Machine Learning and Deep Learning Lecture-01

By: Somnath Mazumdar

Assistant Professor

sma.digi@cbs.dk

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This session's primary AIM is to set **<mark>expectations</mark>**,

rules and other practicalities.

Four Basic Goals

- What is ML/DL?
- What are its components/models/complexities/issues?
- How can we pick a fitting model for an application?
- How can we bring ML advantages to the application?

Learning Objectives

1. Understand fundamental challenges of machine learning (ML) models (selection, complexity).

2. Detect strengths and weaknesses of ML models.

3. Design, implement, ML models and deep learning techniques for realistic applications.

4. Summarize application areas, trends, and challenges in ML.

5. Exhibit deeper knowledge and understanding of covered topics.

6. Reflect on critical awareness of methodological choices with written skills to accepted academic standards.

NORDIC NINE

Copenhagen Business School develops disciplinary skills and transformational capabilities. Together we pursue knowledge that builds values, and values that prepare for action.

Graduating from CBS means that

KNOWLEDGE

you have deep business knowledge placed in a broad context

you are analytical with data and curious about ambiguity

you recognise humanity's challenges and have the entrepreneurial knowledge to help resolve them

VALUES

you are competitive in business and compassionate in society

you understand ethical dilemmas and have the leadership values to overcome them

you are critical when thinking and constructive when collaborating

ACTION

you produce prosperity and protect the prosperity of next generations

you grow by relearning and by teaching others to do the same

you create value from global connections for local communities

Helping Materials

Extra ML Study Materials/Links

🔗 Scikit Material

📎 Long_Cheatsheet.pdf

📎 Mini_Cheatsheet.pdf

📎 Pandas_Cheat_Sheet.pdf

📎 [1]Machine-learning-algorithm_Microsoft.pdf

📎 [2]Machine-learning-algorithm_Microsoft.pdf

EDA

🔗 [Video] Pairplot Sklearn

Resources

Resource#1: UCloud

🔗 Ucloud Login Page

**Resource#2: Data Science Cluster**

🔗 Request Form

Lecture Plan

Lecture	Teacher	Topic(s)	Readings
Lecture-01 Week #06	SM	**Course Intro:** Course practicalities, Introduction to course, & machine learning (ML) lifecycle overview	[HML] Ch. 1/2
Lecture-02 Week #06	SM	**Intro ML, preprocessing:** Data pre-processing and exploratory data analysis, Loss functions, bias-variance, CV schemes	[HML] Ch. 2/3
Lecture-03 Week #08	SM	**Unsupervised ML:** Principles of unsupervised ML; K-Means, DBSCAN, Gaussian Mixture Models	[HML] Ch. 9
Lecture-04 Week #08	SM	**Supervised ML:** KNN, Linear and Logistic regression, L1/L2 Regularization, Elastic Net	[HML] Ch. 3/4
Lecture-05 Week #09	SM	Decision Trees, **Ensembles:** Random Forests, Gradient Boosting; Dimensionality Reduction: Principal Component Analysis	[HML] Ch. 6/7/8
Lecture-06 Week #09	SM	Support Vector Machines (SVM); Performance evaluation metrics (ROC, PR, AUC, F1)	[HML] Ch. 3/5
Lecture-07 Week #10	SM	Outlier Detection: Isolation Forest, Recommender Systems, Class imbalance: SMOTE and ADASYN	HML] Ch. 9 SMOTE: [J01] section 4.2 and ADASYN: [J02]
Lecture-08 Week #10	SM	Gradient Descent (& backpropagation), Early stopping, activation functions, Optimal configurations: Grid Search/Random Search	[HML] Ch. 11
Lecture-09 Week #11	SM	Neural Networks: Introduction, Threshold Logic Units, Multi-layer perceptron, feedforward network, dropout, Batch norm.	[HML] Ch. 10/11
Lecture-10 Week #11	SM	Introduction Tensor flow, RNN/LSTM/GRU/ Bi-LSTM	[https://www.tensorflow. org/tutorials/] &

			[HML] Ch. 12/13/15
Lecture-11 Week #12	SM	Autoencoder, Brief intro to attention/transformers	[HML] Ch. 16/17
Lecture-12 Week #12	SM	CNN, Architectures (VGG, ResNet, MobileNets, YOLO)	[HML] Ch. 14
Lecture-13 Week #13	SM	Adversarial attacks, Hyper Parameter Optimizations	[HML] Ch. 11
Lecture-14 Week #13	SM	Philosophy of AI, Ethics of ML and DL, AI alignment	-
Lecture-15 Week #15	SM	Distributed learning: Federated learning, Explainable AI	[HML] Ch. 19
Lecture-16 Week #15	SM	Recap and conclusion	-

Course is too vast!!

It covers many models.

Book

Exam & Guidelines

Compulsory Assignments

- Activity Type: Mandatory Activities
- Number of mandatory activities: 3
- Activities to be approved to qualify for final exam: 2

Submission Process

- Teacher adds the question paper by creating "CANVAS Assignment".
- Students must add their <mark>student numbers</mark> on the mandatory home assignment (on Canvas) to make it easier for the teacher to find them on Digital Exam.
- Students hand in their mandatory assignment on CANVAS.
- Teacher checks the assignments on CANVAS.
- Teacher grades them on Digital Exam.
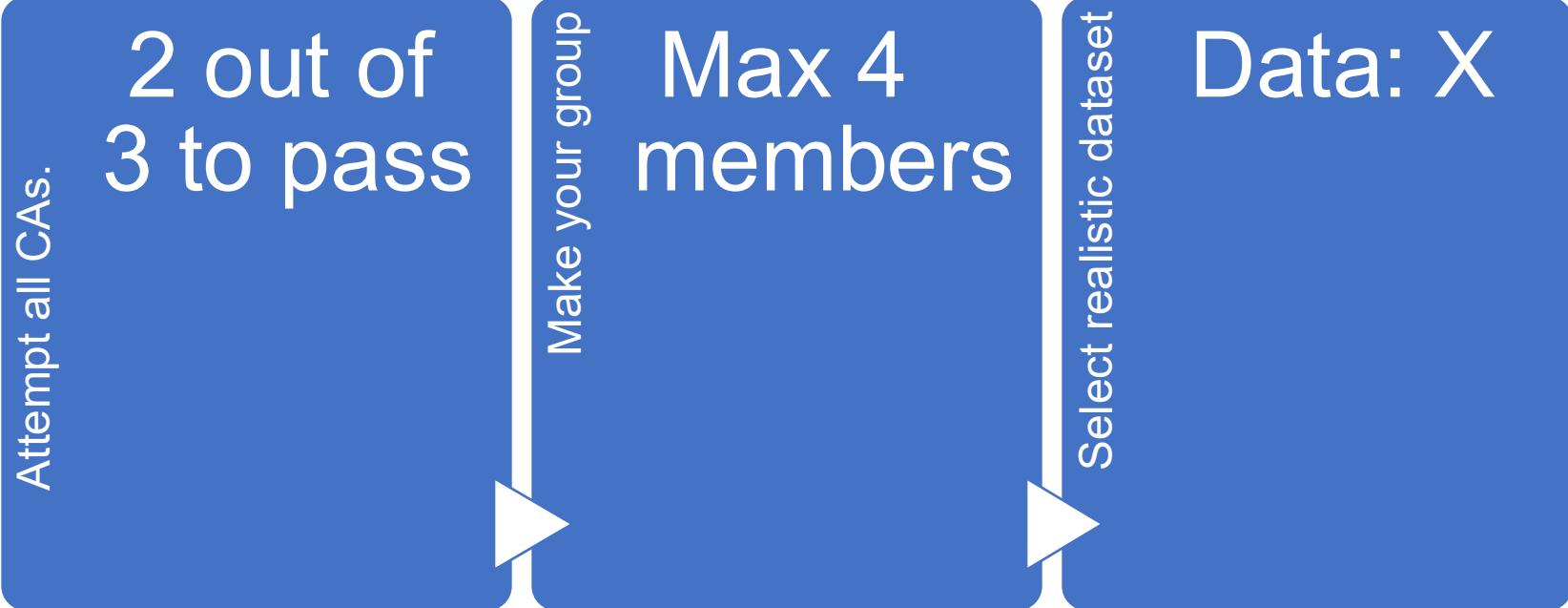
Final Exam

- Assignment type: Project

- Form: <mark>Individual oral exam</mark> based on <mark>written group product</mark>.
  - Model Implementation is important!!

- Number of people in group: 2-4.

- Size of written product: Max. 15 pages.

- Examiner(s): Examiner and internal examiner.

Final Exam Guidelines

- Choose a <mark>realistic</mark> data set.

- Analyse data set <mark>applying covered models.</mark>

- Discuss the rationale behind the <mark>usage selected model(s).</mark>

- Analyse the result for lay man use.

Before Lecture 15

Attempt all CAs.

2 out of 3 to pass

Make your group

Max 4 members

Select realistic dataset

Data: X

Report Structure [Week 15]

Remember!!

Rule: Compulsory Assignments

- If a student did not get his/her compulsory assignments approved, s/he cannot participate in the final exam.

- Student should make a decent try in ALL compulsory assignments.

- We assess students' effort.

[For More]: Check CBS program regulations

Rule: Final Exam & Compulsory Assignments

- For doing group work alone:
  - Go to administration and <mark>*never through the teacher/course coordinator*</mark>.
  - Applies to both final exam and compulsory assignments.
    - A student <mark>*should talk to the teacher*</mark>/course coordinator before applying the Study Board for exemption to do group work alone.
    - When applying for exemption the student is asked to document that the student has <mark>*made an effort*</mark> to find a group.

Rule: Final Exam & Compulsory Assignments

- Guideline also applies where students wishes *for a group size that differs* from what is described in the course catalogue.

A solo member-based group project is FULLY discouraged!!

Teacher *will not ask* any group to include someone!!

Students must *co-operate*!!

UCloud Platform

Exam/Course related Remarks/Questions/Confusions

Let's Get Started
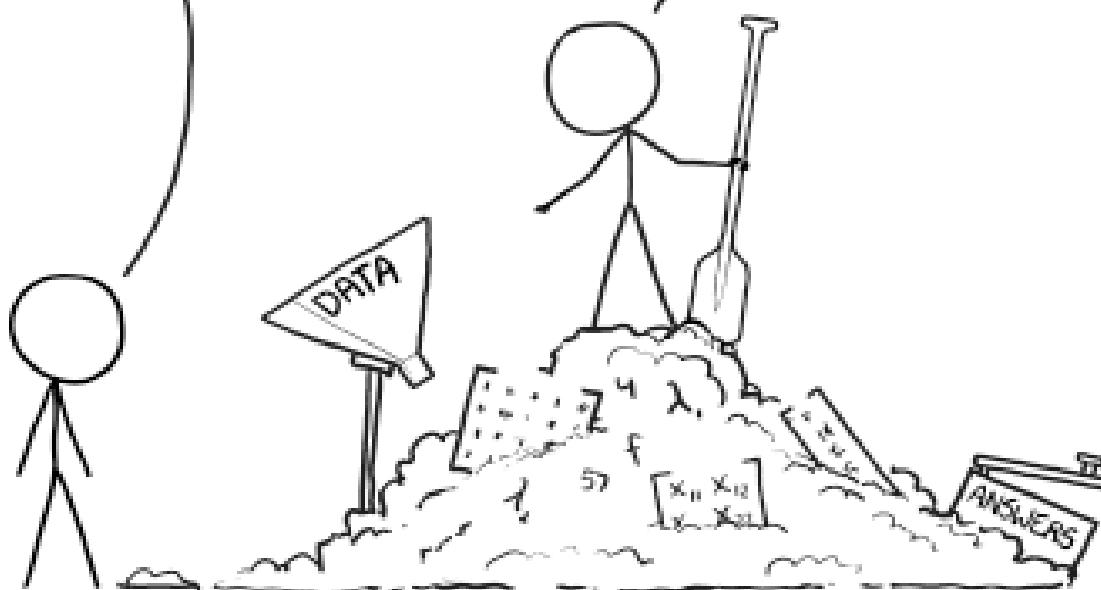
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https://xkcd.com/1838/
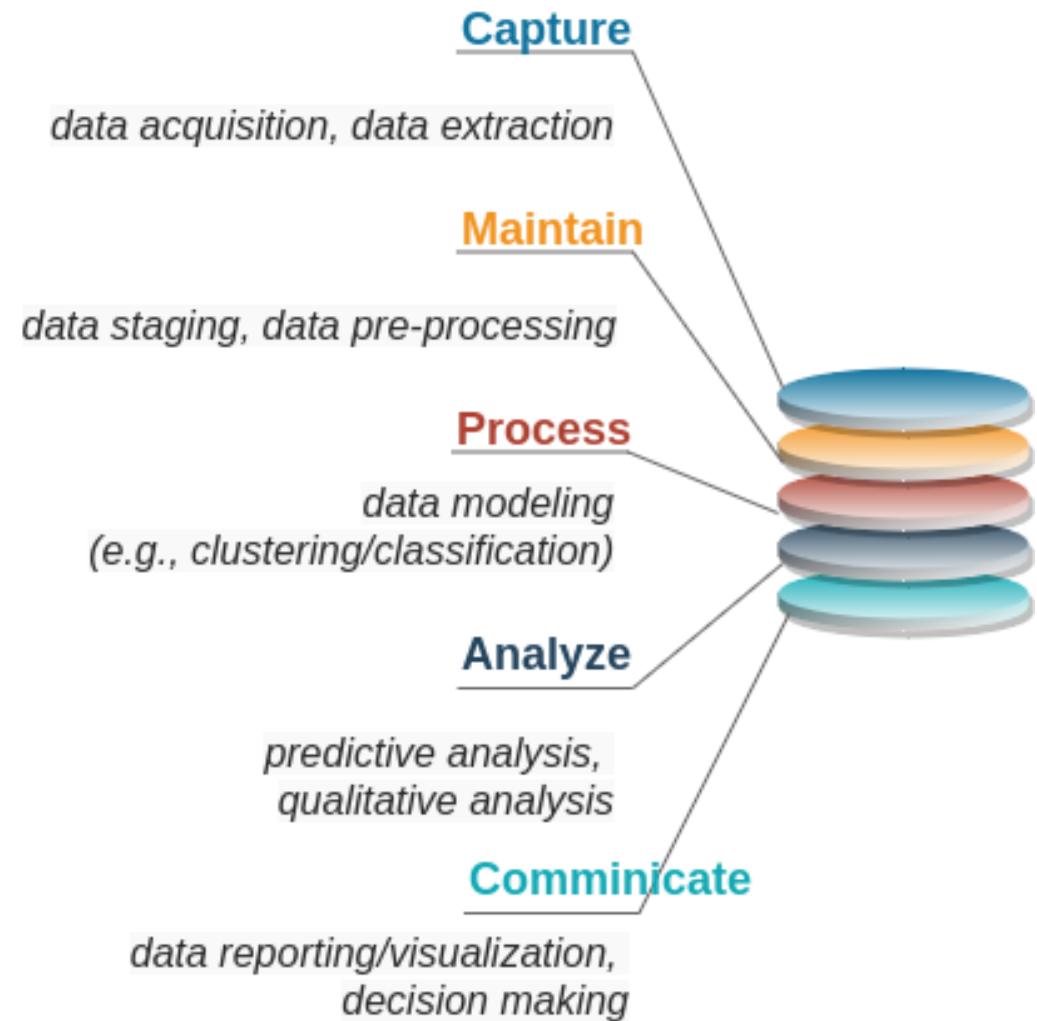
What is Data Science?

"The ability to take data - to be able to understand it, to process it, to extract value from it, to visualize it, to communicate it - that's going to be a hugely important skill in the next decades." - Hal Varian, 2009*

Capture

data acquisition, data extraction

Maintain

data staging, data pre-processing

Process

data modeling
(e.g., clustering/classification)

Analyze

predictive analysis,
qualitative analysis

Comminicate

data reporting/visualization,
decision making

What is Data Science?

- Data science is primarily a collection of statistical and machine learning models.
  - It supports and guides the information and knowledge extraction from data.
  - Offers insights, establishes causality, predictions.

- Application Domains: Banking, Manufacturing, supply chain management, Transportation, Healthcare and many more.
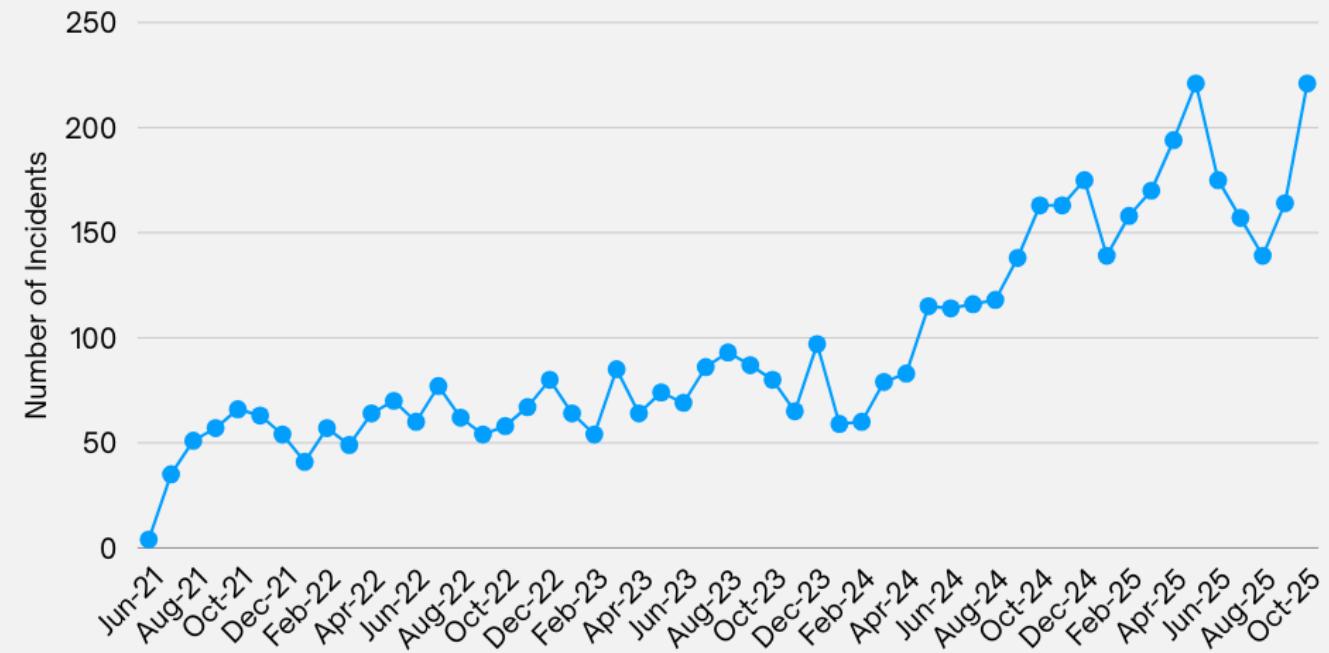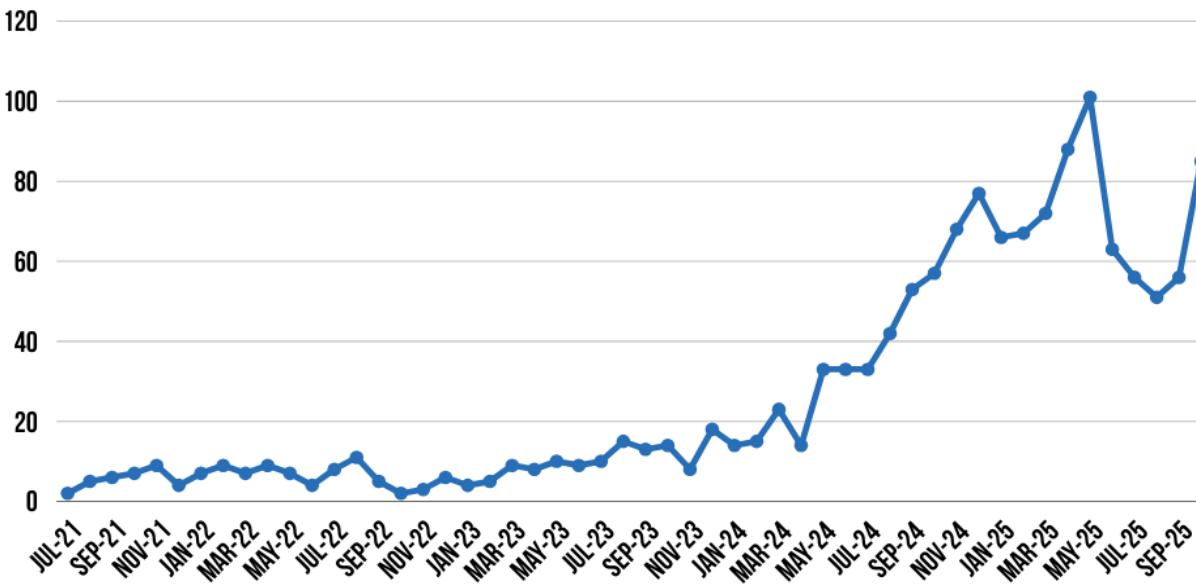
WAYMO ACCIDENT TIMELINE

Number of Crashes by Month & Year (2021-2025)
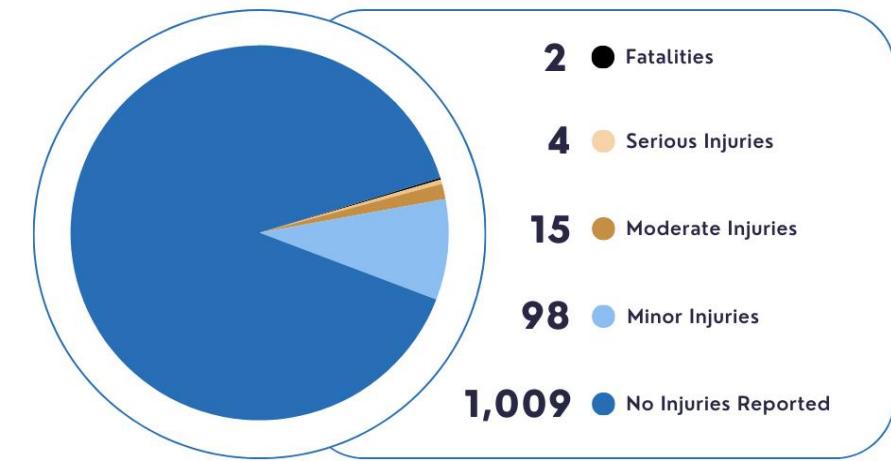
Source: NHTSA ADS Crash Data

WAYMO ACCIDENT INJURIES

2021-2025

2 ● Fatalities

4 ● Serious Injuries

15 ● Moderate Injuries

98 ● Minor Injuries

1,009 ● No Injuries Reported

Source: NHTSA ADS Crash Data

1POINT21

https://www.bbc.com/news/technology-51645566

8/5/2024 12:00:00 PM **Share This Episode**

Hidden Autopilot Data Shows Patterns in Tesla Crashes

A WSJ investigation reveals previously unknowable patterns in crashes involving Tesla's driver-assistant system, Autopilot. Frank Matt, a WSJ senior video journalist, joins host Zoe Thomas to explain the comprehensive analysis of crash data and the longstanding concerns about Tesla's Autopilot. Plus, why Amazon is expanding its ultrafast delivery to rural U.S. communities.

Sign up for the WSJ's free Technology newsletter.

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FULL TRANSCRIPT
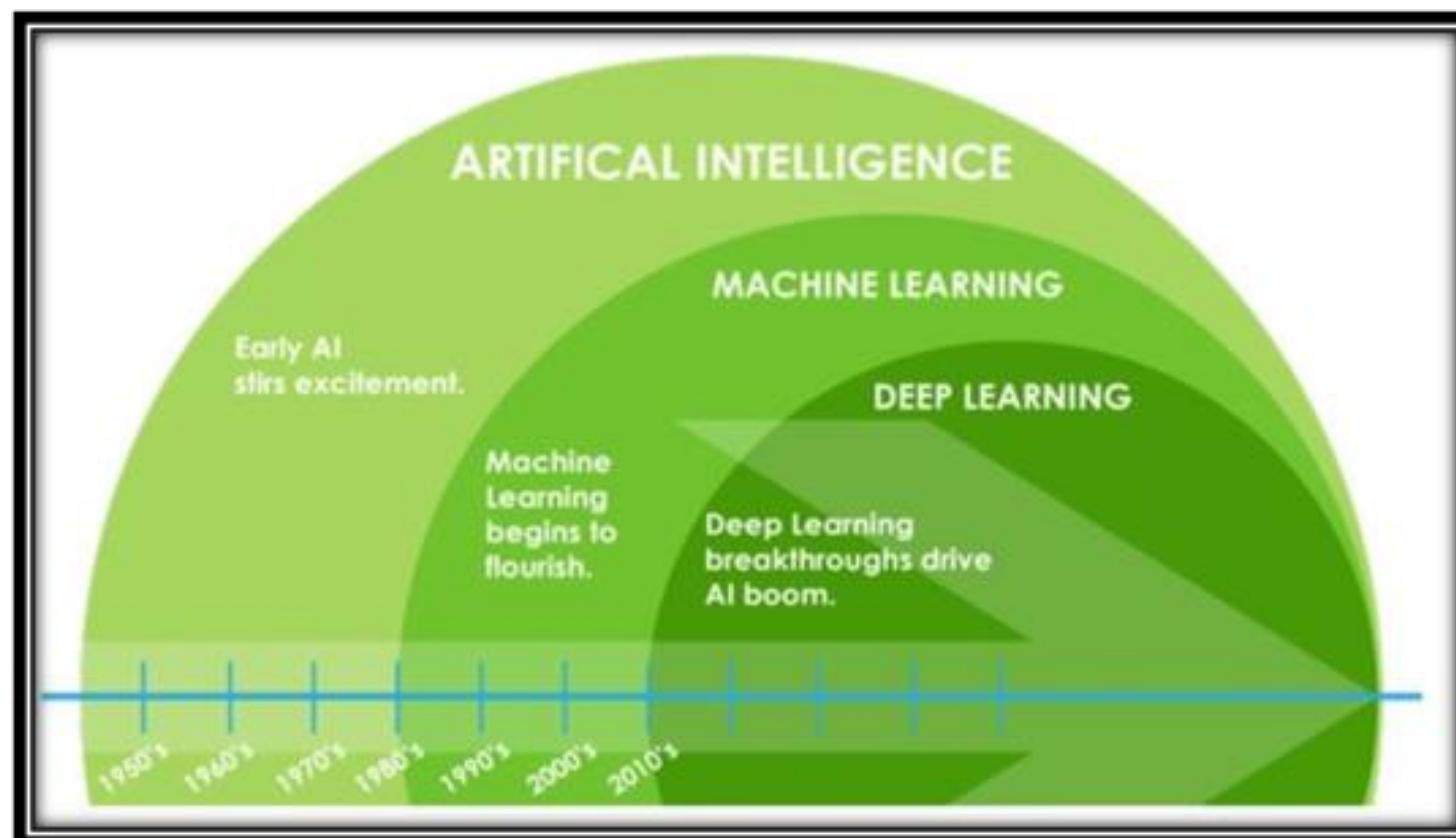
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Zoe Thomas: Welcome to Tech News Briefing. It's Monday, August 5th. I'm Zoe Thomas for the Wall Street Journal. Amazon's last frontier of ultra-fast delivery in the US is reaching into the remote corners of America. We'll tell you why and what it could mean for the US Postal Service. And then, Tesla's semi-autonomous driving system relies mostly on cameras, which differs from the rest of the industry. A WSJ analysis has revealed previously unknowable patterns in crashes involving this system called Autopilot, and found Autopilot sometimes struggles to recognize obstacles or stay on the road. We'll bring you details of that investigation. But

https://www.youtube.com/watch?v=mPUGh0qAqWA
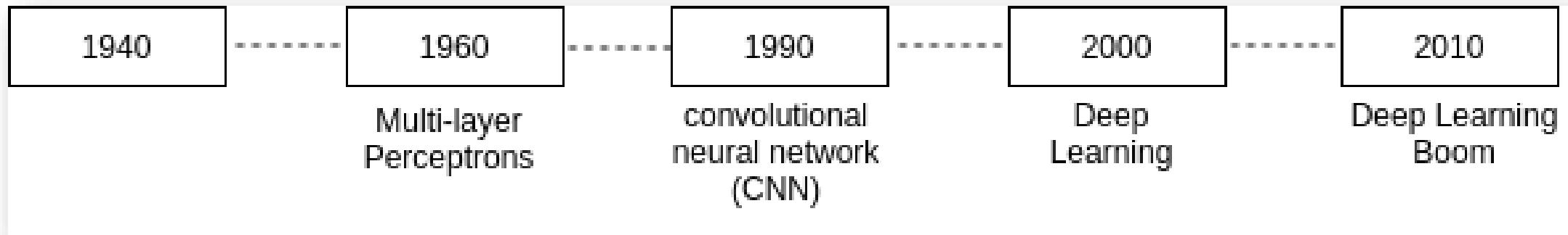
What is machine learning?

- Goal of AI is to create computer models that exhibit "intelligent behaviors" like humans.

- Machine Learning (ML) is one way to use AI.

ARTIFICAL INTELLIGENCE

MACHINE LEARNING

DEEP LEARNING

Early AI stirs excitement.

Machine Learning begins to flourish.

Deep Learning breakthroughs drive AI boom.

1950's 1960's 1970's 1980's 1990's 2000's 2010's

36
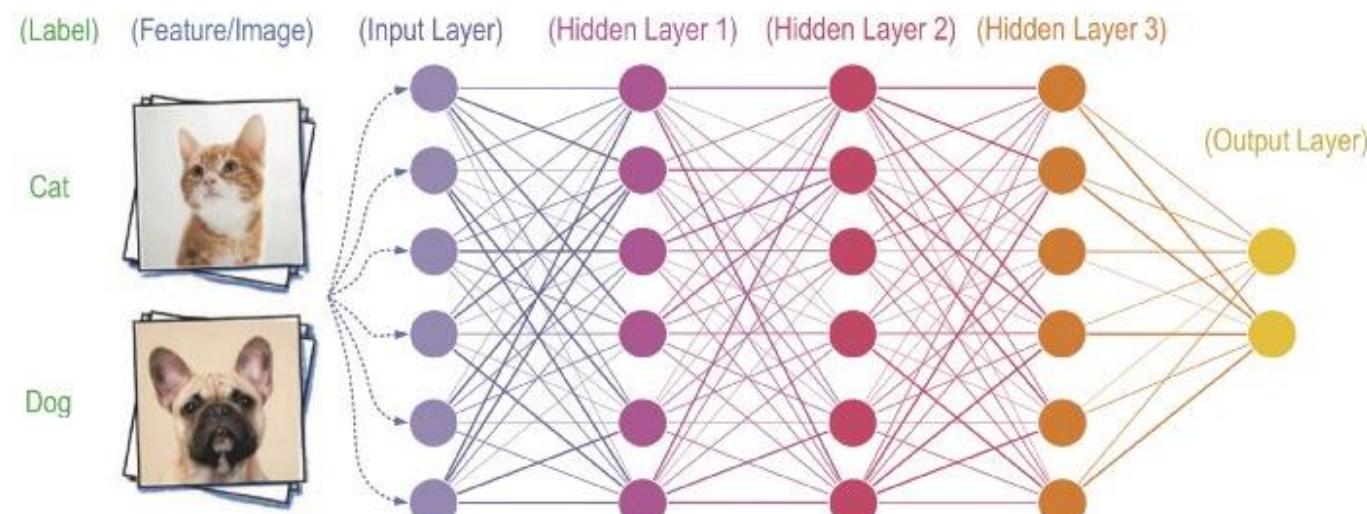
Data Science and Machine Learning

- Components of data science: data, (pre-) processing, statistical model and *machine learning*.
- One of the key feature of machine learning is prediction.
  - In machine learning, we train models and evaluate models.
  - Deep neural network has many hidden layers.
    - Ex- Image classification, Natural language processing
- Multiple machine learning problems overlap with statistics.

1940	1960	1990	2000	2010
	Multi-layer Perceptrons	convolutional neural network (CNN)	Deep Learning	Deep Learning Boom

ML to Deep Learning

- ML was defined in 1950s as "the field of study that gives computers the ability <mark>to learn without explicitly being programmed</mark>."

- Deep learning (DL) is a subfield of ML which uses neural networks with many layers.

  - Layered network can process extensive amounts of data and determine the "weight" of each link in the network.

Terminology

- **Algorithm:** is a set of procedures that creates a model when trained. E.g., linear regression.

- **Model:** is a fitted algorithm that has been trained. E.g. a linear regression model that has been trained to predict prices of 'X'.

- **Parameters** are the internal variables within a model that are adjusted automatically as you train a ML model

- **Hyperparameters** are set by the user to control the algorithm and they define how it learns from the data.

Functioning of ML

- Functions:
    - **Descriptive** meaning that system uses data to explain <mark>what happened.</mark>
    - **Predictive** meaning that system uses data to predict <mark>what will happen.</mark>
    - **Prescriptive** meaning that system will use data to make suggestions about what action to take.

Categories of ML
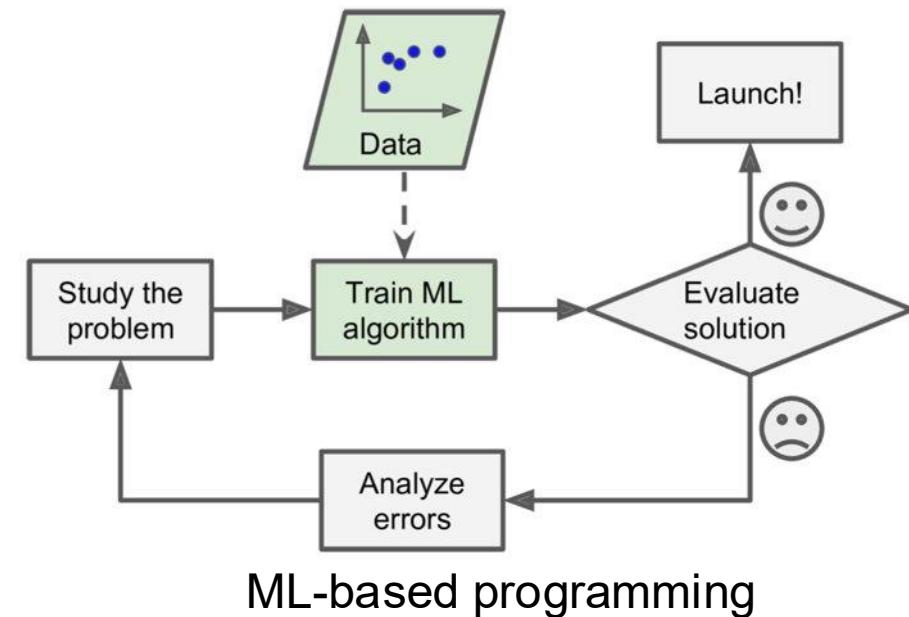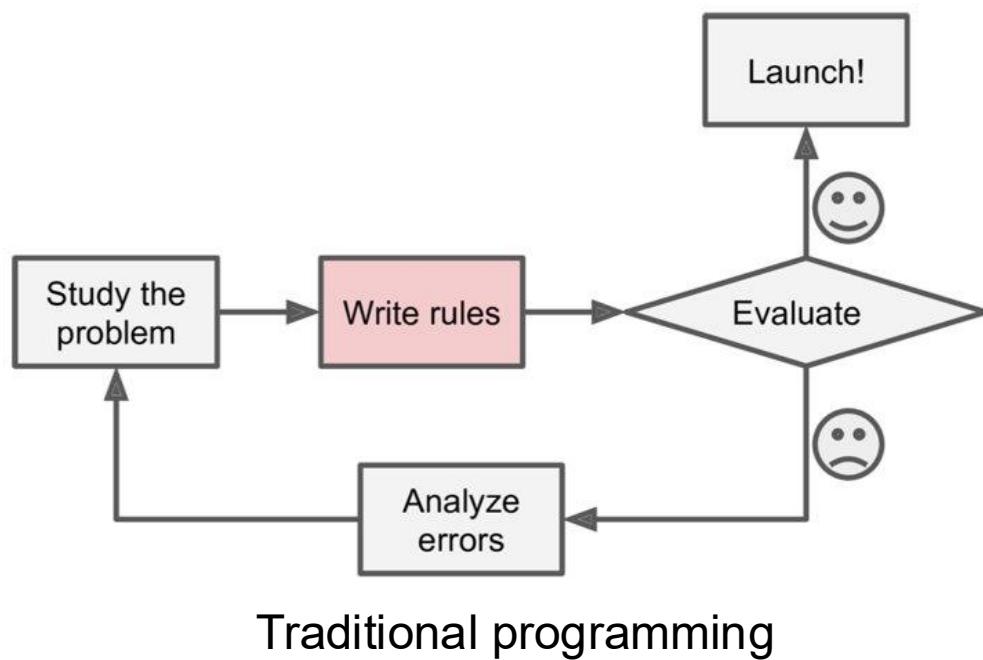
- Subcategories:

  - **Supervised** ML models are trained with labeled data sets.

  - **Unsupervised** ML models looks for patterns in unlabeled data.

  - **Reinforcement** ML trains machines through trial and error to take the best action by establishing a reward system.

    - Difficult to precisely specify the task.

    - Learning process of task can be dangerous.

Subfields of ML

- Subfields:
    - Natural language processing is a field of ML in which machines learn to understand natural language as spoken and written by humans.
    - Neural networks are modeled on the human brain.
    - Deep learning networks are neural networks with many layers.

ML Application
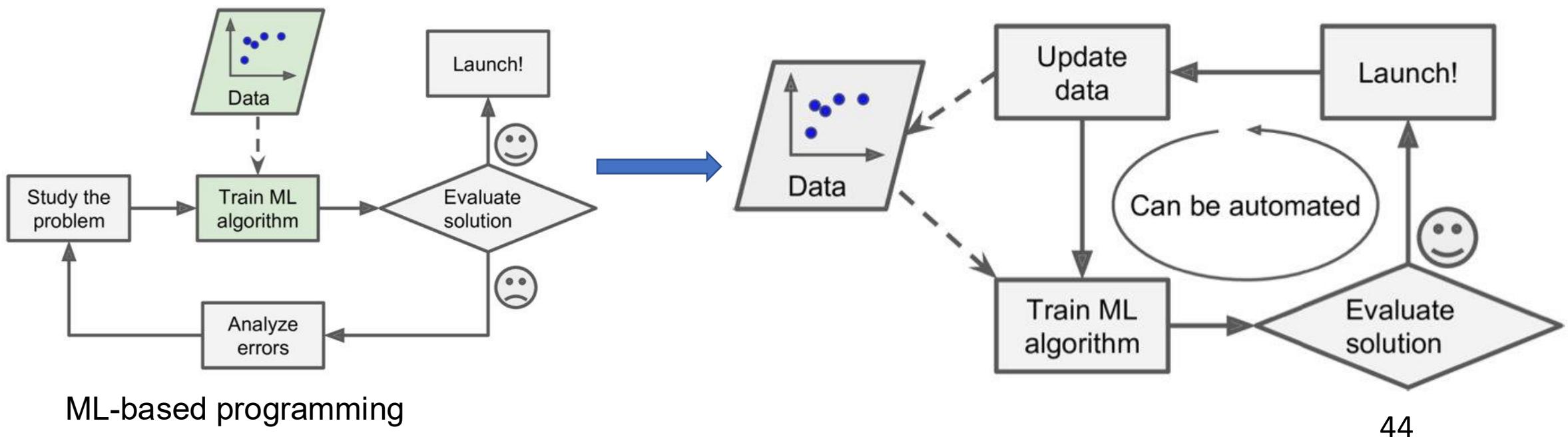
- ML works well where:
    - (Large) data is available.
    - Problem is dynamic or fluctuating.
    - Problem requires predictions or discovering patterns.

Traditional programming

ML-based programming

ML Application
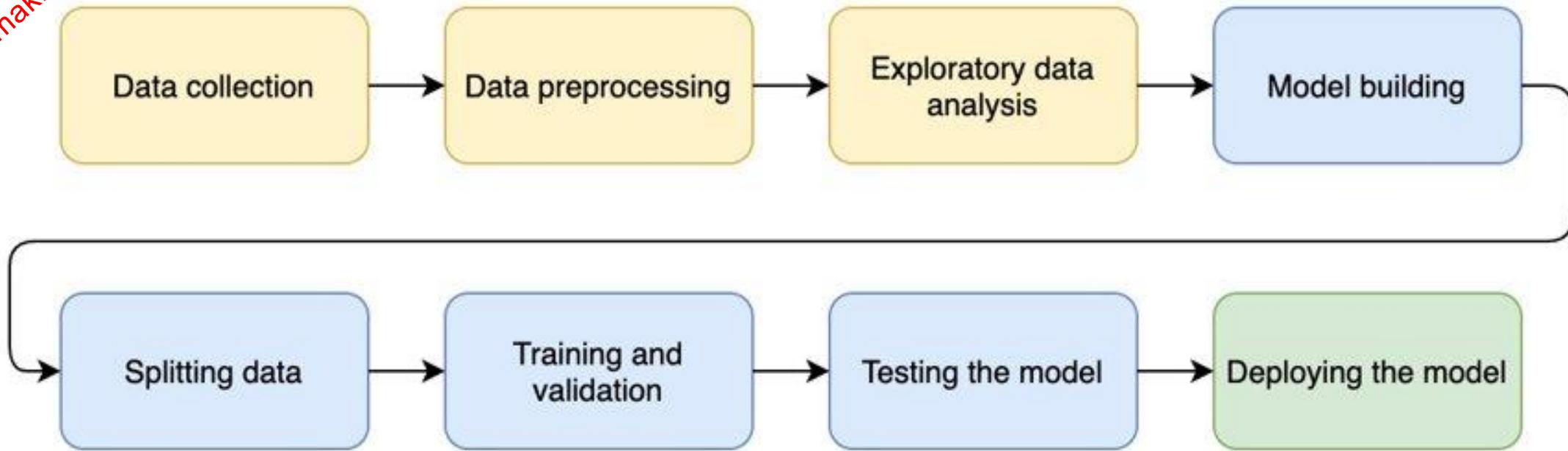
ML works well where:
- (Large) data is available.
- Problem is dynamic or fluctuating.
- Problem requires predictions or discovering patterns.

ML-based programming

44

ML Flow

Consider making your scripts reusable!!

Data collection → Data preprocessing → Exploratory data analysis → Model building

Splitting data → Training and validation → Testing the model → Deploying the model
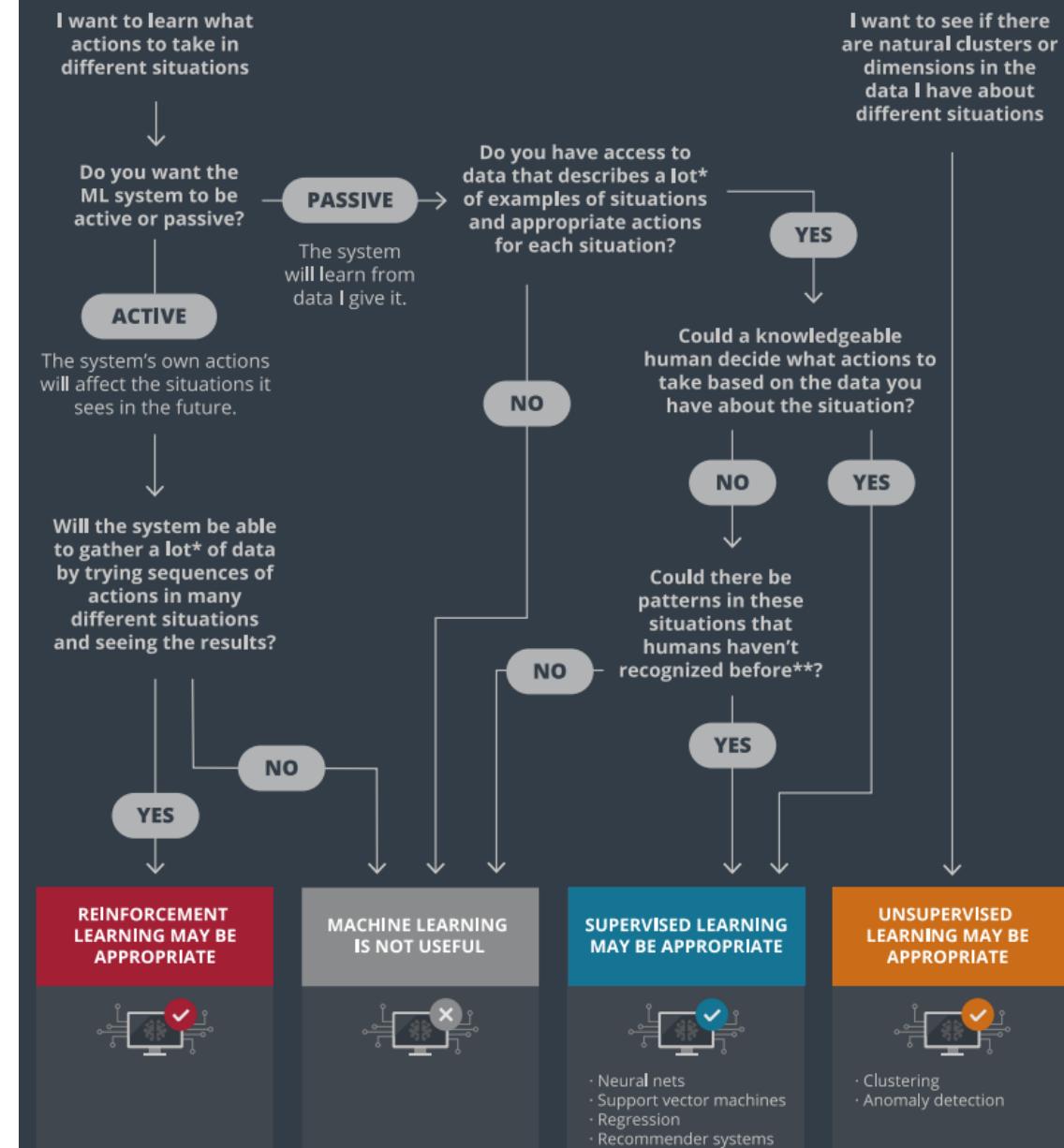
Yellow boxes represent preparation
Blue boxes represent ML model development.

Challenges

- Explainability:
    - What ML models are doing?
    - How they make decisions?

- Bias and unintended outcomes
    - Not enough training data always.
    - Non-representative/biased training data.
    - Less feature rich data.
    - Irrelevant features.
    - Overfitting (overgeneralizing) or underfitting.

What do you want the machine learning system to do?

I want to learn what actions to take in different situations

Do you want the ML system to be active or passive?

PASSIVE — The system will learn from data I give it.

ACTIVE — The system's own actions will affect the situations it sees in the future.

Will the system be able to gather a lot* of data by trying sequences of actions in many different situations and seeing the results?

Do you have access to data that describes a lot* of examples of situations and appropriate actions for each situation?

YES

NO

Could a knowledgeable human decide what actions to take based on the data you have about the situation?

NO

YES

Could there be patterns in these situations that humans haven't recognized before**?

NO

YES

YES

NO

I want to see if there are natural clusters or dimensions in the data I have about different situations

REINFORCEMENT LEARNING MAY BE APPROPRIATE

MACHINE LEARNING IS NOT USEFUL

SUPERVISED LEARNING MAY BE APPROPRIATE
· Neural nets
· Support vector machines
· Regression
· Recommender systems

UNSUPERVISED LEARNING MAY BE APPROPRIATE
· Clustering
· Anomaly detection

* It's very hard to say how much data will be needed until you start to analyze your problem in detail, but often you need hundreds, thousands, or millions of examples.

** For example: Have humans not focused on this problem before? Was the data about this problem not available before? Can the patterns here, if they exist, only be detected by looking at more data than humans can really process?
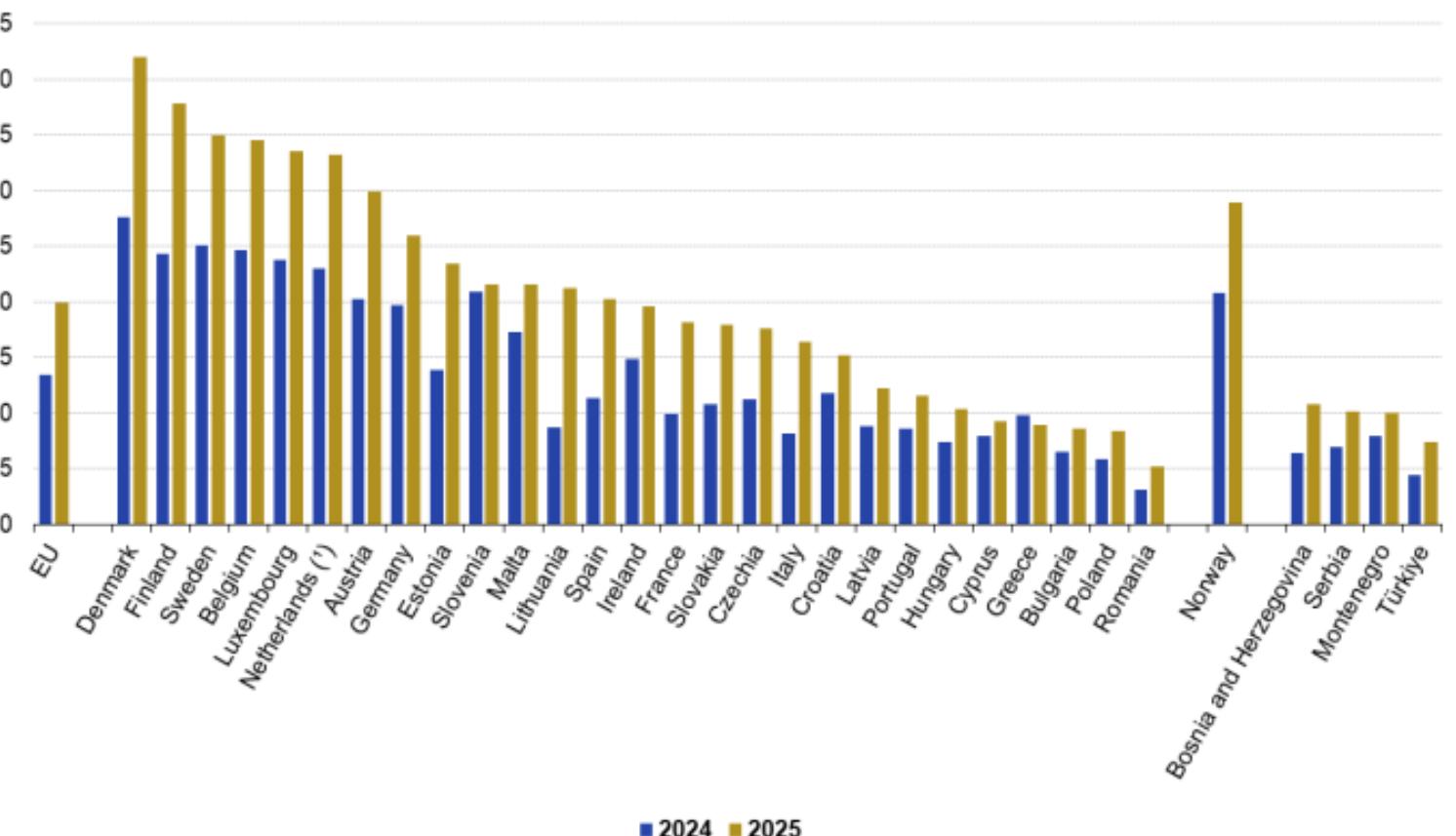
Industry Perspective

- Who is a Data Analyst, Data Engineer and Data Scientist?

  - Data Analyst: analyzes data and infer better decisions. Good understanding of tools.

  - Data Engineer pre-processes data. They develop, tests and maintain complete model.

  - Data Scientist analyses and interpret complex data. Require strong (optimization) knowledge of statistical as well as machine learning model.

AI in Industry

- In 2025, 19.95% of EU enterprises used AI technologies.

- In 2025, 55.03% of large EU enterprises used AI technologies.

- In 2025, AI was used the most by enterprises in the information and communication sector.

Enterprises using AI technologies, 2024 and 2025
(% of enterprises)

■ 2024 ■ 2025
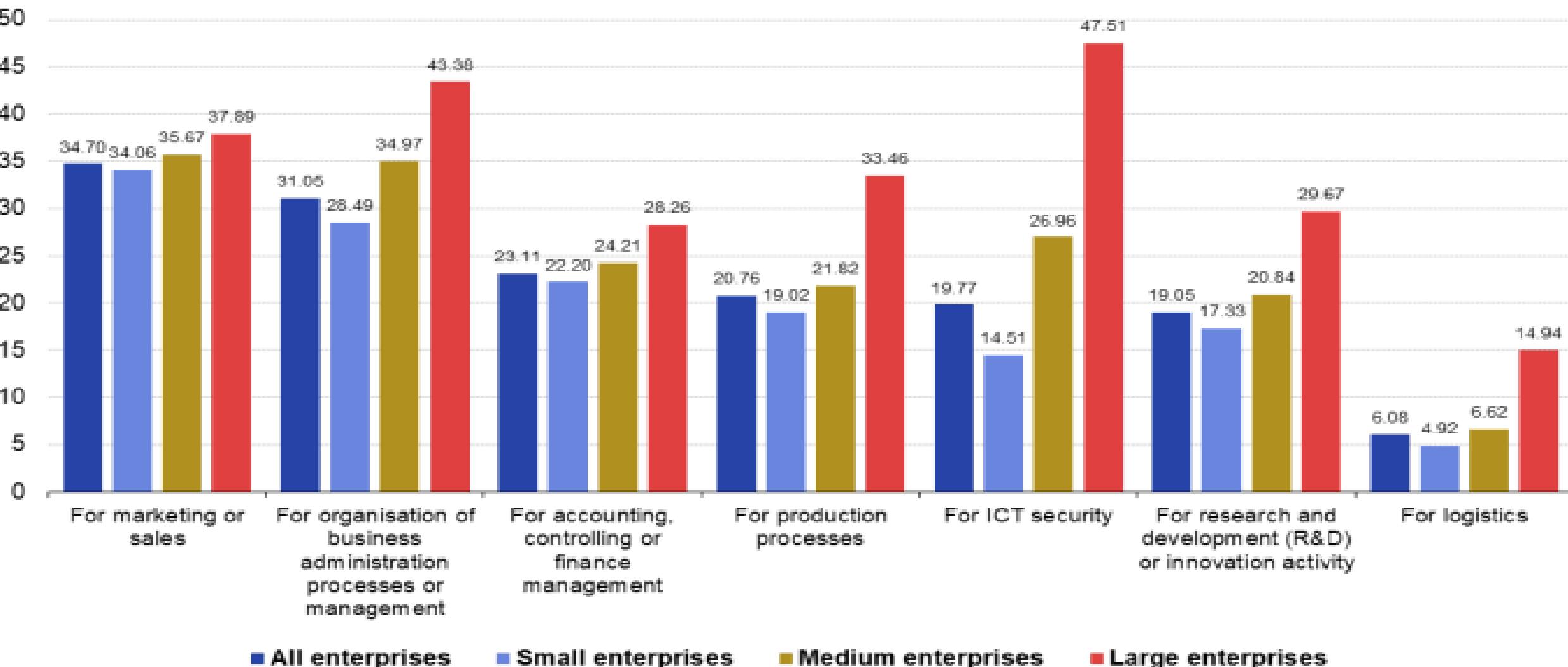
(¹) 2025: Break in the time series.
Source: Eurostat (online data code: isoc_eb_ai)

eurostat

Enterprises using AI technologies by type of purpose and size class, EU, 2025

(% of enterprises using at least one AI technology)

Source: Eurostat (online data code: isoc_eb_ai)

Enterprises that have ever considered using any of the AI technologies by reason for not using, EU, 2025

(% of the enterprises that have ever considered using any of the AI technologies)

Reason	%
Lack of relevant expertise	70.89
Lack of clarity about the legal consequences	52.52
Concerns regarding violation of data protection and privacy	48.83
Difficulties with availability or quality of the necessary data	44.37
Incompatibility with existing equipment, software or systems	41.39
The costs seem too high	33.34
Ethical considerations	23.53
AI technologies are not useful for enterprise	20.68

eurostat