Machine learning

International Baccalaureate · IB Diploma · Computer Science · SL

Scope and prerequisites

This handout teaches Theme A4, Machine learning, for the course first assessed in 2027: what machine learning is, its main types, how models are judged, and its ethical issues.

Prerequisites: reading a scatter graph and a percentage. The datasets here are small and fictional.

What is machine learning?

■ A program that learns from examples

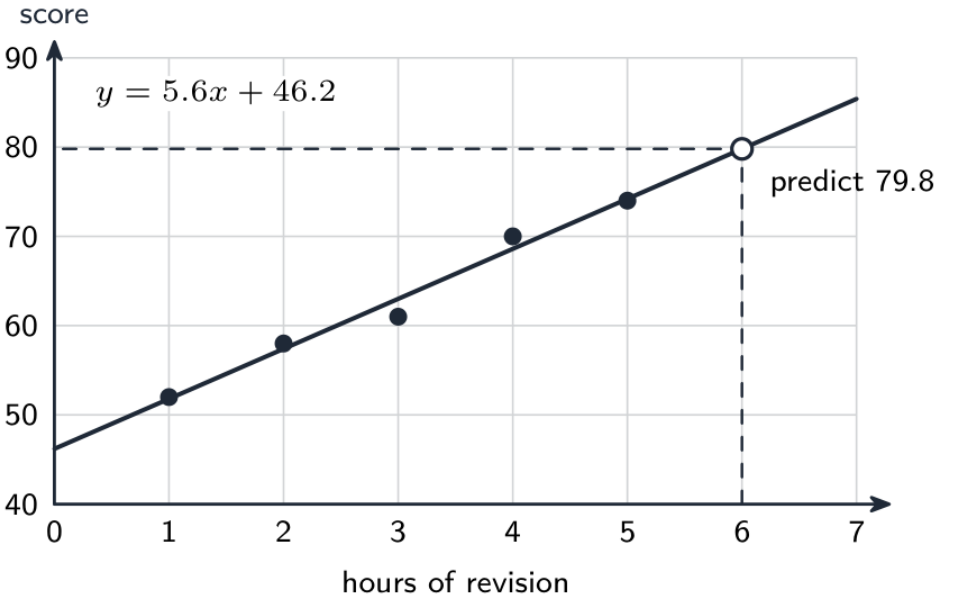
A spam filter is not given a list of rules such as "block any e-mail containing 'prize'". Instead it is shown thousands of e-mails labelled "spam" or "not spam" and finds the patterns itself. When spammers change their wording, it is retrained on new examples. This is **machine learning** (ML): a program improves at a task by learning patterns from data rather than following rules written by a programmer.

ML is one part of **artificial intelligence** (AI), the wider field of making computers do tasks that seem to need human intelligence. **Deep learning** is a kind of ML that uses neural networks with many layers.

■ Types of machine learning

Type	Learns from	Typical task	Example
supervised learning	labelled data: inputs with the right answers	classify, predict a number	spam or not; a house price
unsupervised learning	unlabelled data	find groups or patterns	grouping shoppers by habits
reinforcement learning	rewards and penalties from trial and error	choose actions	a robot learning to walk; a game player

Supervised learning splits into **classification** (the answer is a category: cat or dog) and **regression** (the answer is a number: a score or a price).



Supervised learning: the model learns a line from labelled examples, then predicts a new case

Training and testing

1. Collect and label data.
2. Split it: most for **training** the model, the rest held back as **test data**.
3. Train the model on the training data.
4. Measure it on the test data, which it has never seen.

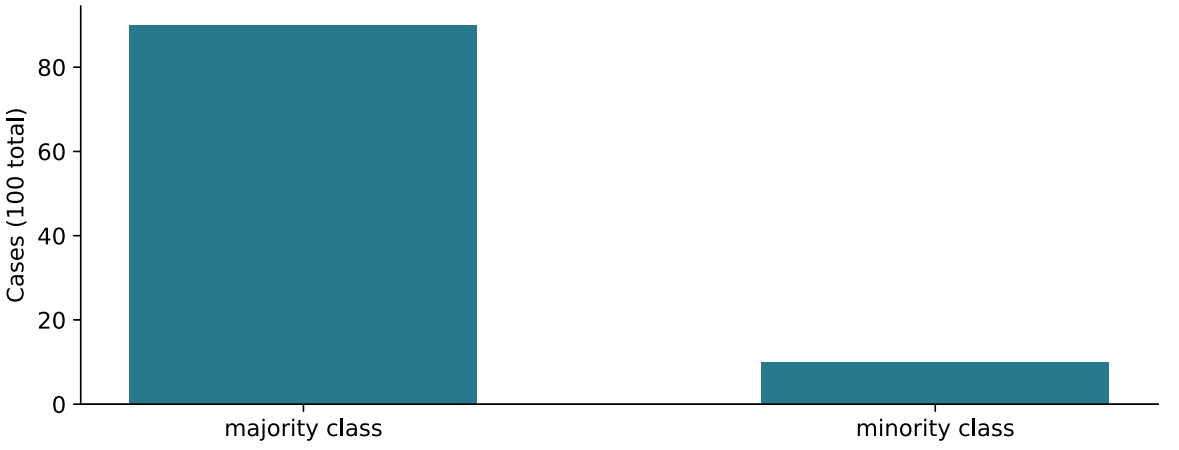
Testing on unseen data shows whether the model has learned the general pattern. A model that memorises its training data but fails on new data is **overfitting**. A model too simple to capture the pattern is **underfitting**.

Measuring a classifier

Accuracy is the share of predictions that are correct:

$$\text{accuracy} = \frac{\text{correct predictions}}{\text{total predictions}} \times 100\%$$

A model correct on 90 of 100 test cases has 90% accuracy. Accuracy can mislead when the classes are unbalanced:



With 90 of 100 cases in one class, always predicting that class scores 90% yet misses every minority case

A "model" that always answers "healthy" for a disease affecting 10% of patients scores 90% and finds no one who is ill. So check how the model does on each class, not just overall.

■ Hardware for machine learning

Training repeats the same arithmetic on huge amounts of data, so it runs on **GPUs** and special chips with thousands of cores working in parallel, often rented in the cloud. Using a trained model (**inference**) needs far less power and can run on a phone.

Ethics of machine learning

■ **Who is affected?**

Issue	What can go wrong	Example
bias	training data under-represents a group, so the model works worse for them	face recognition less accurate for darker skin
privacy	personal data collected or used without consent	photos scraped from social media
transparency	no one can explain why the model decided	a loan refused with no reason given
accountability	unclear who is responsible for a harmful decision	a self-driving car accident
jobs	tasks automated	checkout staff, translators
misuse	realistic fake images, audio or text	deepfakes spread as news

Ways to reduce harm: train on data that represents everyone the model affects; test accuracy separately for each group; keep a human in the loop for serious decisions; collect data with consent and remove what is not needed; explain decisions to the people affected.

Practice

1. Define machine learning, and explain how it differs from a program with written rules.
2. State the type of ML for each: (a) grouping songs by similarity with no labels; (b) predicting tomorrow's temperature from past records; (c) a program learning to play chess by playing itself.
3. State whether each is classification or regression: (a) a house price; (b) whether a photo shows a cat.
4. Explain why a model is tested on data it was not trained on.
5. A model makes 72 correct predictions out of 80. Calculate its accuracy.
6. A model for a rare disease (2% of patients) has 98% accuracy. Explain why this may be useless.
7. Explain **two** ethical issues of using ML to shortlist job applicants, and suggest a way to reduce each.

Answers.

1. ML is a program that improves at a task by learning patterns from data. A rule-based program follows rules a programmer wrote; an ML model finds its own rules from examples.

2. (a) unsupervised; (b) supervised (regression); (c) reinforcement.
3. (a) regression; (b) classification.
4. To check that it has learned the general pattern rather than memorised the training examples (overfitting); unseen data shows how it will work in real use.
5. $\frac{72}{80} \times 100\% = 90\%$.
6. Always predicting "healthy" would also score 98% while finding no sick patients; the model must be judged on how many real cases it finds.
7. E.g. bias: past hiring data may favour one group, so the model repeats it; train on balanced data and test results for each group. Transparency: applicants cannot learn why they were rejected; use an explainable model and keep a human reviewer.
8. Using information that would not be available when the prediction is made, so test results are falsely good; e.g. predicting who will fail a course using their final exam mark.
9. $5.6 \times 3.5 + 46.2 = 19.6 + 46.2 = 65.8$.
10. $k = 1$: the nearest point is B, so **B**; $k = 3$: two A and one B, so **A**.
11. Accuracy $= \frac{30 + 140}{200} = 0.85$; precision $= \frac{30}{40} = 0.75$; recall $= \frac{30}{50} = 0.60$.

Exam tips

- Name the type of learning from the data: labels → supervised; no labels → unsupervised; rewards → reinforcement.
- Say **why** test data is kept separate: to measure performance on unseen data and detect overfitting.
- Do not trust accuracy alone with unbalanced classes; mention per-class results.
- Ethics answers: name the issue, explain the harm **in the scenario**, then give a specific way to reduce it.