

Machine Learning Through Mathematics

Week 1: AI vs Machine Learning

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By the end of this course

- You will be able to correctly identify AI and ML use applications in the real world
- You will know what parts of mathematics are used in ML and how
- You will be able to use Python to do basic ML
- You will (mainly) understand how ChatGPT works

Today's goals

By the end of this lesson, you should be able to

- tell the difference between **artificial intelligence** and **machine learning**
- understand machine learning as **learning a function from data**
- identify the three main types of machine learning

Start with a question

Think first

What do you think **artificial intelligence** means?

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Discussion prompt

Can a machine be “smart” without learning from data?

What is artificial intelligence?

Idea

Artificial intelligence is a broad term for systems that do tasks we usually think of as requiring human intelligence.

- recognizing patterns
- making decisions
- solving problems
- following rules

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Important point

AI can exist **without learning**.

A rule-based system

A system can behave intelligently by following fixed rules written by a human.

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IF temperature $> 30^{\circ}\text{C}$ \rightarrow turn on fan

- no training data needed
- no learning from experience
- the rules are chosen by a person

What is machine learning?

Idea

Machine learning is a way of making computers learn patterns from data.

Main idea

Instead of writing every rule by hand, we let the computer find patterns from examples.

input \rightarrow function \rightarrow output

Key phrase

Machine learning often means **learning a function from data**.

Machine learning as a function

Mathematical view

A machine learning model tries to approximate a relationship like this:

$$f(x) \approx y$$

- x = input
- y = output or answer
- f = the learned model

Example

Input: hours studied → Output: exam score

AI and ML: how do they relate?

Artificial Intelligence	Machine Learning
A broad field	A part of AI
Can use rules or learning	Uses data to learn patterns
May not learn at all	Learns from examples

Essentially

AI is the big umbrella. **ML** is one important part under it.

Exercise 1: AI or ML?

Classify each example

Is it mainly **AI**, **ML**, or **both**?

- 1 A program that turns on a fan when temperature is above 30°C
- 2 A model trained on examples of spam emails
- 3 A chess engine that uses fixed rules only
- 4 A system that learns to recommend videos from user data

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Check your thinking

Which examples are using data to learn? Which are just following rules?

Three types of machine learning

The main branches

- **Supervised learning**
- **Unsupervised learning**
- **Reinforcement learning**

One-sentence summary

- Supervised learning: learn from labelled examples
- Unsupervised learning: find patterns in unlabelled data
- Reinforcement learning: learn by trying actions and receiving rewards

Data looks like this

(x, y)

- the input x is given
- the correct answer y is also given
- the model learns to map inputs to outputs

Example

Predicting house prices from house size, or exam scores from study time

Data looks like this

(x)

- only inputs are given
- there are no labels or answers
- the model looks for structure or groups

Example

Grouping students by similar preferences, or finding clusters in customer data

Learning by trial and reward

An agent takes actions, receives feedback, and improves over time.

- good actions get rewards
- bad actions get no reward or a penalty
- the model learns by interacting with an environment

Example

A game-playing agent learning by winning points

Quick comparison

Type	Data	Goal	Example
Supervised	(x, y)	Predict answers	House prices
Unsupervised	(x)	Find patterns	Clustering
Reinforcement	actions + reward	Learn best action	Games

Exercise 2: Which type of learning?

Match each situation to a learning type

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Exercise 2: Which type of learning?

Match each situation to a learning type

- 1 You are given many photos with the correct animal name for each photo.
- 2 You are given a list of customers and asked to find groups with similar shopping habits.
- 3 A robot learns to move by trying actions and getting rewards.

Choices

Supervised learning ■ Unsupervised learning ■ Reinforcement learning

Vector

Vector

A vector is a list of numbers:

$$\mathbf{x} = [2, 5, 1, 5, 6, 1]$$

Some maths

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Sum

$$\sum_{i=1}^5 i = 1 + 2 + 3 + 4 + 5$$

Some maths

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Sum

$$\sum_{i=1}^5 i = 1 + 2 + 3 + 4 + 5$$

Quick exercise

Work out:

$$\sum_{i=1}^5 2i \quad \text{and} \quad \sum_{i=1}^5 i^2$$

Think a little deeper

For each example below, decide whether it is:

- rule-based AI
 - machine learning
 - not enough information yet
-
- A calculator that follows fixed rules
 - A photo app that recognizes faces after training
 - A chatbot that answers by using a large set of learned patterns

What we learned today

- AI is the broad idea of machines doing intelligent tasks
- ML is a part of AI that learns from data
- ML is often described as learning a function: $f(x) \approx y$
- The three main types are supervised, unsupervised, and reinforcement learning

Next lesson

We will look at supervised learning in more detail.