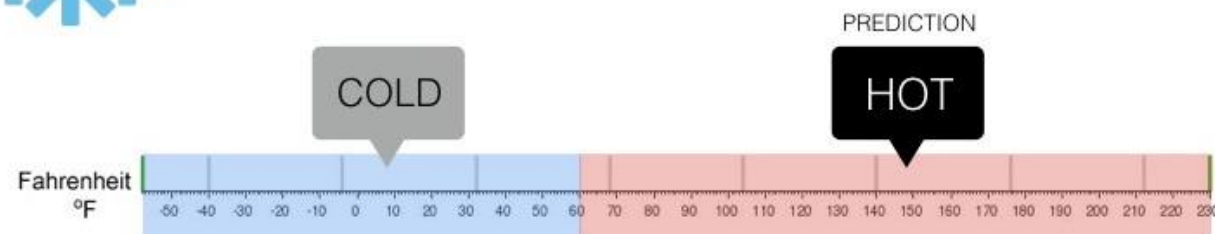
Regression

What is the temperature going to be tomorrow?



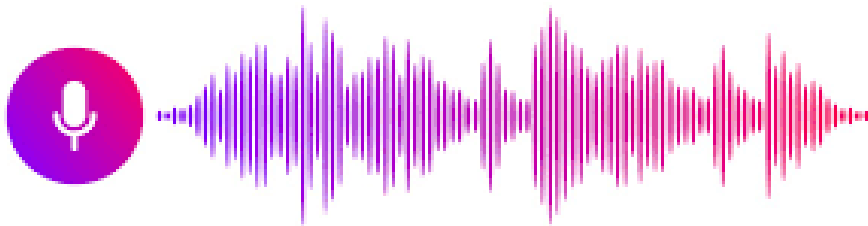
Classification

Will it be Cold or Hot tomorrow?

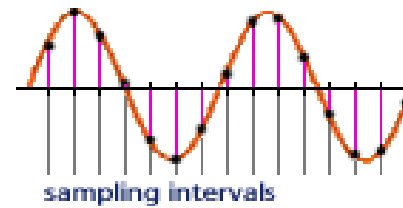


Data Types

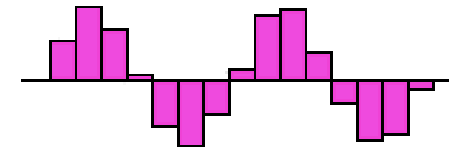
- Audio



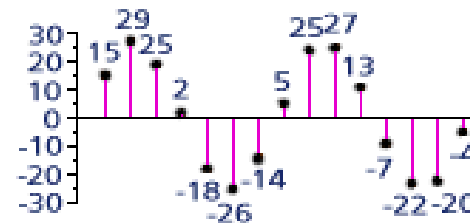
analogue signal



digital signal



digital representation of signal



15 29 30 2 -18 -26 -14
5 25 27 13 -7 -22 -20 -4

Data Types

- Audio

- Images

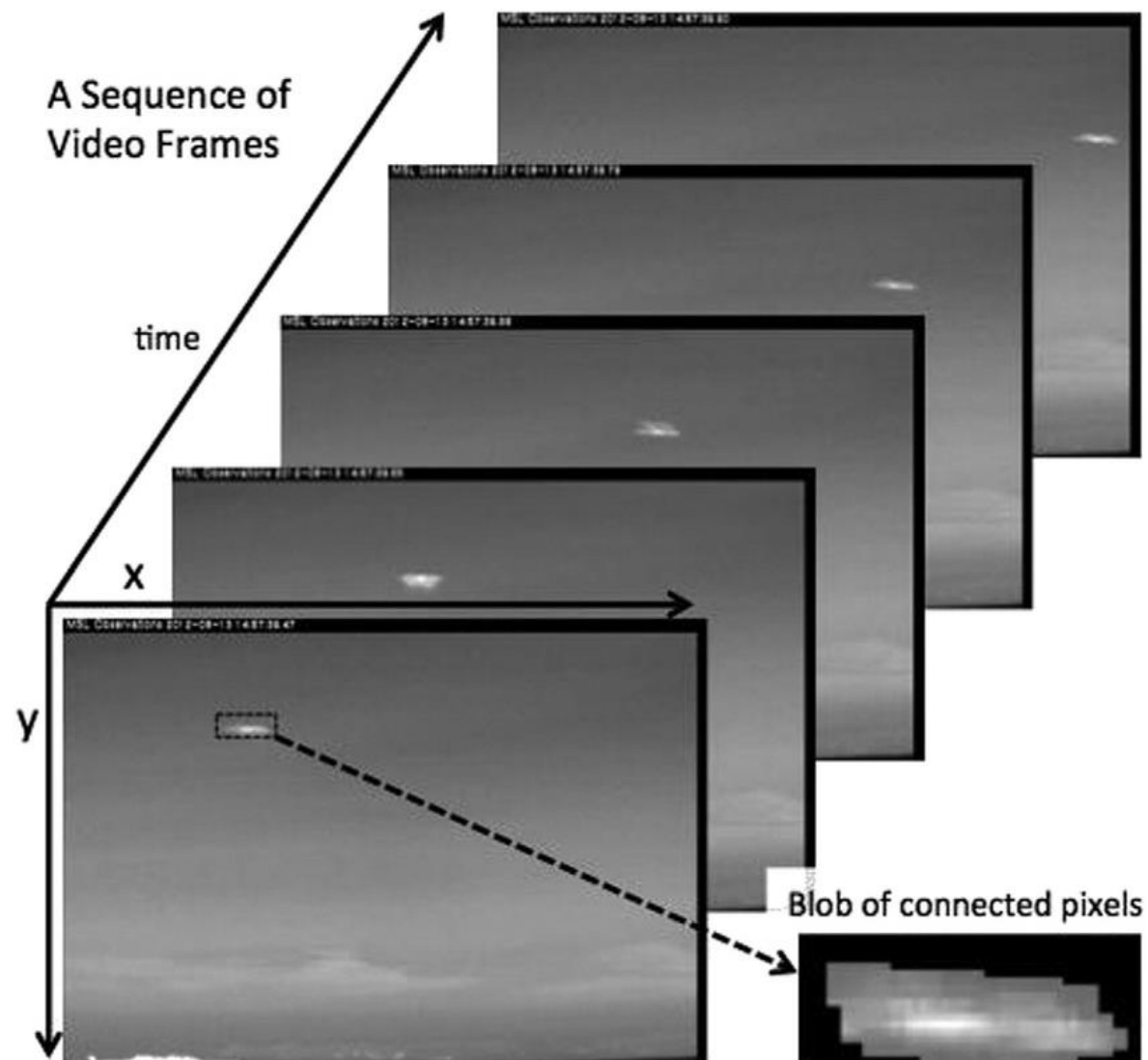


157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
205	109	5	124	131	111	120	204	165	15	55	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	168	139	75	30	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	35	190
205	174	155	252	236	231	149	178	228	43	95	234
190	215	116	149	235	187	85	150	79	38	218	241
190	234	147	108	237	210	127	102	36	101	295	224
190	214	173	65	103	143	95	50	2	109	249	215
187	195	235	75	1	81	47	0	6	217	295	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	95	218

157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
205	109	5	124	131	111	120	204	165	15	55	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
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199	168	191	193	158	227	178	143	182	106	35	190
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195	206	123	207	177	121	123	200	175	13	95	218

Data Types

- Audio
- Images
- **Video**



Data Types

- Audio
- Images
- Video
- Text

The cat sat on the mat

The: [0 1 0 0 0 0 0]

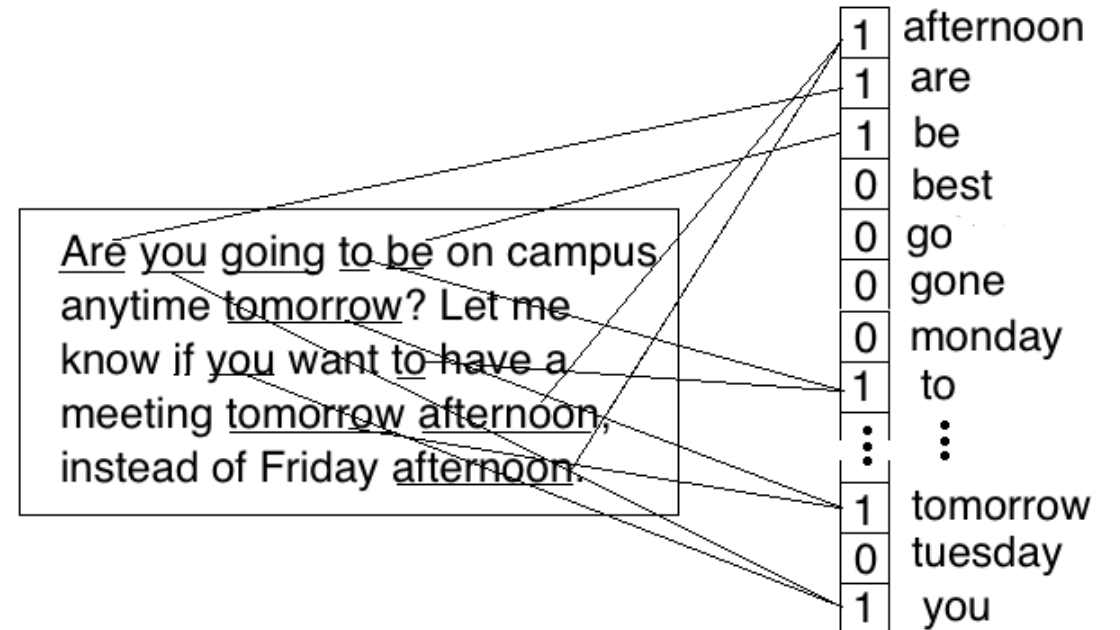
cat: [0 0 1 0 0 0 0]

sat: [0 0 0 1 0 0 0]

on: [0 0 0 0 1 0 0]

the: [0 0 0 0 0 1 0]

mat: [0 0 0 0 0 0 1]



Data Types

- Audio
- Images
- Video
- Text
- **Multi-Modal (combinations of the above)**



Kitten

A kitten or kitty is a juvenile domesticated cat. A feline litter usually consists of two to five kittens. To survive, kittens need the care of their mother for the first several weeks of their life. Kittens are highly social animals and spend most of their waking hours playing and interacting with available companions.



Deep Learning Applications

- **Spam Detection**



Deep Learning Applications

- Recognition



(Face)



(Speech)



(Fraud)

Deep Learning Applications

- Robotics



(Self-driving Vehicles)



(Medical Surgery)



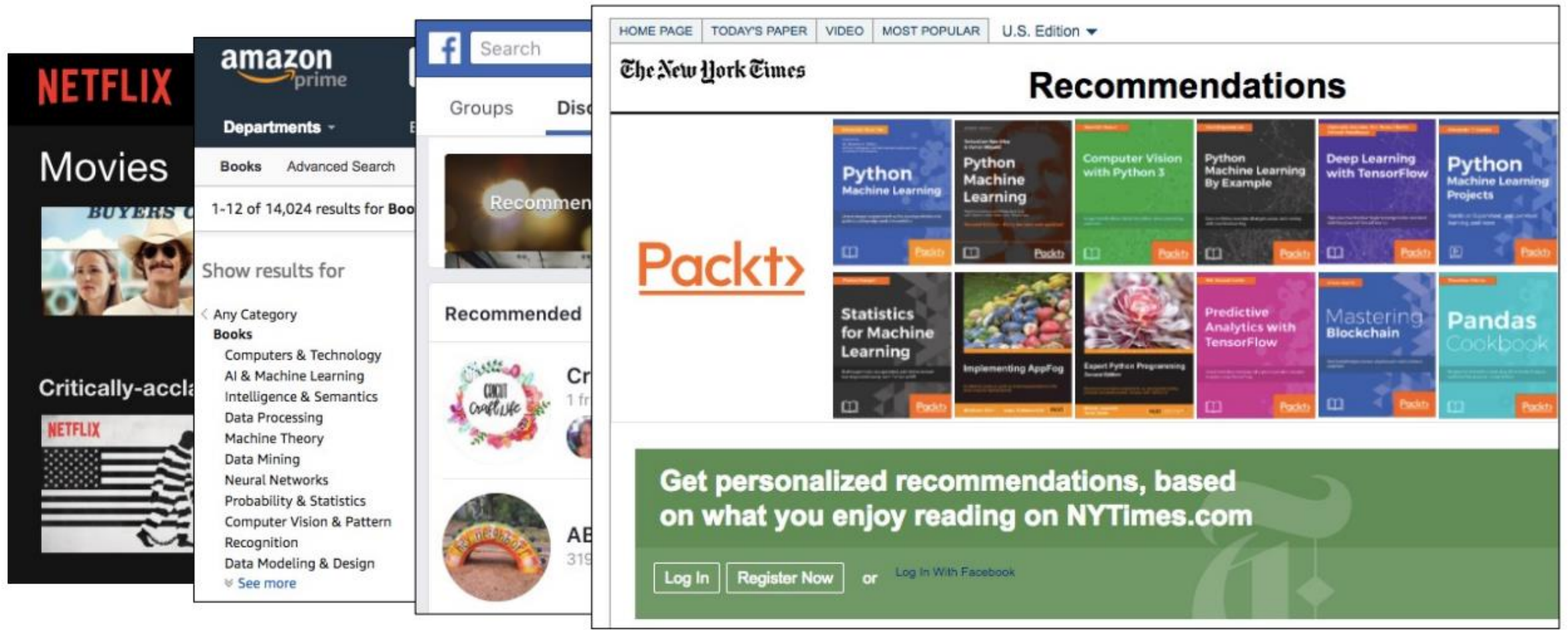
(Manufacturing)

Deep Learning Applications



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- Recommendation Systems

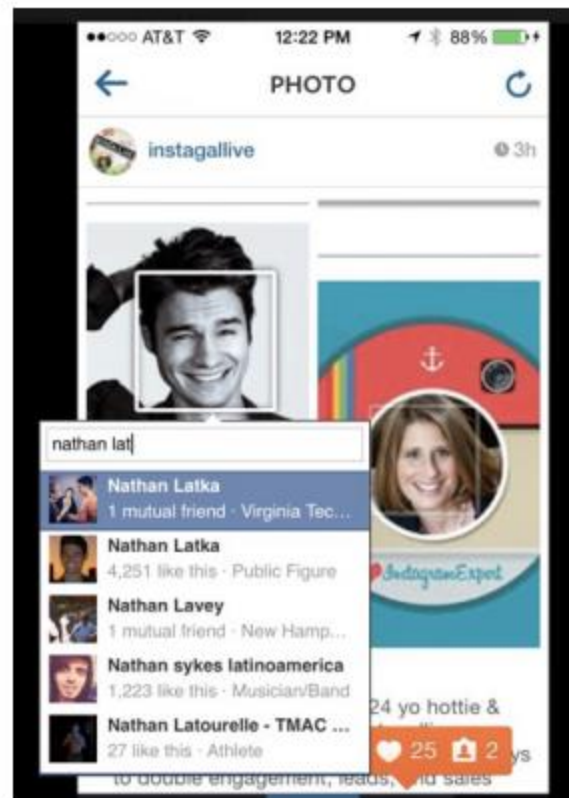


Deep Learning Applications

- Computer Vision Systems



e.g., self-driving vehicle on Mars



e.g., recognizing people



e.g., shopping without a cashier

Deep Learning Applications

- Home Virtual Assistants



e.g., Amazon's Echo with Alexa



e.g., Google Home

GitHub SetUp

- Lectures will be provided both on GitHub and Moodle.
 - https://github.com/LCDA-UCP/dl_with_pytorch
- You will need to fork the repository and then clone it to your local machine.
- Setup a python/conda environment and install the requirements.
 - `$ pip install -r requirements.txt`