Ingénieur en instrumentation

« Introduction »

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Big data

« données massives »

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Understanding Artificial Intelligence:

From Machine Learning to Deep Learning

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Introduction to Artificial Intelligence (AI)

Ways that people use to think and learn about things

- When facing a problem, recall a previous situation where you successfully resolved a similar issue.
- Before taking action, consider the potential outcomes and consequences.
- If you encounter a failure, reflect on alternative approaches you could have taken.
- When observing an event, try to deduce what earlier events might have led to it.
- Upon seeing an object, consider whether it belongs to someone.
- When someone performs an action, think about the possible intentions behind their behavior.
- …

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Are machines better than Humans or vice versa ?

When we compare humans to machines, it is important to note that a machine can be a car, a smart phone, a digital television, a robot etc.

Machines are better than Humans in:

- **Alertness:**

  For instance, Industrial Facility Security Monitoring System

- **Speed and Power:**

  For instance, if the press exerts a force of 50 tons and compresses the parts at a speed of 0.5 meters per second, the power of the press is a combination of this force and this speed

- **Sensor Detection Outside Human Range:**

  For instance, IR sensors can detect objects or temperature changes at a distance that humans cannot perceive directly; Telescope detects celestial objects at incredibly vast distances, far beyond what the human eye can perceive; Radar and LiDAR …)

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- **Routine Work:**

  For instance, a fast, efficient, and consistent production process that reduces human errors and ensures products are packaged uniformly and accurately. The automation of filling, sealing, labeling, quality control, and palletizing processes not only ensures the continuity of the production flow but also maintains a high level of quality and safety for the finished products.

- **Computation:**

  For instance, high-frequency trading systems use algorithms to analyze thousands of transactions per second to optimize the buying and selling of financial assets. These systems can identify trading opportunities in real time, which is impossible for a human analyst due to the speed and volume of data.

- **Simultaneous Activities:**

  For instance, for control and regulation of complex processes such as chemical plants or power stations, automated systems can simultaneously monitor and adjust numerous critical parameters to maintain safety and efficiency. Humans cannot track and adjust as many variables at the same time without technological assistance.

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Humans are better than machines in:

- **Sensory Functions:**

  For instance, humans have a nuanced ability to taste and smell, which allows us to identify and appreciate a wide range of flavors and scents. For instance, professional chefs and sommeliers use their sense of taste and smell to distinguish between subtle differences in ingredients and wines.

- **Perceptual Abilities:**

  For instance, humans can detect and interpret subtle emotional cues, such as a slight change in someone's facial expression or tone of voice, which provides insights into their feelings or intentions. This perceptual ability is crucial in social interactions and empathy. Machines and AI, despite advances in emotion recognition, often lack the depth of understanding and nuance that humans naturally bring to interpersonal communication.

- **Flexibility:**

  For instance, if you a given a new tool or method to complete a task you have never encountered before, you can quickly adapt your approach based on your understanding and creativity. In contrast, machines and AI typically require specific programming or training for each new scenario and may struggle without clear instructions or sufficient data (and Ability to improvise)

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- **Judgment**

- **Selective Recall:**

  Humans tend to remember events and details that have emotional significance more vividly. Machines and algorithms can store and retrieve large amounts of data, but they generally lack the emotional context that helps humans prioritize and recall specific memories.

- **Inductive Reasoning:**

  For instance, humans can quickly recognize patterns and trends from limited data. For example, if you notice that every time you eat a certain food, you feel unwell, you might generalize that this food is causing your discomfort.

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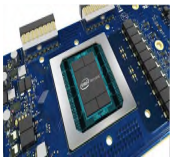
Human Intelligence vs. Artificial Intelligence

In conclusion: Machines are much better than humans in deterministic tasks involving process-oriented and quantitative reasoning skills, but humans are far better in more ambiguous cross-functional reasoning skills tasks.

- **Our hope:** The brain functions like a computer.
- **Our goal:** To create computer intelligence through programming, similar to how people gain intelligence through learning.



However, we observe that the computer does not function like the brain.

The computer executes tasks without comprehending their meaning.

Machine

Human

-- Artificial Intelligence (AI) –

The study of computer systems that attempt to model and apply the intelligence of the human mind.

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Artificial Intelligence history

Here is a brief overview, including the development of Large Language Models (LLMs) and Vision-Language Models (VLMs):

20th Century Beginnings (since 74 years ago !)

•1940s-1950s: The formal birth of AI as a field can be traced to the mid-20th century. In 1950, Alan Turing introduced the Turing Test to measure a machine's ability to exhibit intelligent behavior equivalent to a human.

•1956: The term "Artificial Intelligence" was coined by John McCarthy during the Dartmouth Conference, which is considered the founding event of AI as a field of research.

Early AI Research

•1950s-1960s: Early AI research focused on problem-solving and symbolic methods. Programs like the Logic Theorist and the General Problem Solver were developed.

•1970s: The era saw the rise of expert systems, which were designed to mimic the decision-making abilities of human experts. Notable systems include MYCIN for medical diagnosis.

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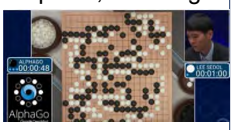
AI Winter

•**1970s-1980s**: The field experienced its first "AI winter," a period of reduced funding and interest due to unmet expectations and limited computational power.

Renewed Interest and Growth

•**1980s-1990s**: AI research gained renewed interest with the development of machine learning, neural networks, and the advent of faster computers.

•**1997**: IBM's Deep Blue defeated world chess champion Garry Kasparov, marking a significant milestone in AI.



21st Century Advances

•**2000s**: The field saw significant advances with the growth of data and the development of powerful algorithms. AI began to be applied in various domains such as finance, healthcare, and autonomous vehicles.

•**2011**: IBM's Watson won the quiz show Jeopardy!, demonstrating the power of natural language processing and information retrieval.

•**2010s**: Deep learning, a subset of machine learning involving neural networks with many layers, revolutionized AI. Notable achievements include Google's DeepMind developing AlphaGo, which defeated the world champion Go player in 2016.

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Modern AI and LLMs/VLMs

•**2020s**: The rise of Large Language Models (LLMs) like OpenAI's GPT-3 and GPT-4 has transformed natural language understanding and generation, enabling applications from chatbots to automated content creation. Vision-Language Models (VLMs) like OpenAI's CLIP and DALL-E have integrated vision and language processing, enabling sophisticated tasks like image captioning, generation, and understanding.

•**Current Applications**: AI is now embedded in everyday technology, from virtual assistants like Siri and Alexa to advanced applications in medical diagnosis, autonomous driving, and more.

•**Future Prospects**: Ongoing research focuses on achieving general AI, addressing ethical considerations, and ensuring AI benefits society while minimizing risks.

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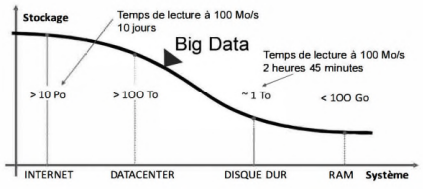
Why have we seen such significant advances in recent years ?

Growth in data volume due to changes in our habits

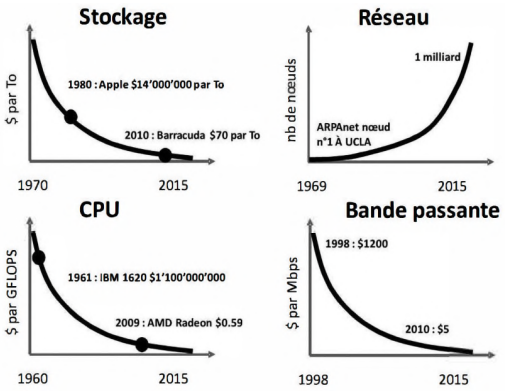
- **Expectations of our computers have changed**
- **Democratization of smartphones and tablets**
- **Proliferartion of social networks**
- **Progress driven by WEB giants** (New technologies, particularly in parallel processing; Automating the parallelization of a large class of processes; Advances in software engineering; A new class of non-relational database management systems)

Boundaries of big data :

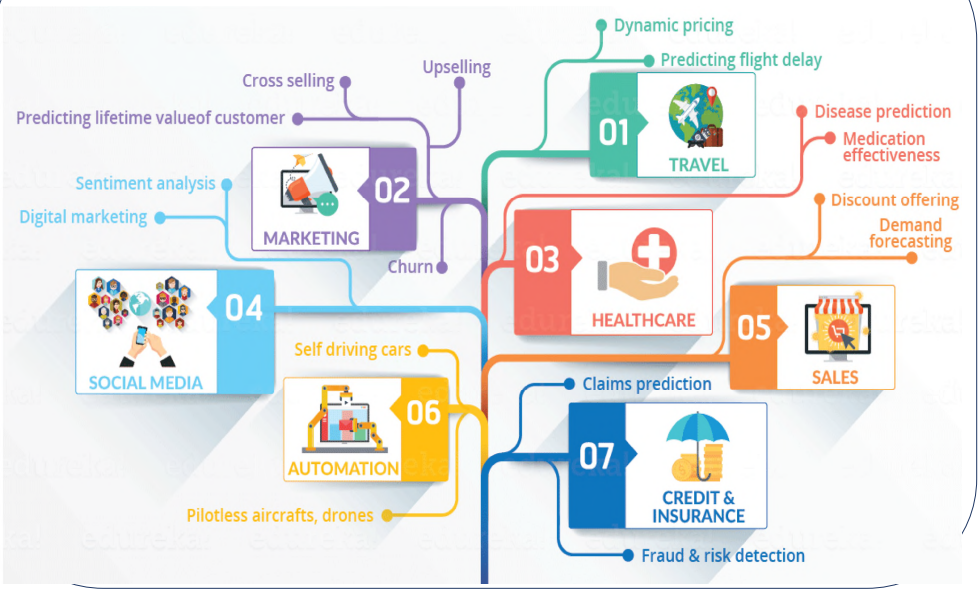


The causes of the rise of big data are both economic and technological

An exponential decrease in prices



Big data: where and why ?



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Structured data ---------- Unstructured data

- **Examples of structured data:**
  - •Database entries
  - •Transactional information
  - •Wikipedia infobox
  - •Knowledge graph
  - •Hierarchies

- **Examples of unstructured data:**
  - •Textual (mails, etc.)
  - •Images
  - •Videos
  - •Spoken language
  - •Music
  - •Sensor data

Structured data is code in a specific format, written in such a way that search engines can understand it. Search engines read the code and use it to display search results in a specific and much richer manner.

Unstructured data refers to data that is represented or stored without a predefined format, intended for human use rather than machines. This lack of format leads to irregularities and ambiguities that can make it difficult to interpret the data.

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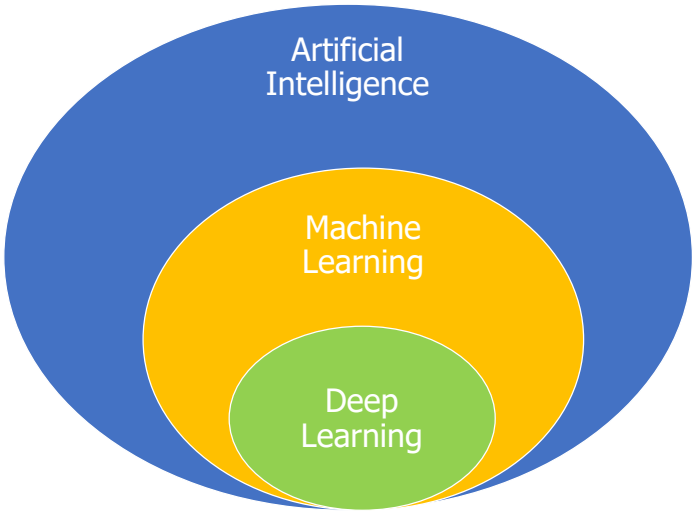
Artificial Intelligence (AI)



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What is Machine Learning ?

Machine Learning (ML) is a subset of Artificial Intelligence (AI) that enables systems to learn and improve automatically from experience without being explicitly programmed. ML involves developing algorithms that allows computer programs to access, analyze, and utilize data independently.

ML has become an essential component in both academic and industrial worlds. It provides solutions to various problems across different application domains (summarized into 5 types of questions):

1. **How much ? (Regression)**
2. **What category ? (Classification)**
3. **Which groups ? (Clustering)**
4. **Is there any anomaly ?**
5. **What action ? (Reinforcement Leraning)**

Why is ML important ?

ML is now used in a wide range of applications (for example, Facebook's news feed uses machine learning to personalize the feed for each member).

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What makes a good ML algorithm?

The main quality expected are :

- **Deployability: The algorithms should ensure scalability;**
- **Robustness: The ability to handle noisy, inconsistent, and incomplete data;**
- **Transparency: Applications that integrate ML should show improvement in ML performance as the learning process progresses;**
- **Suitability: An algorithm should not require excessive expertise for its implementation or optimization;**
- **The amount of energy or time invested in improving or optimizing an algorithm should be proportional to the benefit gained (e.g., it is unnecessary to invest a year of R&D by a hundred researchers for a 1% improvement).**

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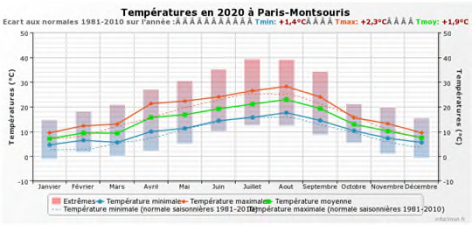
Examples of use cases

How many ? « Regression »

- **What will the temperature be on Monday, July 29, 2024, in Kuala Lumpur?**



- **Is this sales lead promising?**
- **How many Twitter followers will I have by the end of the year?**
- **How tall will this child as an adult?**

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■ What are the incomes of the individus?

Age	Postal code	Annual income
20	94100	10 Keurso
30	92110	30 Keuros
35	94300	35 Keuros
40	93430	35 Keuros
50	91200	45 Keuros
60	94310	50 Keurso

« Training data (dataset) »

Age	Postal code	Annual income
25	93100	?
28	94110	?
39	91300	?
48	94430	?
54	92200	?
58	93130	?

« Test data »

In a supervised ML system, a computer learns from examples that are provided to it (training data).

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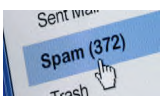
What category? « Classification »

■ Artificial vision : Is this a photo of a cat or a dog?

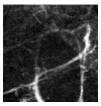
■ Reading the postal code on the envelope: Which digit is it referring to?

MNIST

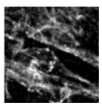
■ Filtering unwanted emails: Is this message an email spam or not?



■ Medical diagnostic assistance (lung imaging): Are the alveoscopic images healthy or pathological?



Healthy



Pathological

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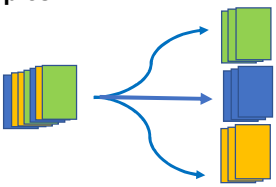
Which groups ? « Clustering »

- Personalized marketing and customer segmentation

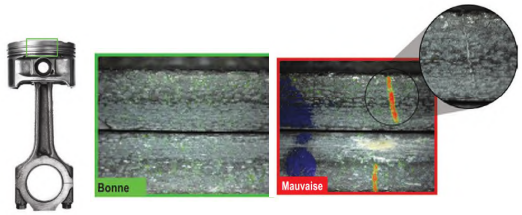
- How to group these documents by topics?



- Image Semantic Segmentation

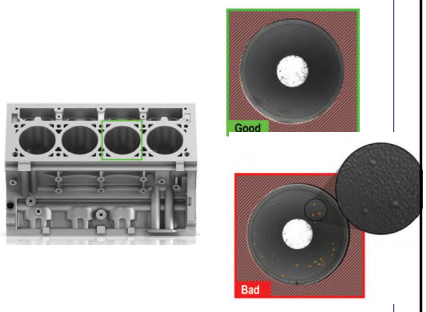
Is there an anomaly?

- Automatic cylinder inspection (automotive engine): Detection and segmentation of scratches



- Does this sensor display an abnormally high value?
- Does this credit card transaction seem fraudulent?
- Is someone trying to hack my system?

- Automatic cylinder inspection (automotive engine): Detection of pores



- Is the information detected on social media false.

Which action should be taken in reinforcement learning?

- Should I accelerate or stop at this yellow light?

- Should I continue vacuuming or return to my charging station?

- Should I increase or decrease the temperature?

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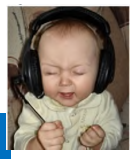

Machine Learning

- **Supervised Learning**
  - Regression
  - Classification
- **Reinforcement Learning**
- **Unsupervised Learning**
  - Anomaly detection
  - Clustering
  - Dimensionality Reduction

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Basic Concepts

Why datasets ?

- Provide standardized image datasets for specific tasks
- Offer a common set of tools for accessing datasets and annotations
- Enable the evaluation and comparison of different methods
- Organize challenges evaluating performance using different models

MNIST

Handwritten digits for pattern recognition

60 000 training samples (32-by-32 images)
10 000 test samples of size-normalized
https://yann.lecun.com/exdb/mnist/

SVHN

From house numbers in Google Street View images for pattern recognition

73 257 digits for training, 26 032 digits for testing, and 531 131 additional (32-by-32 images)
http://ufldl.stanford.edu/housenumbers/

Yann Lecun
Chief AI Scientist, Meta

MS COCO

Microsoft Common Objects in Context

Large-scale object detection, segmentation, key-point detection, and captioning dataset

https://paperswithcode.com/dataset/coco

LVIS

Dataset for Large Vocabulary Instance Segmentation

https://paperswithcode.com/dataset/lvis

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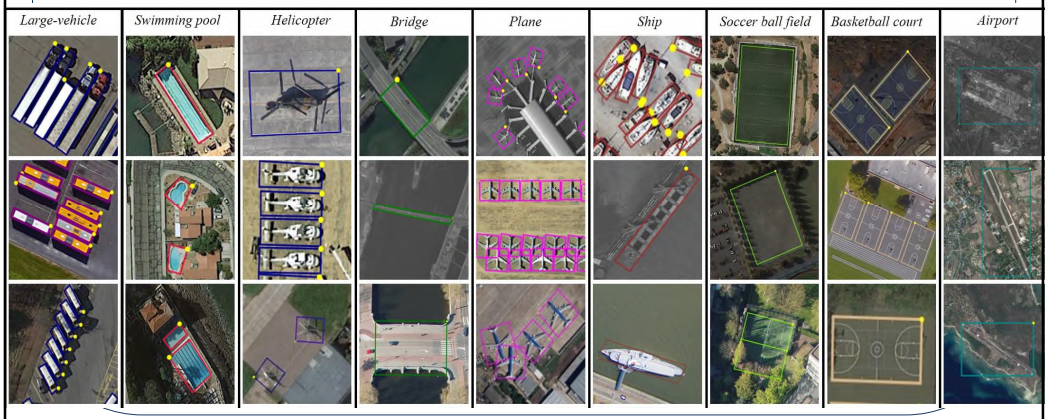
Exemples of Annotated Images

DOTA dataset

Object Detection on Aerial Images

https://captain-whu.github.io/DOTA/index.html



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Exemples of Annotated Images

DOTA dataset

Object Detection on Aerial Images

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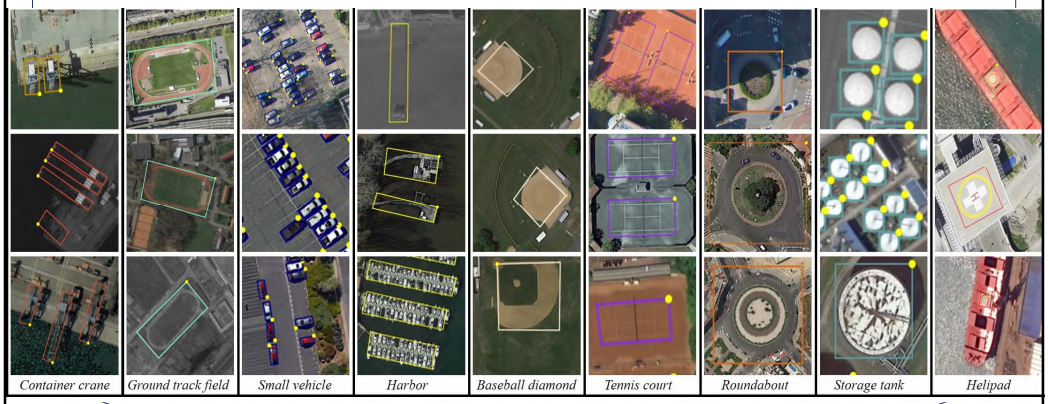

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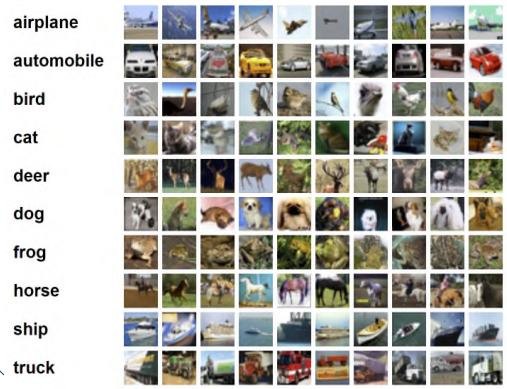
Exemples of Annotated Images

CIFAR-10 dataset

Image Classification

https://www.cs.toronto.edu/~kriz/cifar.html



CIFAR-10 consists of 60 000, 32x32 colour images

10 classes, with 6000 images per class

Split:
50 000 training images
10 000 test images.

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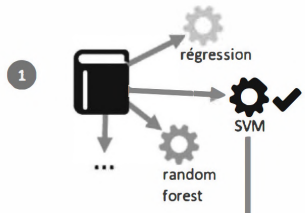
Supervised Learning

Learning from labeled data

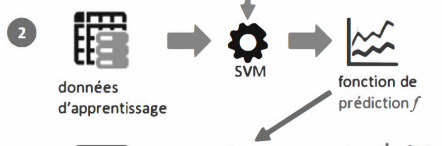
Steps for learning:

Choice of a ML model



Selecting an ML algorithm from a ML library

Training dataset



Training the selected algorithm on the data produces a prediction function

New data (unseen)

Prediction for a new observation

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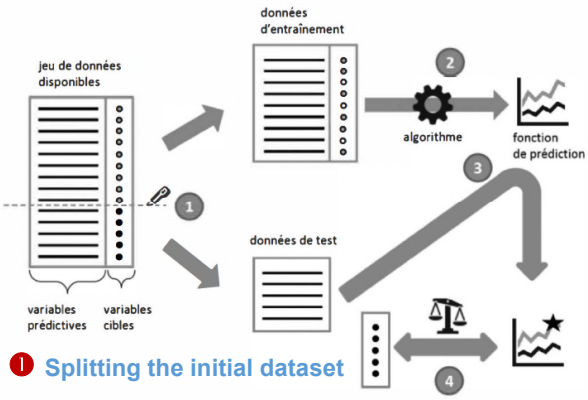
Splitting the dataset



❷ Training the algorithm with the training data to produce a prediction function

❸ Evaluating the prediction function on the test data to obtain predictions

❶ Splitting the initial dataset into two subsets (training and test)

❹ Comparing the predictions to the target values of the test data

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