Computing in Context: Fall 2024

Lecture 10 | Intro to ML for Healthcare

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Section I : Introduction & Overview

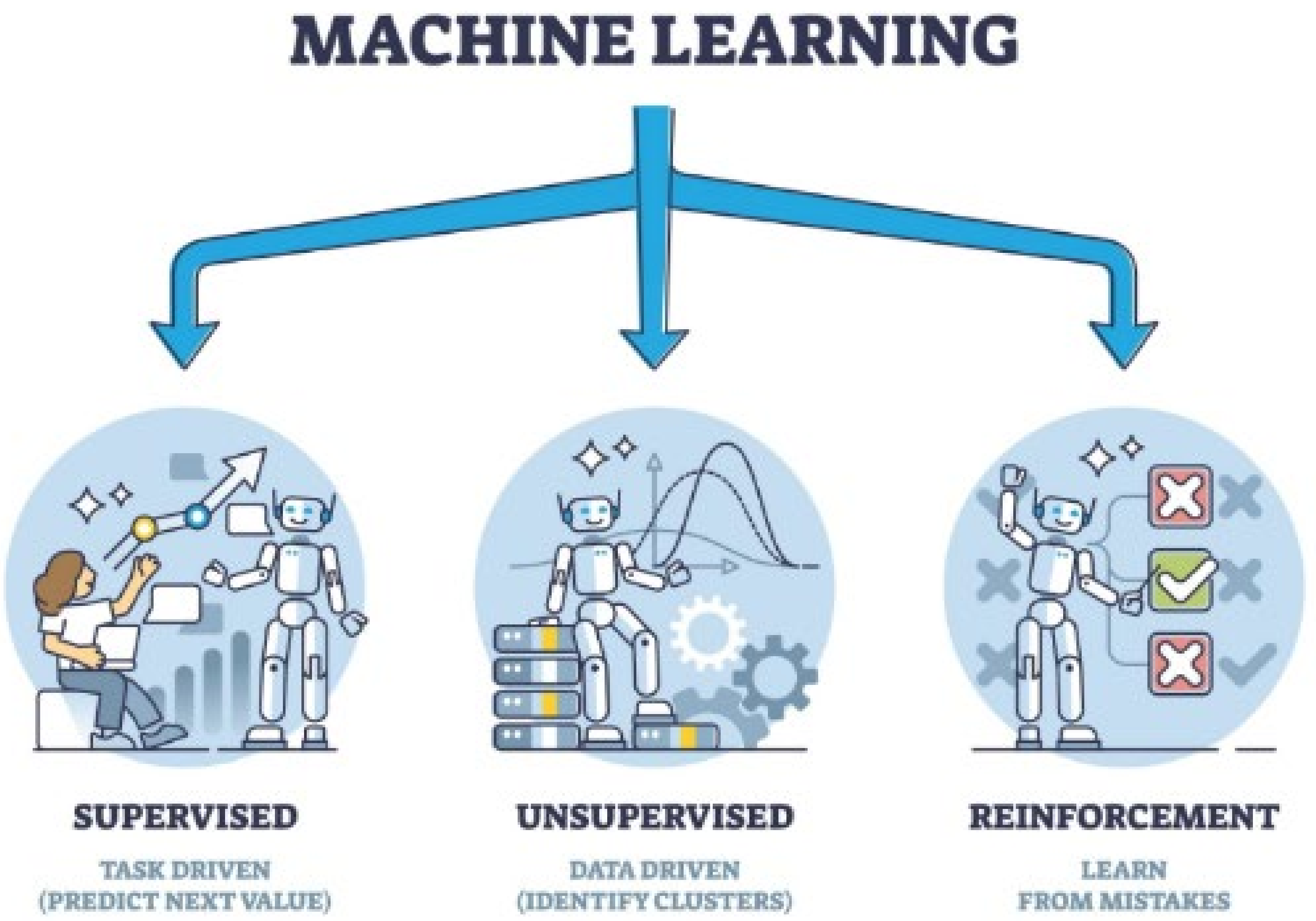
What is Machine Learning?

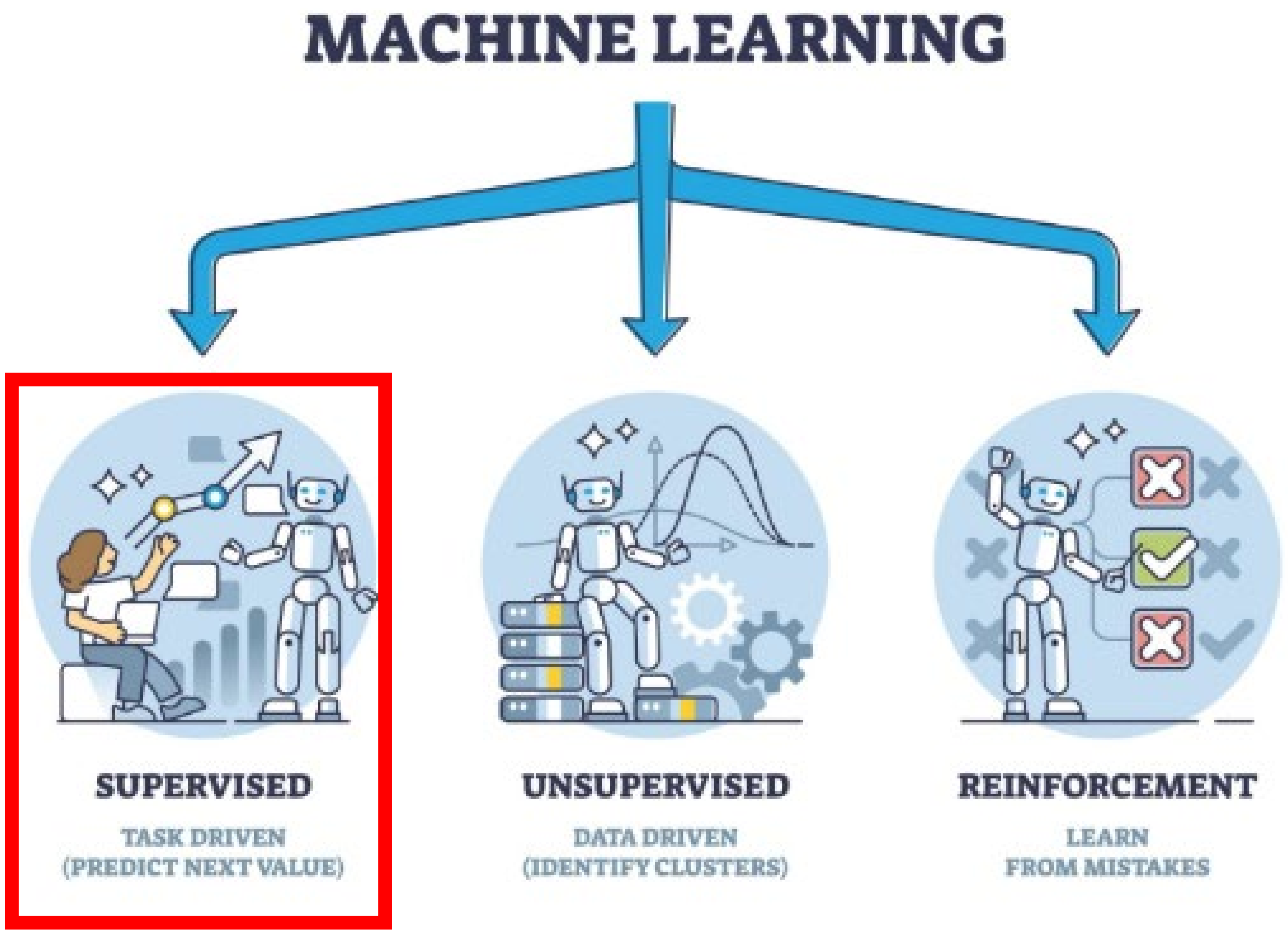
- Machine learning (ML) enables computers to learn from data.
  - teaching a computer to recognize patterns and make predictions
  - e.g. Netflix recommendation, Spotify shuffle, etc.

- ML in healthcare works on improving diagnosis and personalized treatment
  - building predictions and suggestions based on Big Data in healthcare

Key Terms (before we begin!)

- **Data:** Input variables like patient age, lab results.
- **Features:** Attributes used for predictions (e.g., glucose levels).
- **Labels:** Known outcomes (e.g., disease present or absent).


MACHINE LEARNING
SUPERVISED
TASK DRIVEN
(PREDICT NEXT VALUE)
UNSUPERVISED
DATA DRIVEN
(IDENTIFY CLUSTERS)
REINFORCEMENT
LEARN
FROM MISTAKES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Learning Types in ML

- **Supervised Learning:** Uses labeled data
  - (e.g., diagnosing a specific disease)

- **Unsupervised Learning:** Finds patterns without labels
  - (e.g., patient segmentation/clustering).

- **Reinforcement Learning:** Learns from outcomes to make decisions
  - (e.g., treatment recommendations).

Why Healthcare Needs Machine Learning

Big Picture:

- Rapid analysis of large datasets for faster, more accurate decisions.

- Potential to improve patient outcomes and reduce healthcare costs.

Down in the details:

- Faster Diagnoses: Analyze medical images in seconds.
- Predictive Analytics: Forecast disease progression.
- Personalized Medicine: Tailor treatments based on genetics.
- Operational Efficiency: Optimize hospital workflows.

Real world impact

EnM Endocrinology and Metabolism http://www.e-enm.org

▸ Endocrinol Metab (Seoul). 2024 Jun 10;39(3):416–424. doi: 10.3803/EnM.2023.1913

Artificial Intelligence Applications in Diabetic Retinopathy: What We Have Now and What to Expect in the Future

Mingui Kong [1], Su Jeong Song [1,2,✉]

▸ Author information ▸ Article notes ▸ Copyright and License information

PMCID: PMC11220221 PMID: 38853435

https://pmc.ncbi.nlm.nih.gov/articles/PMC11220221/#:~:text=Currently%2C%20AI%20applications%20in%20DR,microvascular%20changes%2C%20as%20previously%20mentioned.

Real world impact

ACI
Applied Clinical Informatics
Thieme

Appl Clin Inform. 2020 Sep 2;11(4):570–577. doi: 10.1055/s-0040-1715827

Implementation of Artificial Intelligence-Based Clinical Decision Support to Reduce Hospital Readmissions at a Regional Hospital

Santiago Romero-Brufau [1,2], Kirk D Wyatt [3], Patricia Boyum [1], Mindy Mickelson [1], Matthew Moore [1], Cheristi Cognetta-Rieke [4]

Author information Article notes Copyright and License information

PMCID: PMC7467834 PMID: 32877943

https://pmc.ncbi.nlm.nih.gov/articles/PMC7467834/#:~:text=Clinical%20Relevance%20Statement,period%20(%20p%20%3C%200.001).

Section II : How ML Works

ML Workflow in Healthcare: Overview

Data Collection: EHR, imaging, genomics.

Data Preprocessing: Cleaning, normalization.

Model Training: Feed data into the algorithm.

Evaluation: Validate on new data.

Deployment: Integration into clinical practice.

ML Workflow in Healthcare: Rule 1

"Garbage in Garbage out"

Rule 1: *Garbage in Garbage out*

RESEARCH ARTICLE

Dissecting racial bias in an algorithm used to manage the health of populations

ZIAD OBERMEYER, BRIAN POWERS, CHRISTINE VOGELI, AND SENDHIL MULLAINATHAN Authors Info & Affiliations

SCIENCE • 25 Oct 2019 • Vol 366, Issue 6464 • pp. 447-453 • DOI: 10.1126/science.aax2342

https://www.science.org/doi/full/10.1126/science.aax2342

ML Workflow in Healthcare: Rule 2

“All models are wrong, but some are useful”
George Box

Rule 2: *All models are wrong*

- **Decision Tree:** A simple, intuitive algorithm that splits data based on feature values into branches to make predictions.

- **Random Forest:** An ensemble of multiple decision trees to improve accuracy and reduce overfitting. It averages the predictions from many trees for a more robust result.

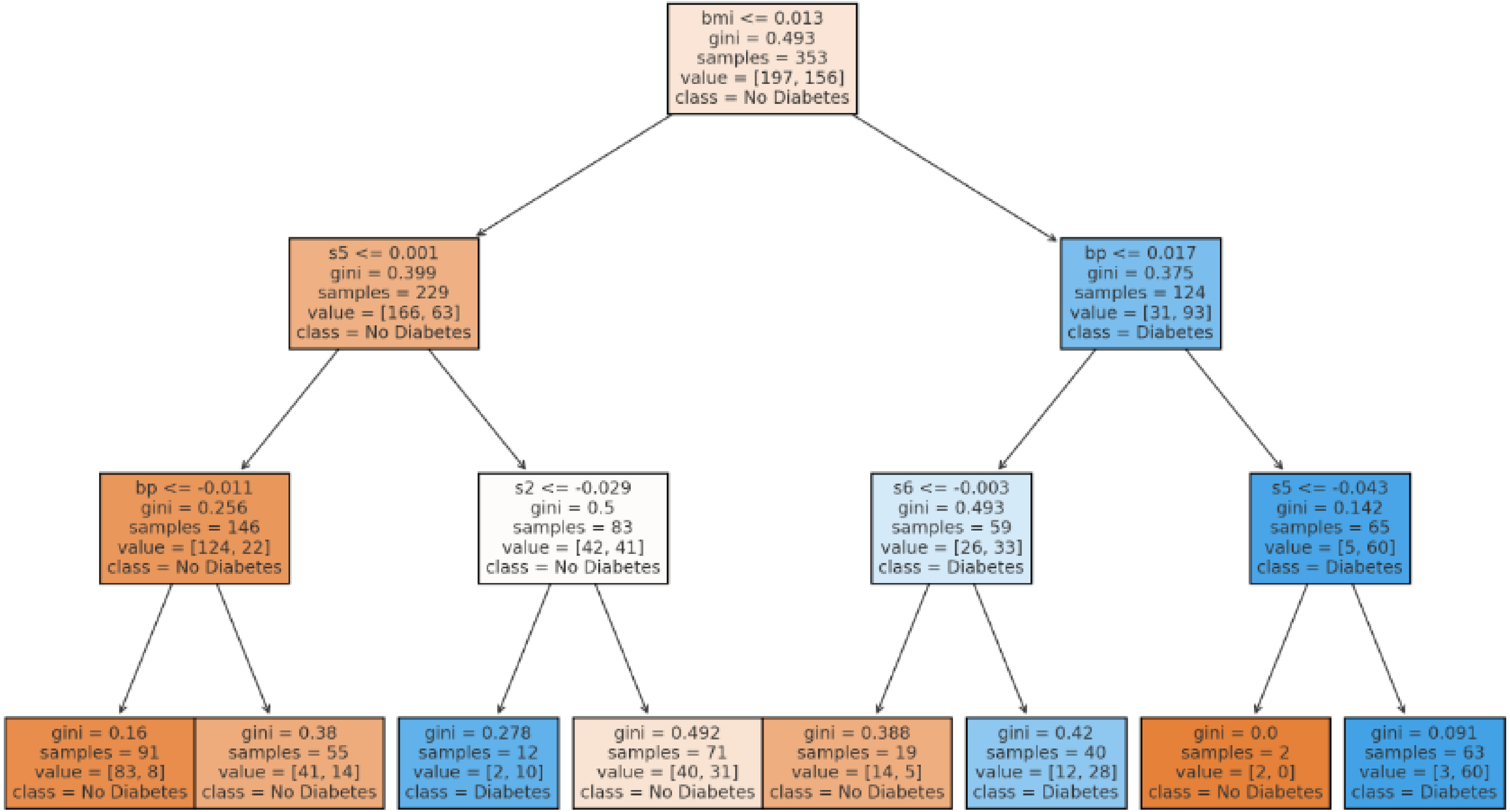
- **CNNs:** A type of deep learning algorithm specialized in processing grid-like data such as images. CNNs use layers of filters to automatically detect patterns and features in images.

Rule 2: *Some models are useful*

Algorithm	Key Strengths	Common Use Cases
Decision Tree/Random Forest	Interpretability, flexibility	Disease diagnosis, treatment recommendations
CNN (Convolutional Neural Network)	Image analysis, high accuracy	Medical imaging, pathology detection

Section III : Worked Example

Decision tree classifier in Python



Core ingredients of a "decision": Splitting Criterion

- **Gini Impurity:** Measures how often a randomly chosen element would be incorrectly labeled if randomly classified based on the distribution of labels in the dataset.
- **Entropy (Information Gain):** Measures the randomness in the dataset. The algorithm selects splits that maximize **Information Gain**, which is the reduction in entropy after the split.

Key Issue:

Instability: Small changes in data can lead to different splits and different trees.

Core ingredients of a "decision": Stopping Criteria

- max_depth: Limits the depth of the tree to prevent overfitting.
- min_samples_leaf: The minimum number of samples that must be present in a leaf node.

Key Issue:

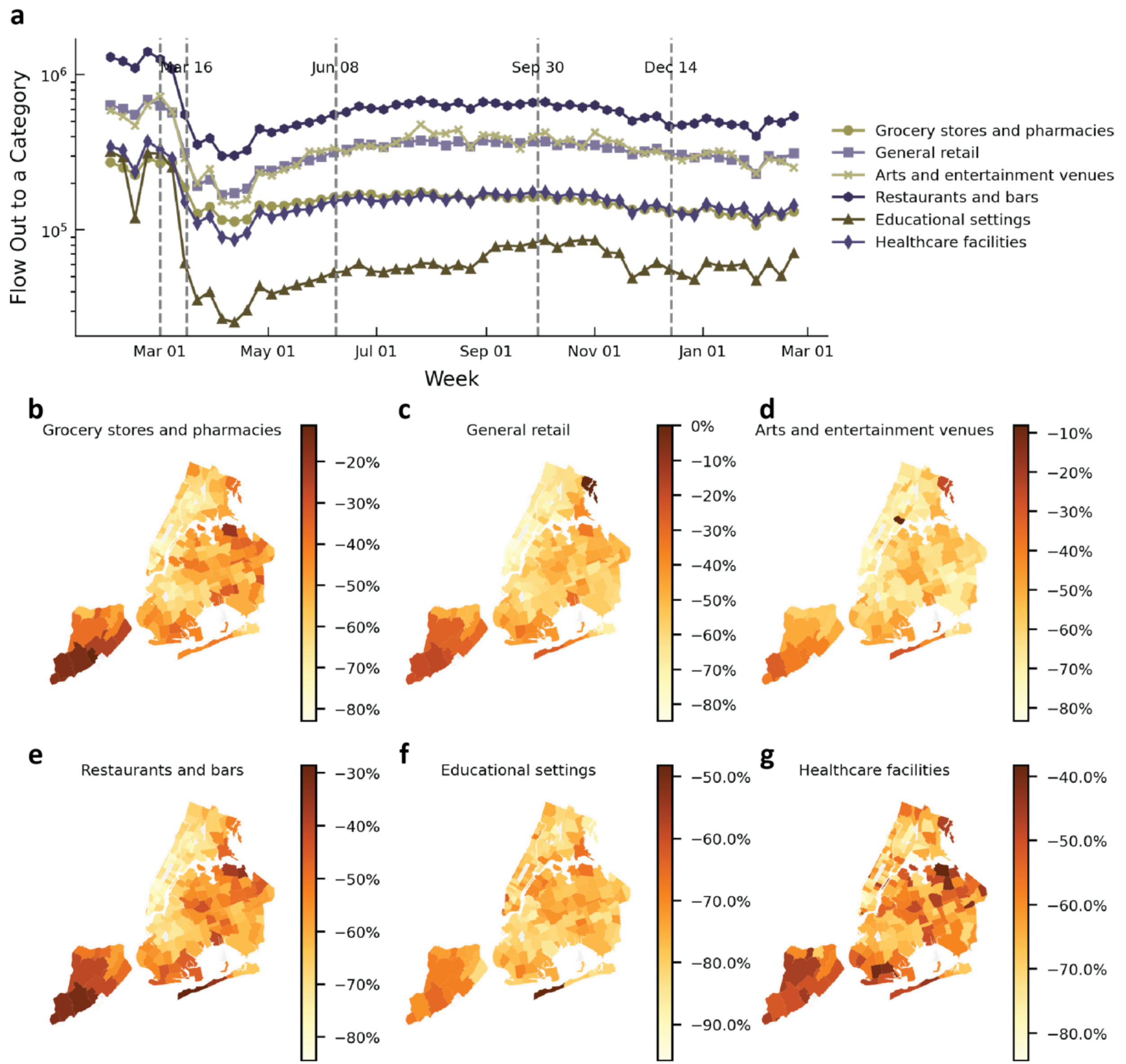
Overfitting: Decision trees can easily overfit to training data, especially if the tree is too deep.

Example in Python:

Example in my work:

Human mobility in times of crisis:

- Pandemic case study
- Across NYC zipcodes and boroughs
- Who went where, when, and why?
- Behavioral measures and agency



Example in my work:

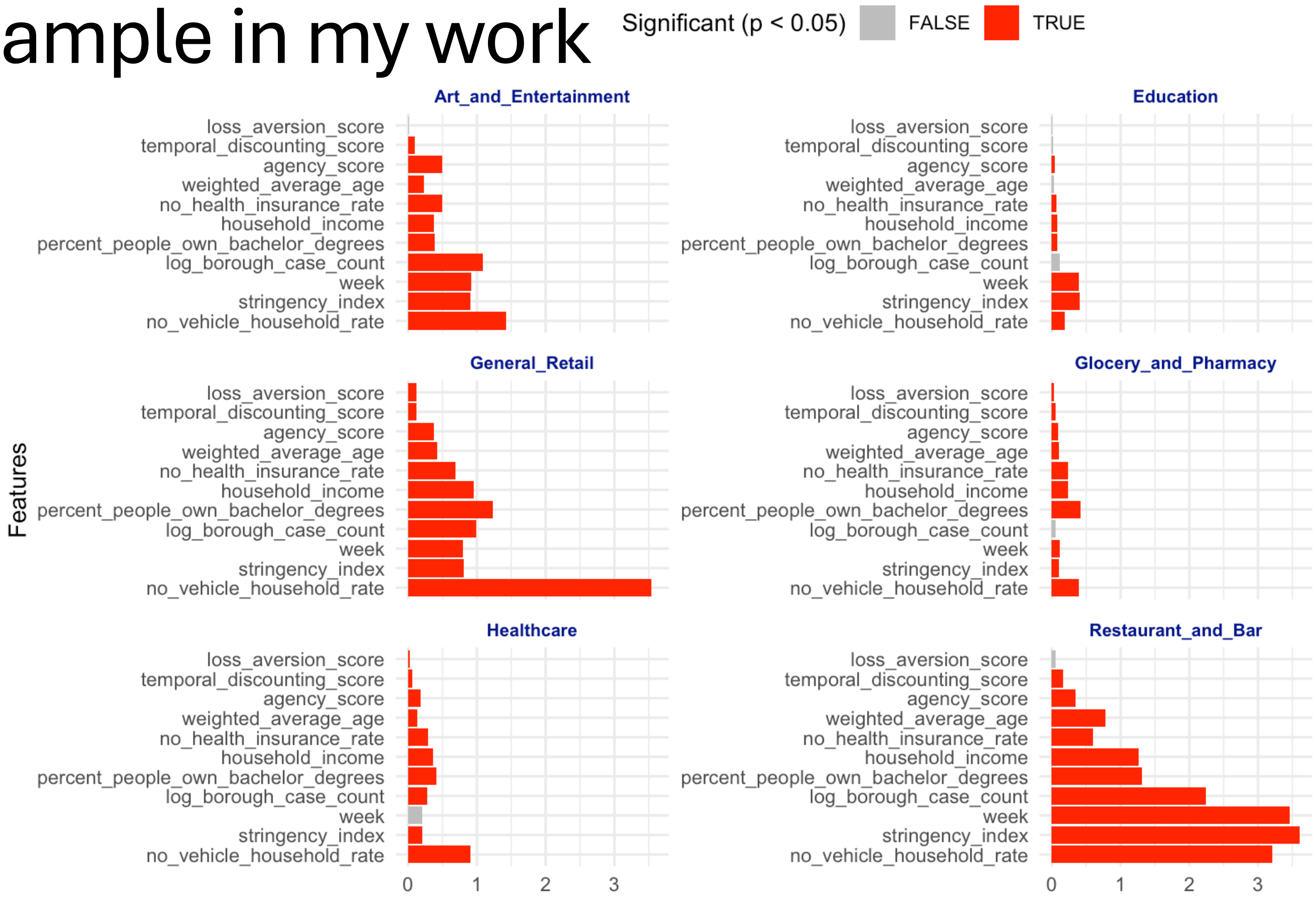
Random Forests:

ML algorithm that combines multiple independent decision trees, each trained on a random subset of the data.

- At each split, randomly choose a subset of features to consider (no overfit)
- When making a prediction, aggregate the results from all trees by taking the majority vote (classification) or averaging (regression)

N.B: Provides a built-in mechanism to identify the most important features in the data based on how frequently they are used in the decision trees

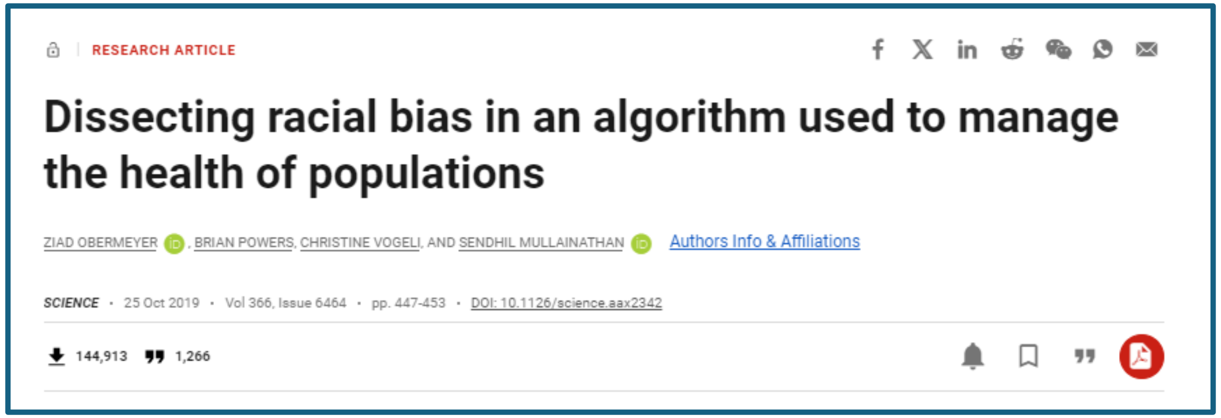
Example in my work



Section IV : Discussion

Discussion points:

- How could ML be applied in underserved healthcare systems?
- What ethical concerns resonate most with you?
- Where can you imagine bias emerging in ML models?



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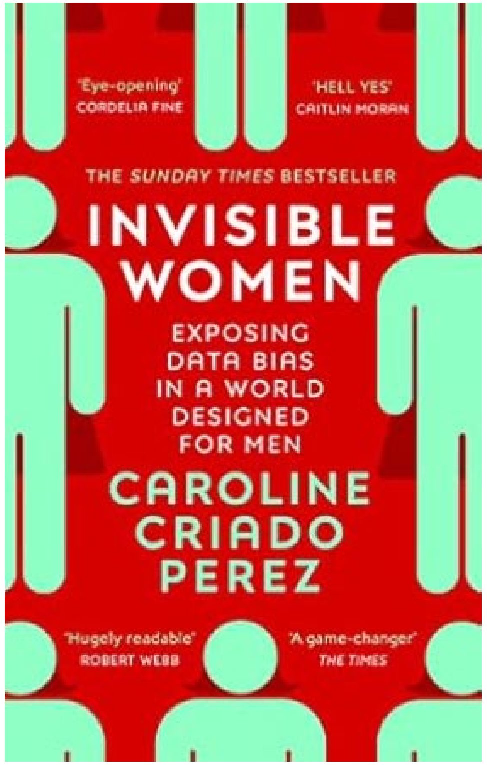

Free Resources
(aka you don’t need a paid bootcamp)

- Courses:
  - AI and Medical Diagnosis Coursera (applied, light touch),
  - ML Engineering (more abstract and heavy),

- Books:
  - Little book of ML (short and sweet),
  - Big Book of ML (advanced),
  - DeepLearning (overview),
  - d2l (comprehensive DL overview),

- General/Misc:
  - LLMs (cool website for explanatory visualizations of LLMs and genAI)

Questions?