NAIRR Pilot

National Artificial Intelligence Research Resource Pilot

Machine Learning vs. Deep Learning

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AI Unlocked NAIRR Workshop, Denver, CO April 2-3, 2025

Machine Learning vs. Deep Learning

Track 2 – Intermediate or Advanced Participant

Welcome!

About this training!

- 1.5 hour of presentations + hands-on training.
- Assumes some background in Machine Learning.
- Assumes you are familiar with Jupyter notebooks, PyTorch, and OOD.
- Requires you to have set up your ACCESS ID.
- Requires access to Delta, DeltaAI, and Expanse.
- Access to dedicated Slack channel for support.

Instructors and Support Staff

- Paola A. Buitrago, instructor

- Dana O'Connor
- Juliana Duncan
- Andrew Pasquale
- Vikram Gazula
- Devin Bayly (online)

Hands-On Segment of the Session

- How to ask for help?
    - Place a sticky notes on your laptop to signal that you need help!

Outline

This session provides a comparative overview of deep learning and machine learning, focusing on their distinct characteristics, applications, and requirements.

Key topics include:

1. Overview of Deep Learning vs. Machine Learning
2. Applications of Sample Models
3. What You Need to Know Before Using These Models

By the end of the session, participants will have gained a deeper understanding on the differences and similarities of ML and DL. This deeper understanding will allow them to better decide when to use deep learning versus machine learning and will allow them to implement each approach effectively.

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This session provides a comparative overview of deep learning and machine learning, focusing on their distinct characteristics, applications, and requirements.

Key topics include:

1. **Overview of Deep Learning vs. Machine Learning:**
   Explanation of the differences between deep learning and traditional machine learning.

2. Applications of Sample Models:

3. What You Need to Know Before Using These Models:

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Key topics include:

1. Overview of Deep Learning vs. Machine Learning:

2. **Applications of Sample Models:**
   - Deep learning applications in image recognition, natural language processing, and speech recognition.
   - Machine learning applications in predictive analytics, classification, and clustering.

3. What You Need to Know Before Using These Models:

By the end of the session, participants will have gained a deeper understanding on the differences and similarities of ML and DL. This deeper understanding will allow them to better decide when to use deep learning versus machine learning and will allow them to implement each approach effectively.

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Key topics include:

1. Overview of Deep Learning vs. Machine Learning:

2. Applications of Sample Models:

3. **What You Need to Know Before Using These Models:**
   - Prerequisites for using DL and ML, such as data quality, computational power, and algorithm selection.
   - Considerations for choosing the right approach based on project requirements and available resources.

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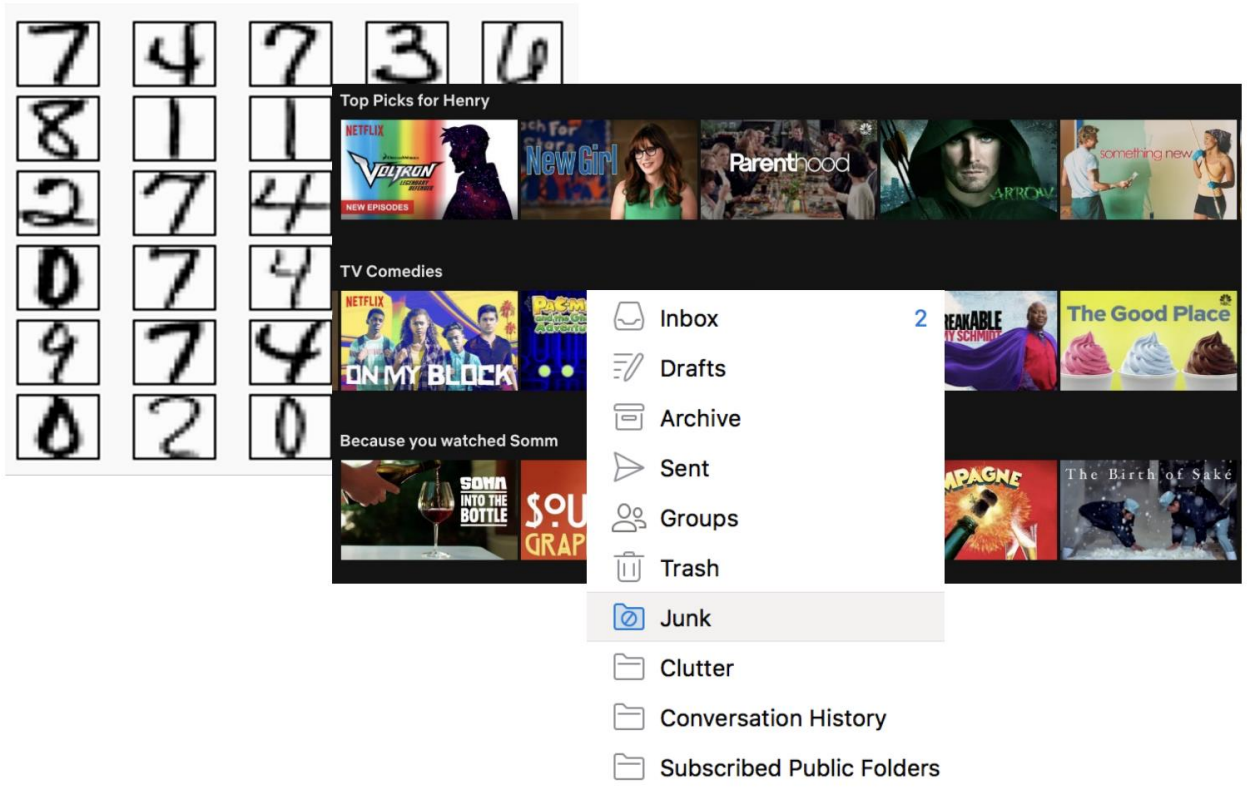
Outline

1. **Overview of Deep Learning vs. Machine Learning**
2. Applications of Sample Models
3. What You Need to Know Before Using These Models

What's is Machine Learning

Machine Learning a long time ago...



What's is Machine Learning

Machine Learning not so long ago...

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What's is Machine Learning

Machine learning definition:

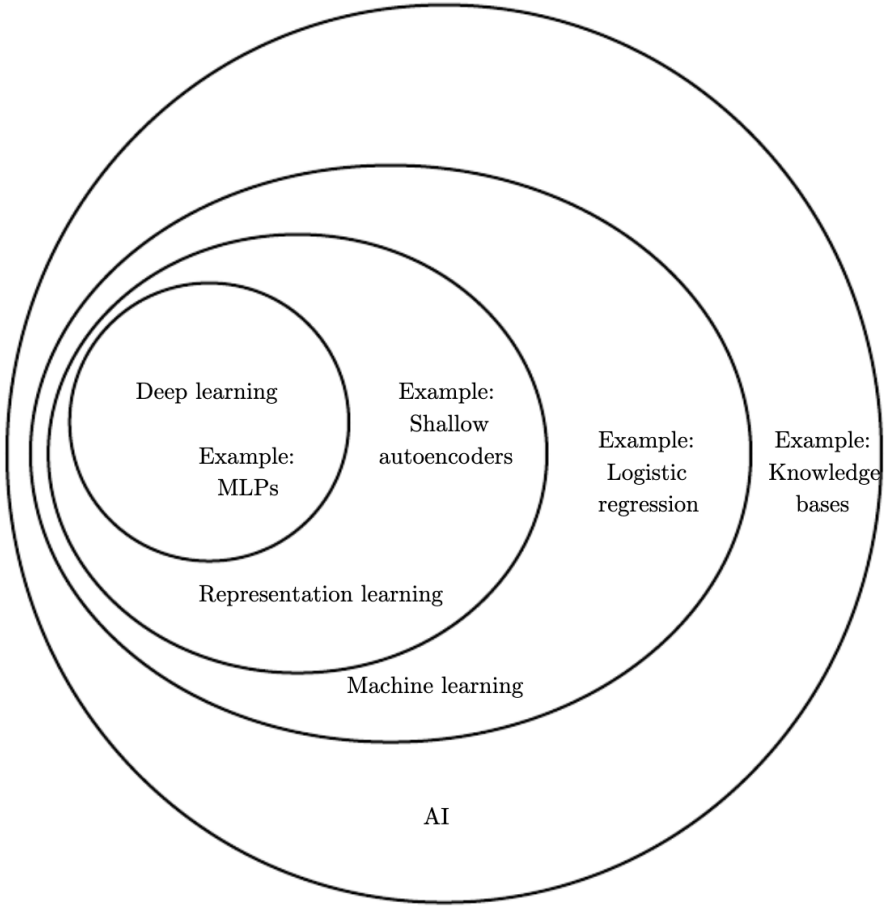
Machine Learning (ML) is a subset of artificial intelligence (AI) that enables computers to learn from data and make predictions or decisions without being explicitly programmed. Instead of following a fixed set of rules, ML models identify patterns in data and improve their performance as they are exposed to more information.

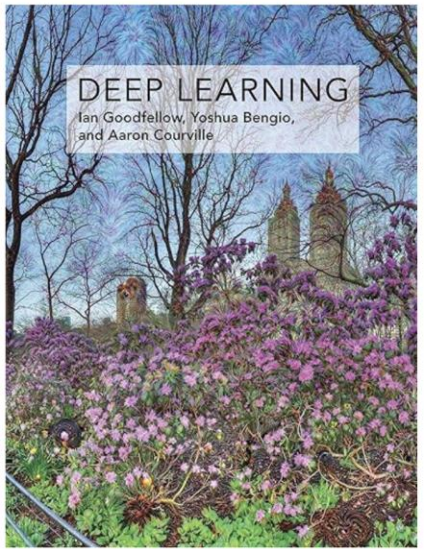
What's is Machine Learning

Machine learning definition:

- A computer program is said to **learn** if its *performance*, P, as some *task*, T, improves with *experience* E.
- Three components:

Machine Learning vs. Deep Learning



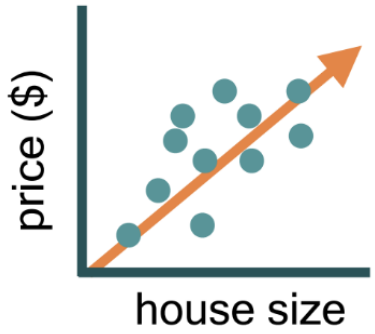


A Venn diagram showing how deep learning is a kind of representation learning, which is in turn a kind of machine learning, which is used for many but not all approaches to AI. Each section of the Venn diagram includes an example of an AI technology. Source: https://www.deeplearningbook.org/contents/intro.html

Machine Learning Pipeline

Task 1 - Regression

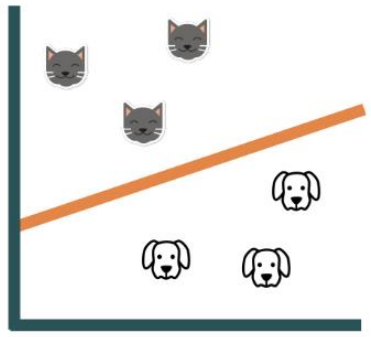
How much should you sell your house for?



input: houses & features **learn**: $x \rightarrow y$ relationship **predict**: y (*continuous*)

Task 2 - Classification

Cat or dog?



= ??

input: cats and dogs

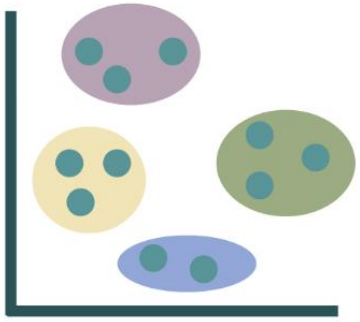
learn: $x \rightarrow y$ relationship

predict: y (*categorical*)

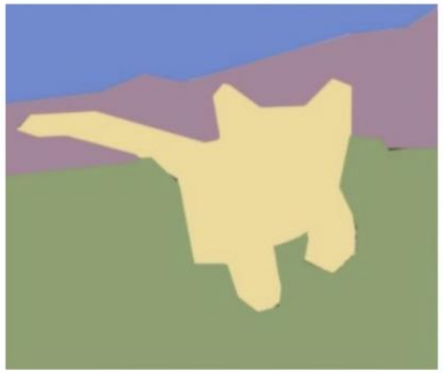
Task 3 - Clustering

How to segment an image?

input: raw pixels $\{x\}$



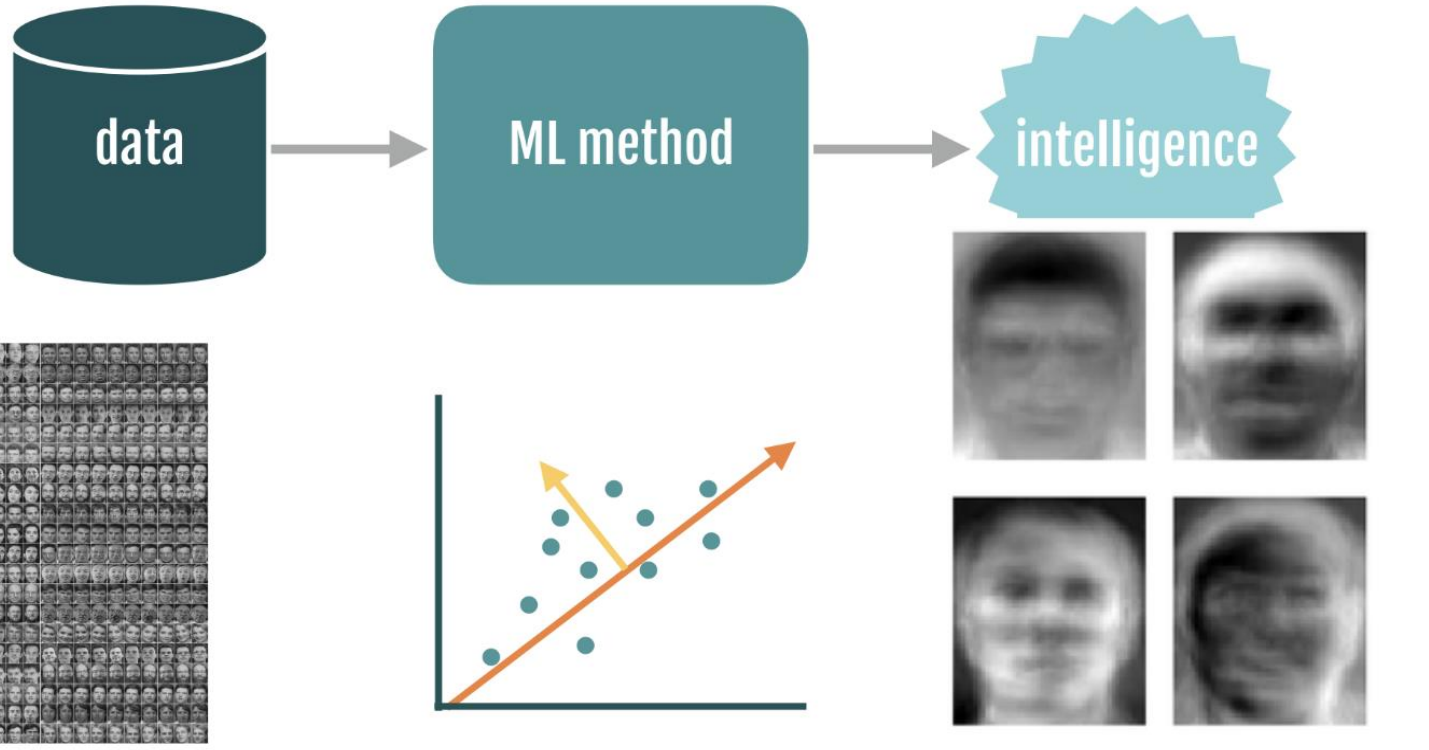
separate: $\{x\}$ into sets



output: cluster labels $\{z\}$

Task 4 - Embedding

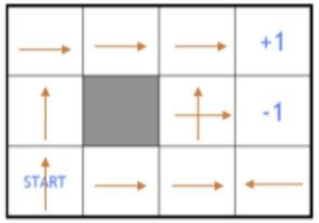
How to efficiently represent data?



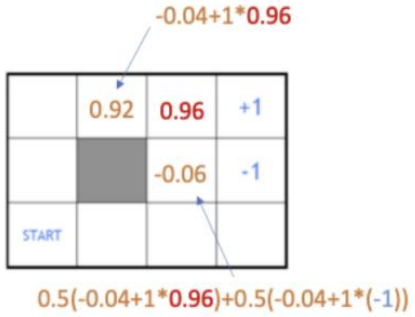
input: large dataset $\{x\}$ **find**: sources of variation **return**: representation $\{z\}$

Task 5 - Reinforcement Learning

How to take the actions that maximize reward?



input:
state-action-reward trajectories



find: Value function or Q function

actions: UP, DOWN, LEFT, RIGHT

UP

80% move UP
10% move LEFT
10% move RIGHT

return: Optimal Policy π

Other Tasks

Computer Vision

- Depth Estimation
- Image Classification
- Object Detection
- Image Segmentation
- Text-to-Image
- Image-to-Text
- Image-to-Image
- Image-to-Video
- Unconditional Image Generation
- Video Classification
- Text-to-Video
- Zero-Shot Image Classification
- Mask Generation
- Zero-Shot Object Detection
- Text-to-3D
- Image-to-3D
- Image Feature Extraction
- Keypoint Detection

Natural Language Processing

- Text Classification
- Token Classification
- Table Question Answering
- Question Answering
- Zero-Shot Classification
- Translation
- Summarization
- Feature Extraction
- Text Generation
- Text2Text Generation
- Fill-Mask
- Sentence Similarity

Audio

- Text-to-Speech
- Text-to-Audio
- Automatic Speech Recognition
- Audio-to-Audio
- Audio Classification
- Voice Activity Detection

Other Tasks

Multimodal

- Audio-Text-to-Text
- Image-Text-to-Text
- Visual Question Answering
- Document Question Answering
- Video-Text-to-Text
- Visual Document Retrieval
- Any-to-Any

Tabular

- Tabular Classification
- Tabular Regression
- Time Series Forecasting

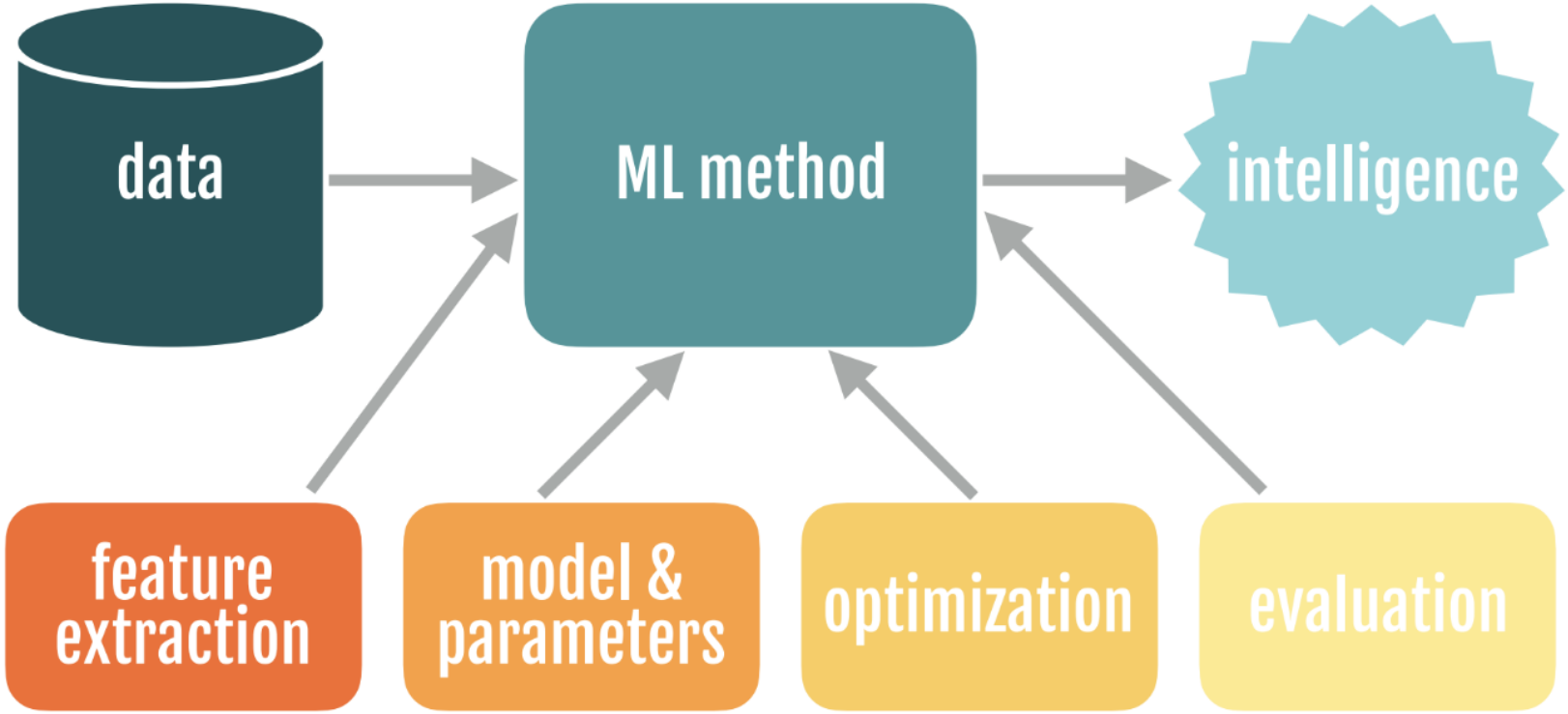
Reinforcement Learning

- Reinforcement Learning
- Robotics

Other

- Graph Machine Learning

Machine Learning Pipeline



Hands-On Section 1
Let's Get Our Environment (Jupyter Instance) Ready

Hands-On Section 1: Let's Get Our Environment Ready

Goals:

1. Access at least one of the systems (Expanse, Delta, and DeltaAI) through their Open On Demand portal.
2. Get a copy of the workshop Github repository.
3. Get an instance of Jupyter (Lab or Notebook) running.

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Actions

1. Using a browser, get the document with detailed instructions for one system.
2. Follow the instructions in the document.
3. Request help by placing a post-it in the top part of your laptop!

Bonus points

-> Get access to all the three systems and clone the repo in each system.
-> Get a Jupyter instance only in one of them!

Outline

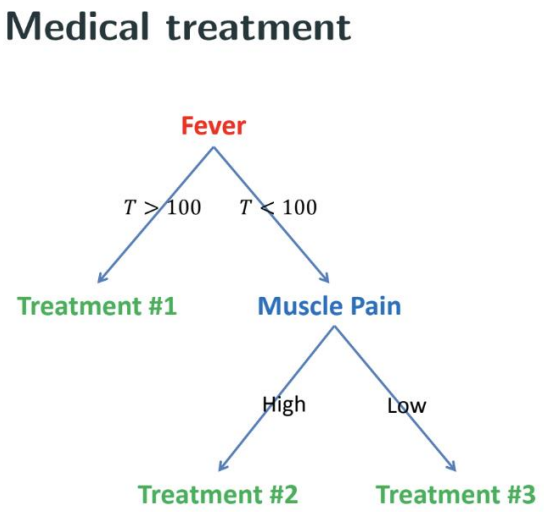
1. Overview of Deep Learning vs. Machine Learning
2. **Applications of Sample Models**
3. What You Need to Know Before Using These Models

Decision Trees

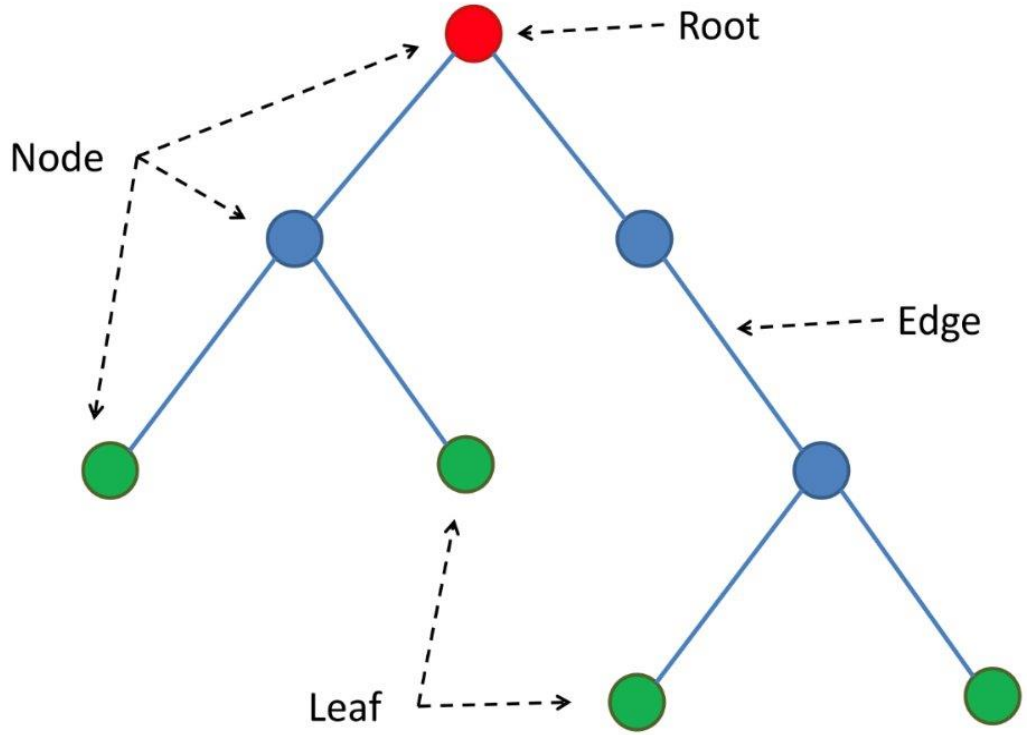
Task: Multiclass Classification

Advantages:

- Explain the reasoning in clear terms.

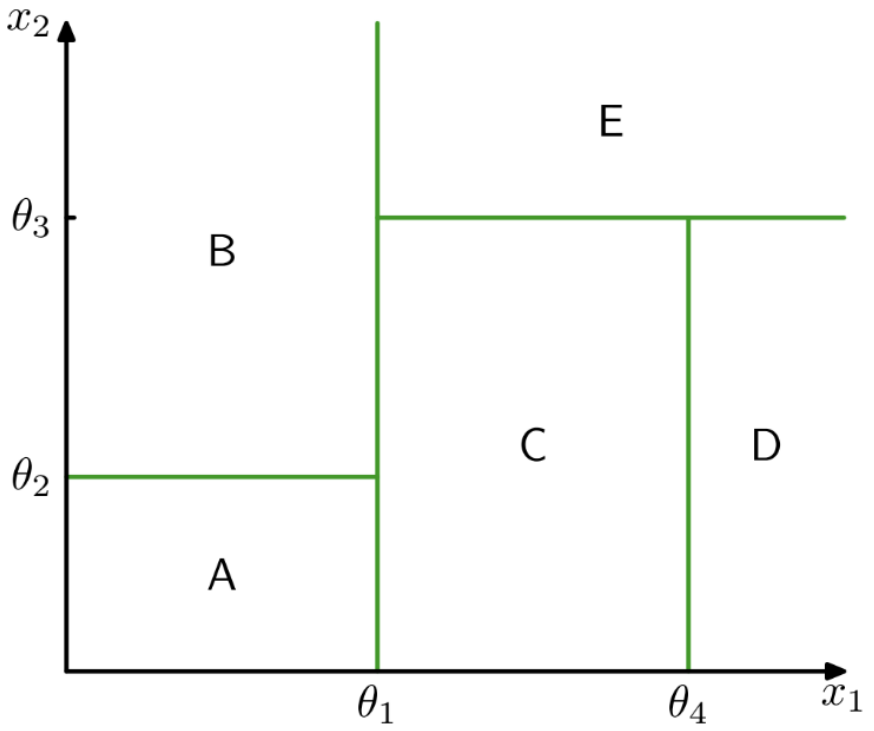


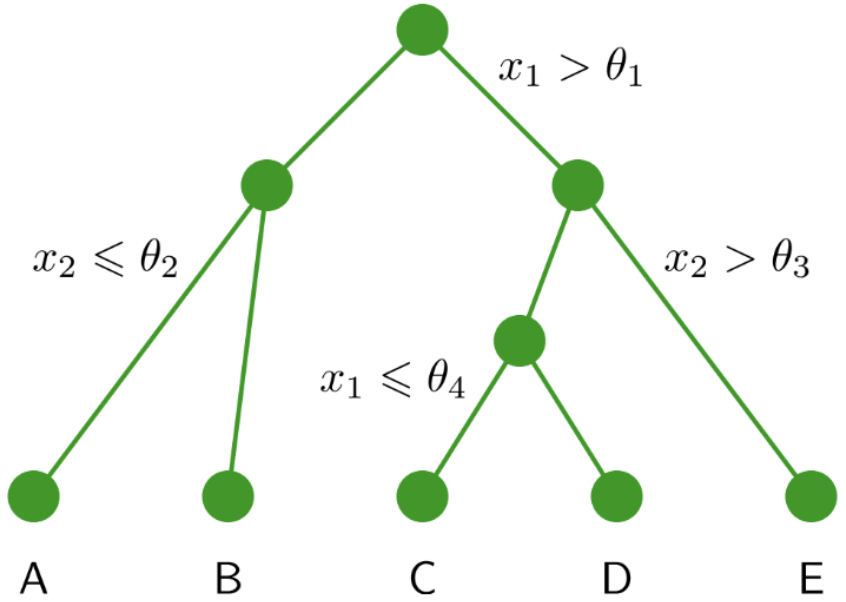
Model structure:



Decision Trees

Feature space partitioning





Decision Trees

Data example

Attributes										Target
Alt	*Bar*	*Fri*	*Hun*	*Pat*	*Price*	*Rain*	*Res*	*Type*	*Est*	*WillWait*
T	*F*	*F*	*T*	*Some*	*$$$*	*F*	*T*	*French*	*0–10*	*T*
T	*F*	*F*	*T*	*Full*	*$*	*F*	*F*	*Thai*	*30–60*	*F*
F	*T*	*F*	*F*	*Some*	*$*	*F*	*F*	*Burger*	*0–10*	*T*
T	*F*	*T*	*T*	*Full*	*$*	*F*	*F*	*Thai*	*10–30*	*T*
T	*F*	*T*	*F*	*Full*	*$$$*	*F*	*T*	*French*	*>60*	*F*
F	*T*	*F*	*T*	*Some*	*$$*	*T*	*T*	*Italian*	*0–10*	*T*
F	*T*	*F*	*F*	*None*	*$*	*T*	*F*	*Burger*	*0–10*	*F*
F	*F*	*F*	*T*	*Some*	*$$*	*T*	*T*	*Thai*	*0–10*	*T*
F	*T*	*T*	*F*	*Full*	*$*	*T*	*F*	*Burger*	*>60*	*F*
T	*T*	*T*	*T*	*Full*	*$$$*	*F*	*T*	*Italian*	*10–30*	*F*
F	*F*	*F*	*F*	*None*	*$*	*F*	*F*	*Thai*	*0–10*	*F*
T	*T*	*T*	*T*	*Full*	*$*	*F*	*F*	*Burger*	*30–60*	*T*

Task

- Decide whether to wait or not to wait for a service (e.g. in a restaurant).

Decision Trees

Advantages

- Can be interpreted by humans (as long as the tree is not too big)
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- Handles both numerical and categorical features.
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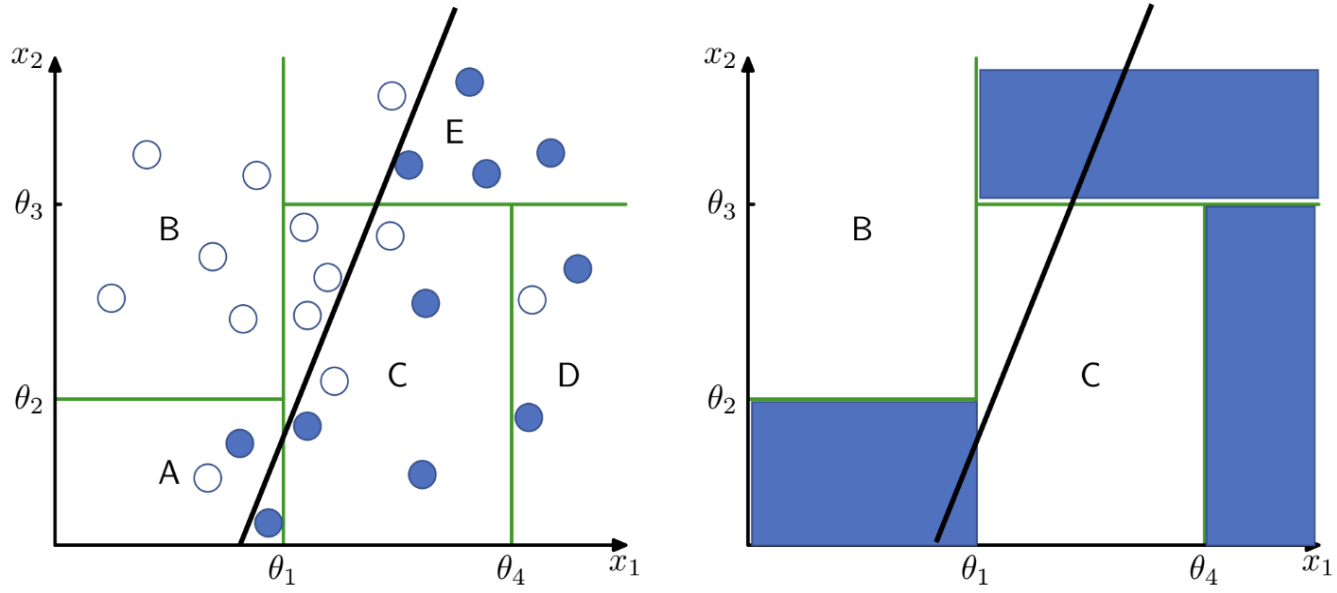
- Decision trees are prone to overfitting!



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Strategies to avoid overfitting

- Stop growing when data split is not statistically significant.
- Acquire more training data.
- Remove irrelevant attributes (manual process, not always possible).
- Grow full tree, then post-prune.
- **Use tree ensembles**

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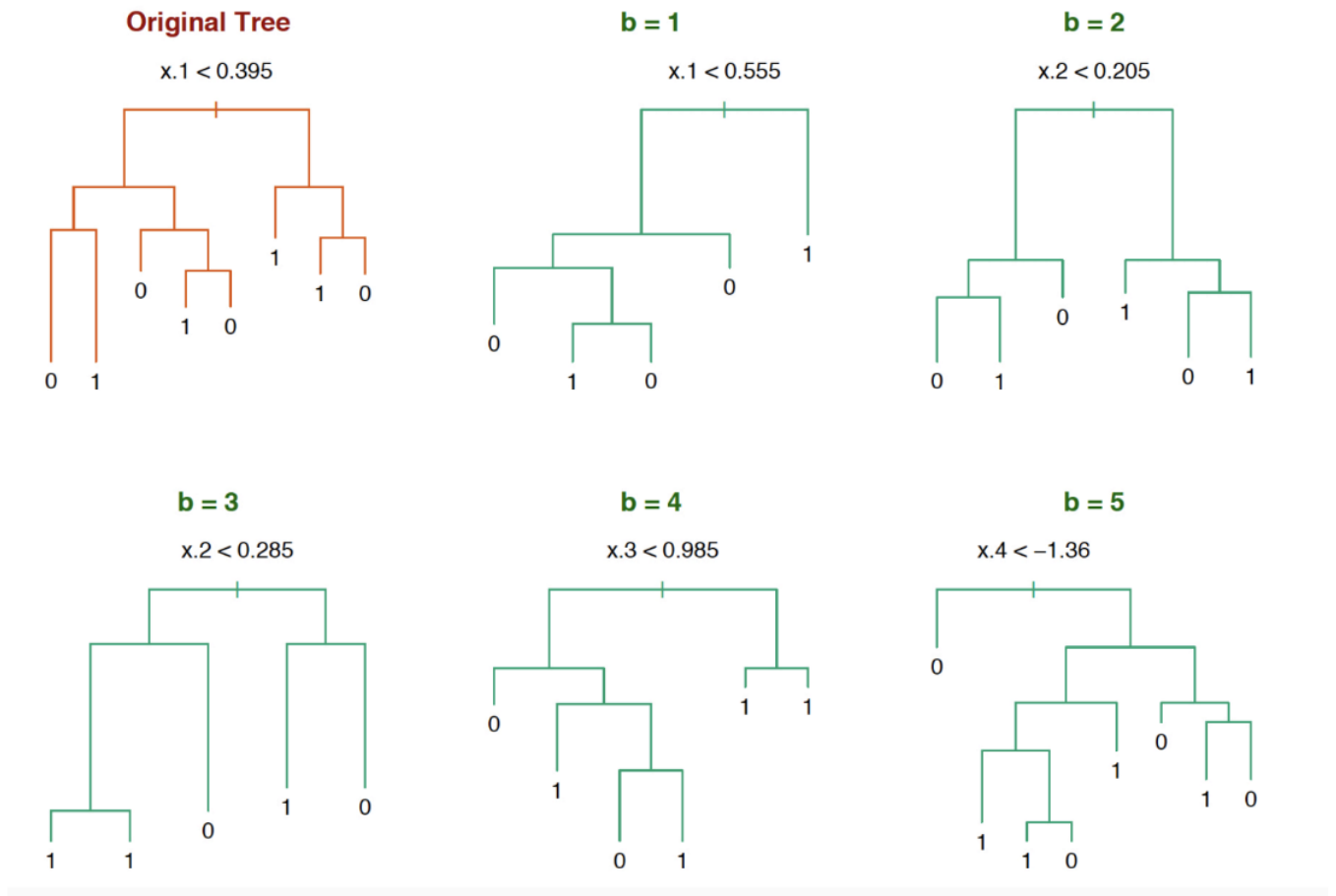
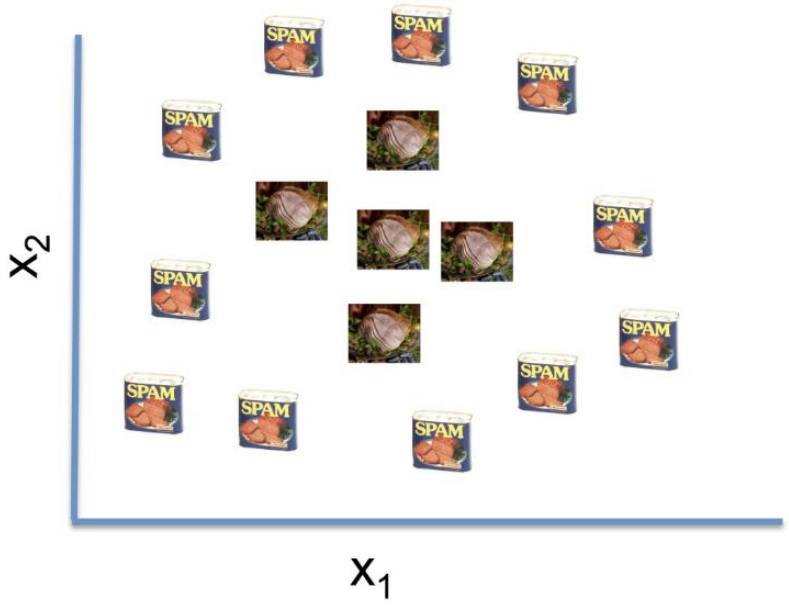
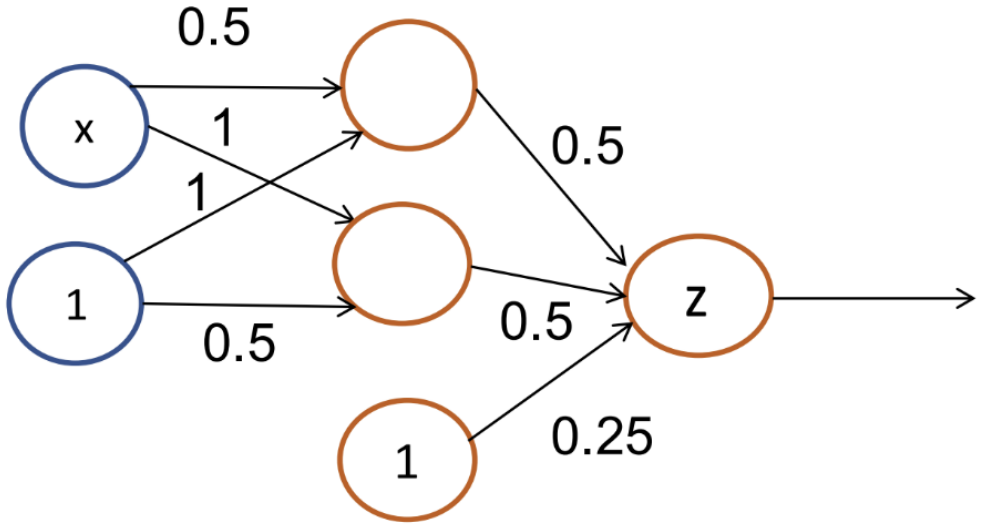
Random Forest



Neural Networks





Outline

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2. Applications of Each Model
3. **What You Need to Know Before Using These Models**

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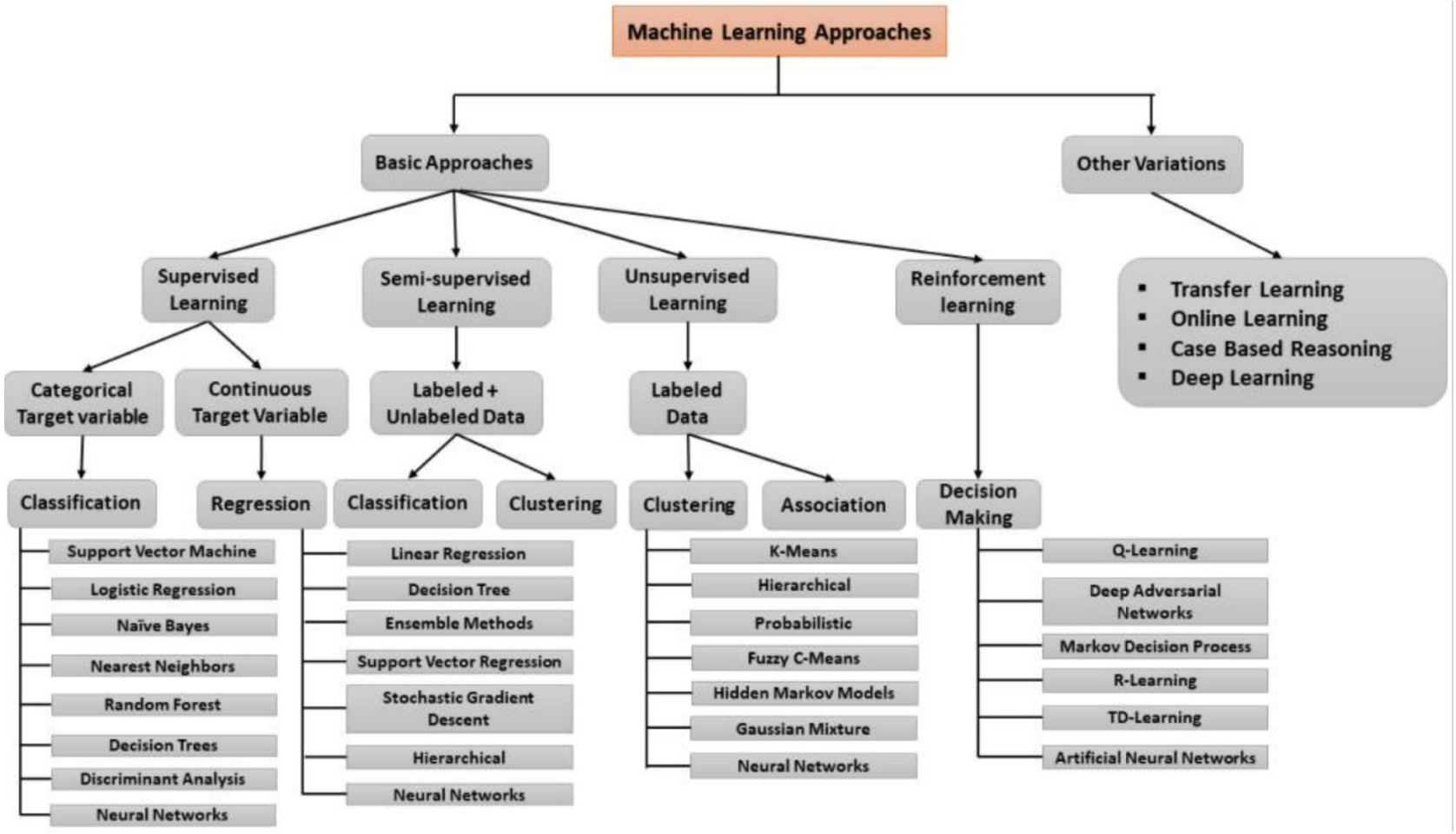


What You Need to Know Before Using These Models

1. Identify your task
2. Characterize the type of data available (supervised vs. unsupervised)
3. **Identify approaches that are ideally suited for your task and your data.**
    - **Aim to use the simplest approach first.**

Hands-On Section 2
Let's Train and Compare ML and DL models!

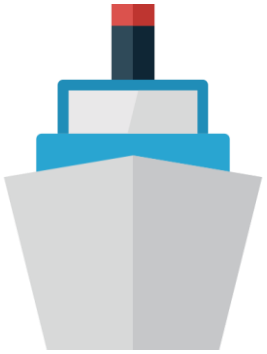
Hands-on Section 2

- Supervised Binary classification and multiclass classification
- Jupyter notebook

Datasets:

Heart disease dataset

Wine quality dataset



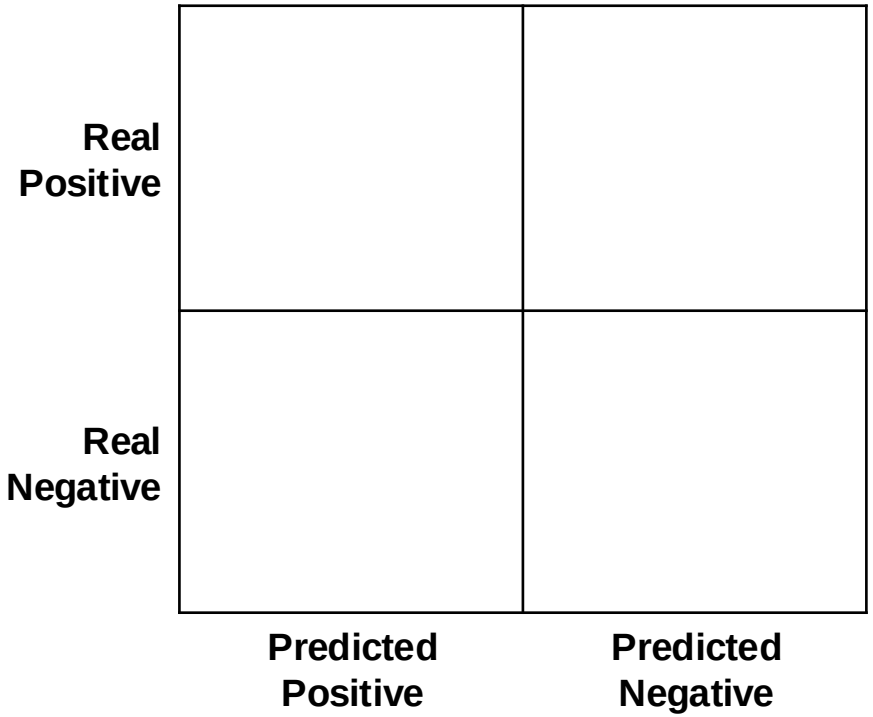
Titanic dataset

Mushroom dataset

Hands-on Section 2

Classification metrics

- Binary Classification



Hands-on Section 2

Classification metrics

- Binary Classification

Real Positive	**True Positive (TP)**	**False Negative (FN)**
Real Negative	**False Positive (FP)**	**True Negative (TN)**
	Predicted Positive	**Predicted Negative**

Hands-on Section 2

Classification metrics

- Binary Classification

$$\text{Accuracy} = \frac{\text{True Positives} + \text{True Negatives}}{\text{Total Predictions}}$$

$$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

$$\text{Recall} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$

$$\text{F1 Score} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

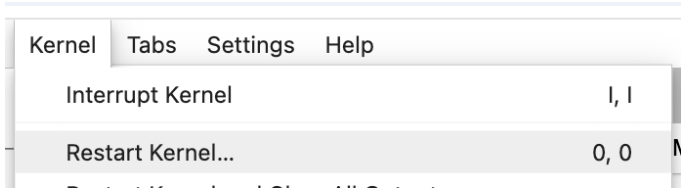
Real Positive	**True Positive (TP)**	**False Negative (FN)**
Real Negative	**False Positive (FP)**	**True Negative (TN)**
	Predicted Positive	**Predicted Negative**

Hands-On Section 2: Let's Compare ML and DL models

Goals

Using the Jupyter Instance we started in the previous hands-on section.
1. Explore the sample Jupyter notebook.
2. Load a dataset and train three different models to perform classification.
3. Compare the models using classification metrics.

If you need to install some of the libraries, you might need to restart the kernel!



Actions

1. Go to the Jupyter instance you started in the previous hands-on section.
2. Explore the Jupyter notebook, select a dataset, and run the notebook.
3. Based on the results you got, decide which model would you select for that task and that data.

Bonus points

-> Execute the Jupyter notebook for all the four available datasets.
-> Implement a fourth model of your choice.

Summary

Participants have gained a deeper understanding on the differences and similarities of ML and DL. This deeper understanding allows them to better decide when to use deep learning versus machine learning and this will allow them to implement each approach effectively.

Hands on sections goals:

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Q&A