Week 1 - Introduction to Artificial Intelligence

Understanding the role of machine learning

UdeM AI — Université de Montréal

What is Artificial Intelligence?

Artificial intelligence (AI) refers to methods aimed at building systems capable of:

- perceiving their environment (data, signals),
- making decisions or producing predictions,
- accomplishing a defined task.

AI is a broad goal, not a single technique.

Where does machine learning fit?

Machine learning (ML) is a central approach within AI.

Key idea:

- we don't explicitly hard-code the rules,
- the system learns from examples.

ML is especially useful when:

- the rules are complex,
- data is abundant,
- the phenomenon is not well understood.

How do we view an ML problem?

An ML problem often starts with:

- observations (images, text, measurements),
- associated outcomes (labels, values, decisions).

We assume there is a relationship between the two, even if we do not know it explicitly.

Learning means trying to capture that relationship.

Core idea: learning a relationship

Informally, ML tries to learn a rule of the form:

$$\text{input} \longrightarrow \text{output}.$$

This rule is not given in advance:

- it is inferred from data,
- it depends on the assumptions we make.

ML is therefore a problem of **approximation**.

Choosing a form for the relationship

To learn, we must decide *how* the relationship is allowed to behave.

Examples of possible choices:

- simple, global relationships,
- combinations of non-linear functions,
- models that capture local structure,
- models guided by physics or domain knowledge.

This choice is an assumption about the world.

Fitting the model from data

Once the form is chosen, we fit the model so that it:

- produces outputs close to the observations,
- behaves reasonably on new data.

This step is often called **training**.

This is where numerical optimization comes in.

Why optimization is not the most important part

Finding good parameters is necessary, but it is not the main decision.

In practice:

- multiple models can fit the same data well,
- some generalize better than others,
- the model structure is decisive.

A central part of ML is **model choice**.

Putting it all together (simply)

We can summarize ML in a few steps:

- observe data,
- assume a relationship exists,
- choose how that relationship can be expressed,
- fit the model using examples.

Data informs the model, but assumptions guide learning.

Expressiveness and efficiency

Two important questions:

- **Expressiveness**: is the model flexible enough?
- **Efficiency**: can it learn with little data and few parameters?

A very flexible model can be difficult to learn reliably.

Why ML can feel abstract

ML combines several ideas at once:

- modeling,
- imperfect data,
- numerical computation,
- generalization.

It's normal if everything is not immediately clear.

Where does code come in?

Code is used to:

- implement a model,
- train that model on data,
- test ideas quickly.

Code is a tool for exploration and understanding.

Conclusion

Key takeaways:

- ML learns relationships from data,
- model choice is central,
- optimization is a means, not a goal,
- understanding comes gradually.