Artificial Intelligence: past, present, future(s)

Baptiste Pesquet

A brief history of AI

A recent discipline

Kickoff: 1956 Dartmouth workshop on Artificial Intelligence.

> "AI is the science and engineering of making intelligent machines." (John McCarthy)

> "AI is the science of making machines do things that would require intelligence if done by men." (Marvin Minsky)



Image credits: the Marvin Minsky family

High ambitions

> "Every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it." (Dartmouth workshop proposal, 1956)

> "Machines will be capable, within twenty years, of doing any work a man can do." (Herbert Simon, 1965)

> "In from three to eight years we will have a machine with the general intelligence of an average human being." (Marvin Minsky, 1970)

What is intelligence, by the way?

Controversial definition, varying in what its abilities are and whether or not it is quantifiable [Legg and Hutter, 2007].

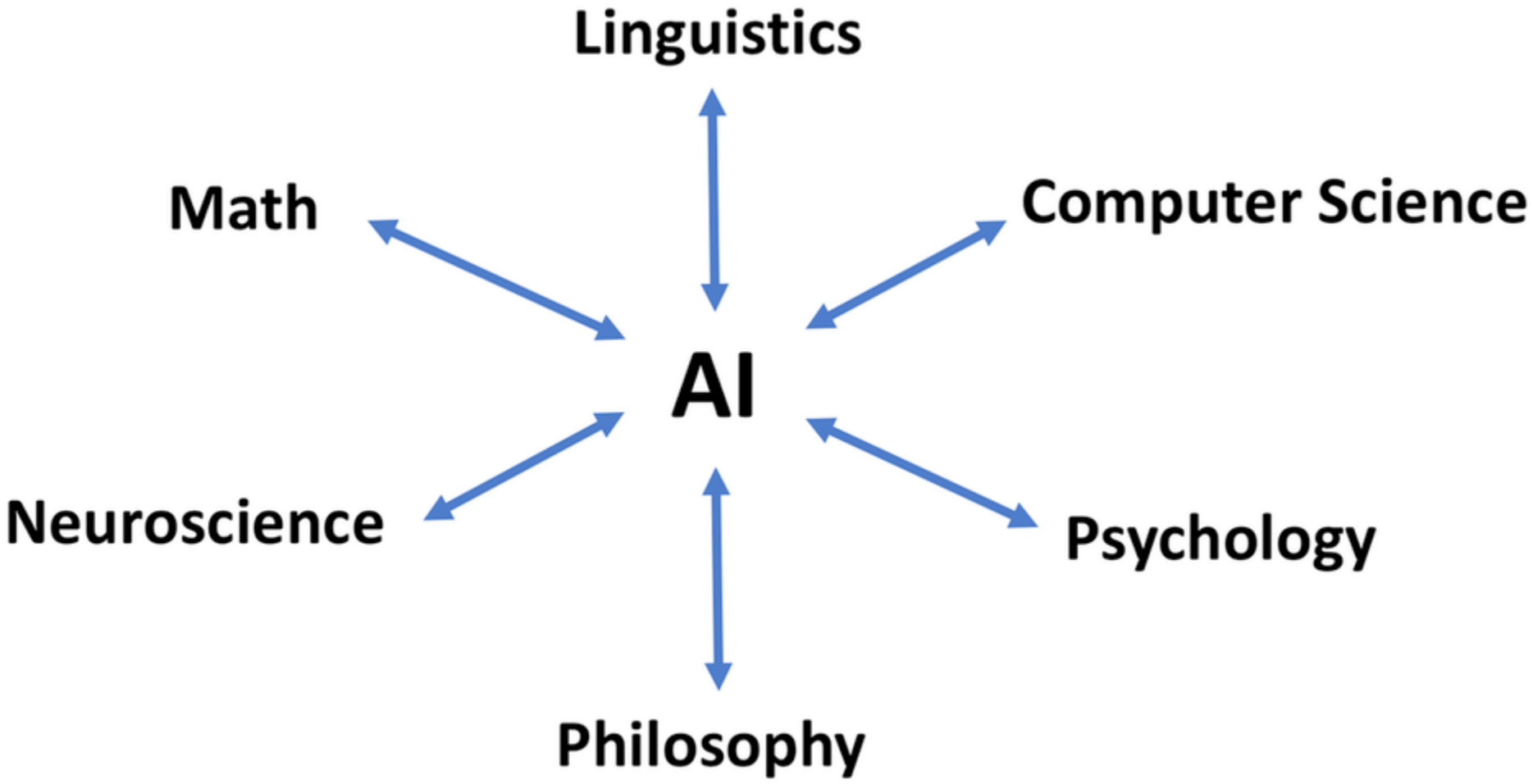
> "Intelligence is the ability to perceive or infer information; and to retain it as knowledge to be applied to adaptive behaviors within an environment or context [Radha R. Sharma, 2008]."

> "Intelligence is what you use when you don't know what to do." (Jean Piaget)

The AI landscape

- Main fields of research:
  - **Problem solving** (e.g. search algorithms, constraint solving).
  - **Reasoning** and **decision making** (e.g. logic, knowledge representation).
  - **Machine Learning** (e.g. systems that improve with experience).
  - **Real-world interactions** (e.g. computer vision, natural language understanding).
- Either purely **software**-based, or embedded in **hardware** devices.

A highly interdisciplinary field



A tumultuous history

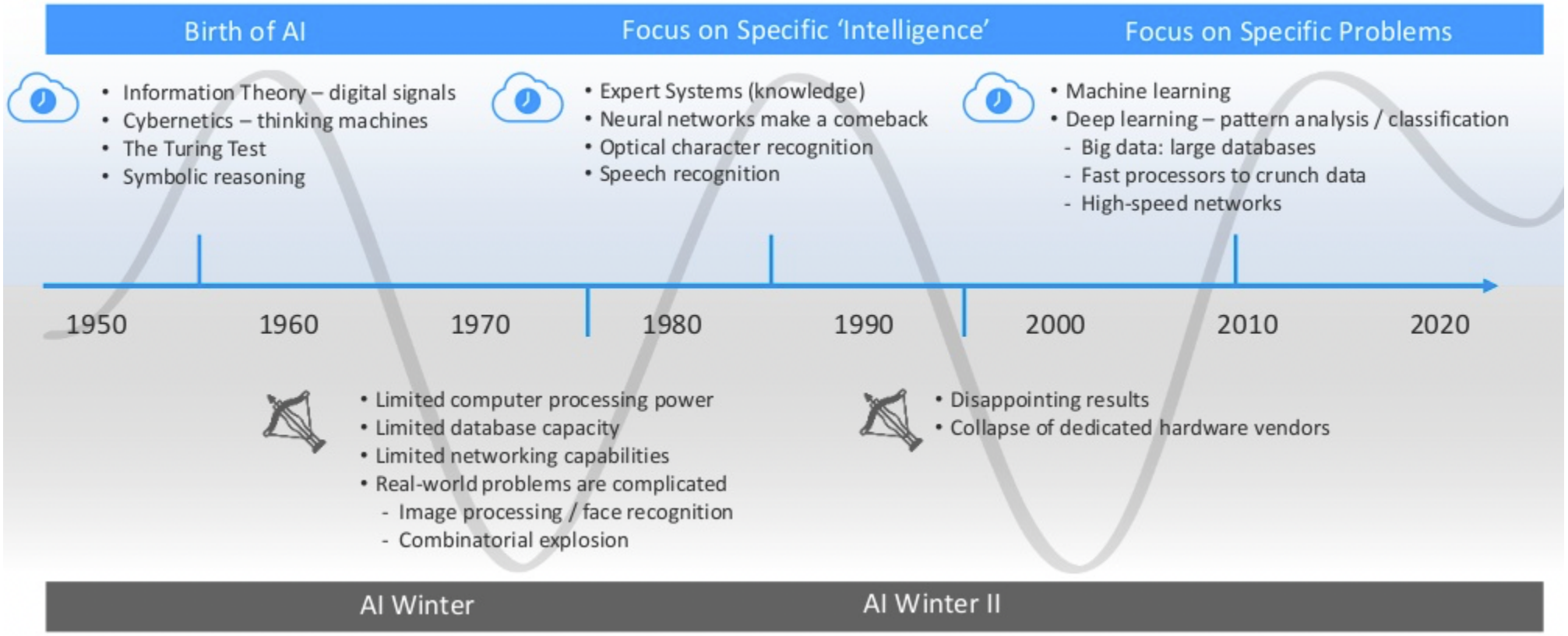


Image credits: David Lavenda

Two competing approaches

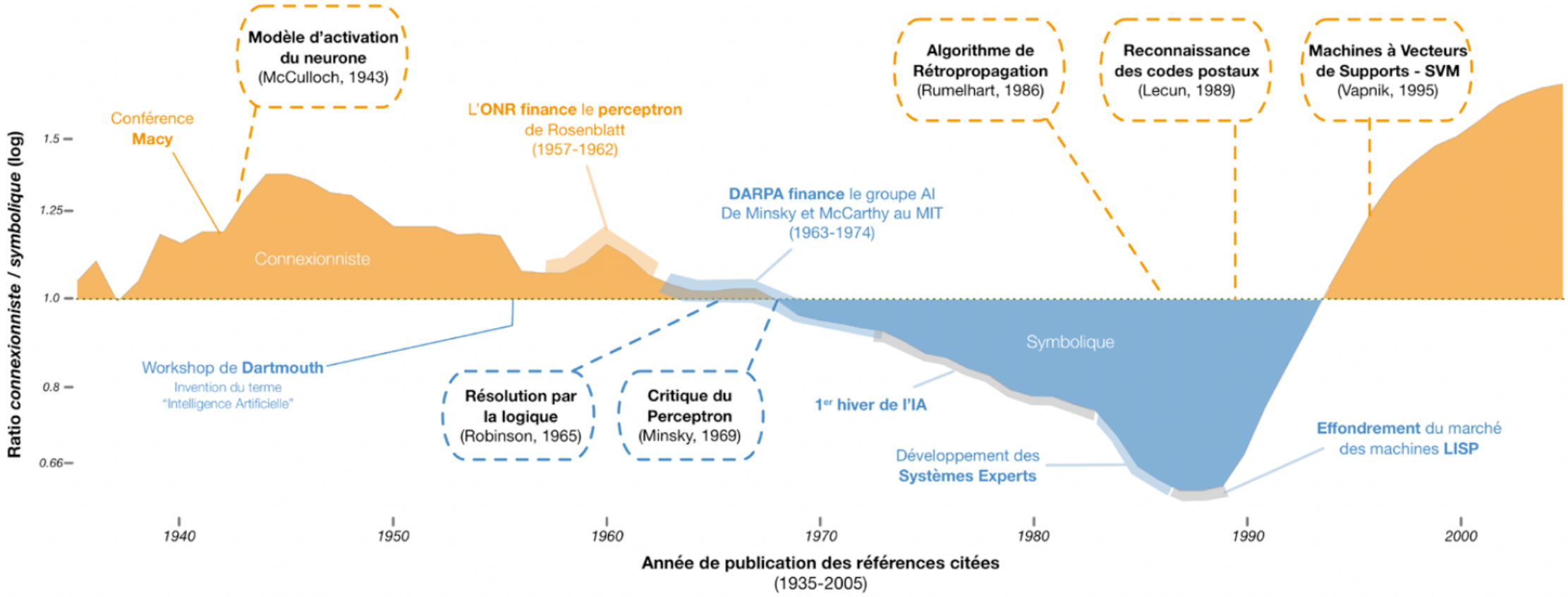


Image credits: [Cardon et al., 2018]

How to define AI?

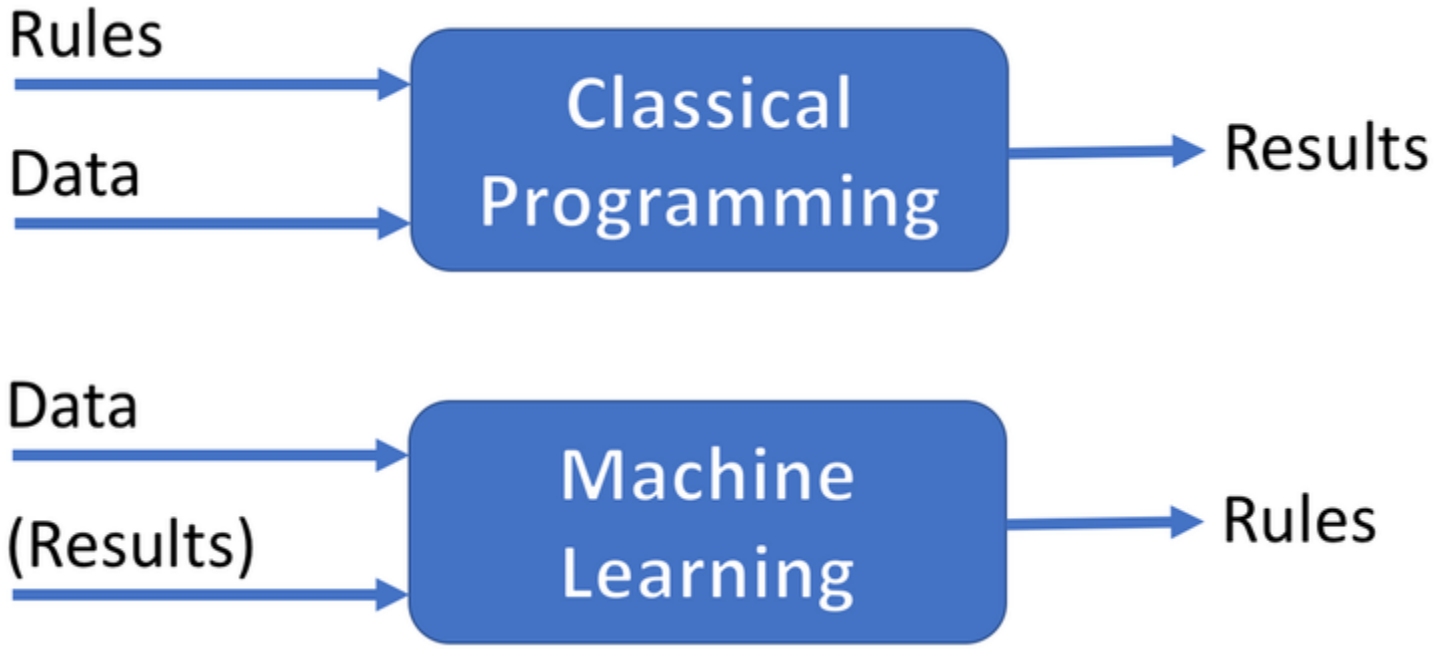
> "AI is an **interdisciplinary** field aiming at **understanding** and **imitating** the mechanisms of **cognition** and **reasoning**, in order to **assist** or **substitute** humans in their activities." (Commission d'enrichissement de la langue française, 2018)

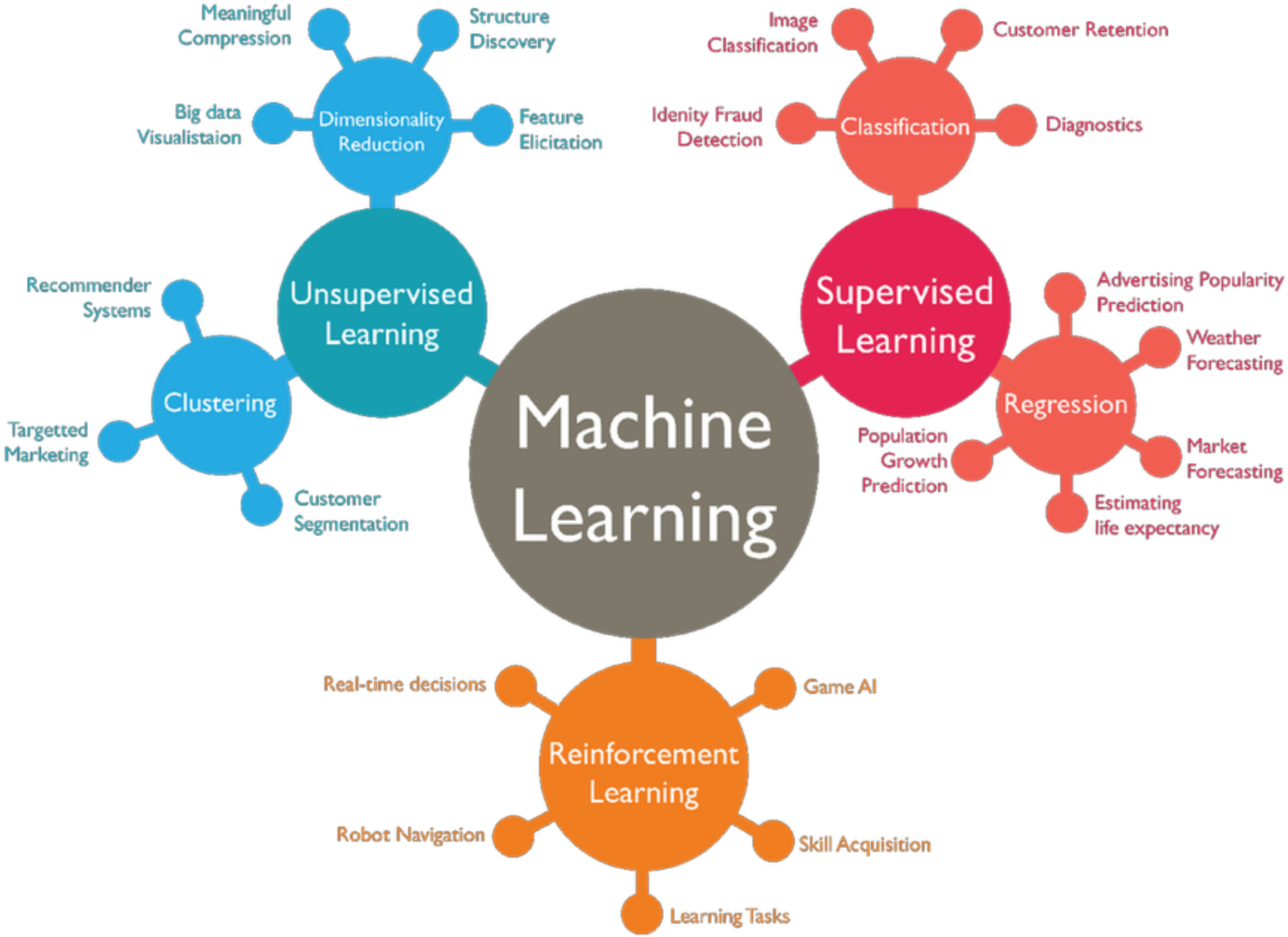
> "AI is whatever hasn't been done yet." (Larry Tesler)

AI's booming present

Machine Learning: a new paradigm

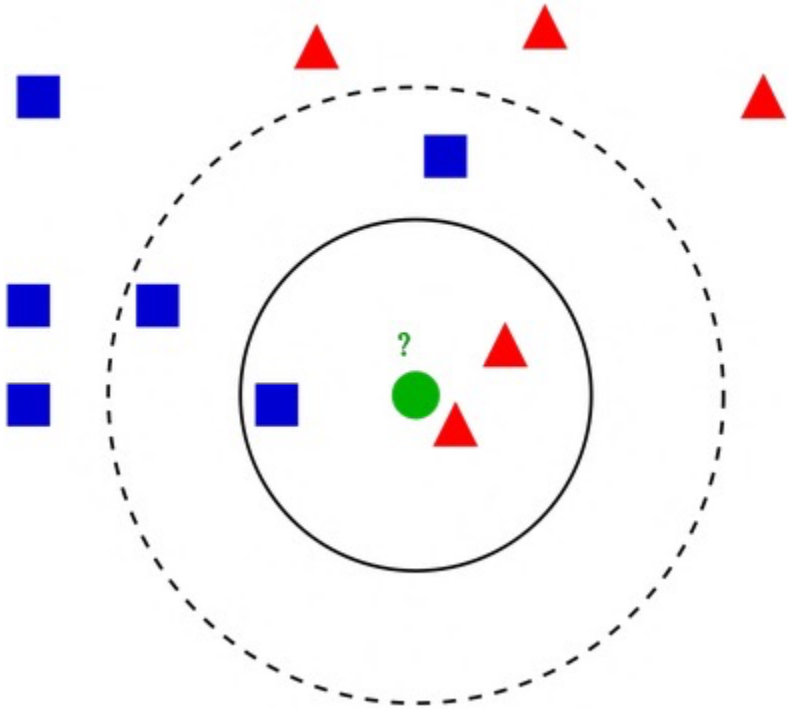
> "The field of study that gives computers the ability to learn without being explicitly programmed." (Arthur Samuel, 1959).




Machine Learning
Unsupervised Learning
Dimensionality Reduction
Meaningful Compression
Structure Discovery
Big data Visualistaion
Feature Elicitation
Clustering
Recommender Systems
Targetted Marketing
Customer Segmentation
Supervised Learning
Classification
Image Classification
Customer Retention
Idenity Fraud Detection
Diagnostics
Regression
Advertising Popularity Prediction
Weather Forecasting
Population Growth Prediction
Market Forecasting
Estimating life expectancy
Reinforcement Learning
Real-time decisions
Game AI
Robot Navigation
Skill Acquisition
Learning Tasks

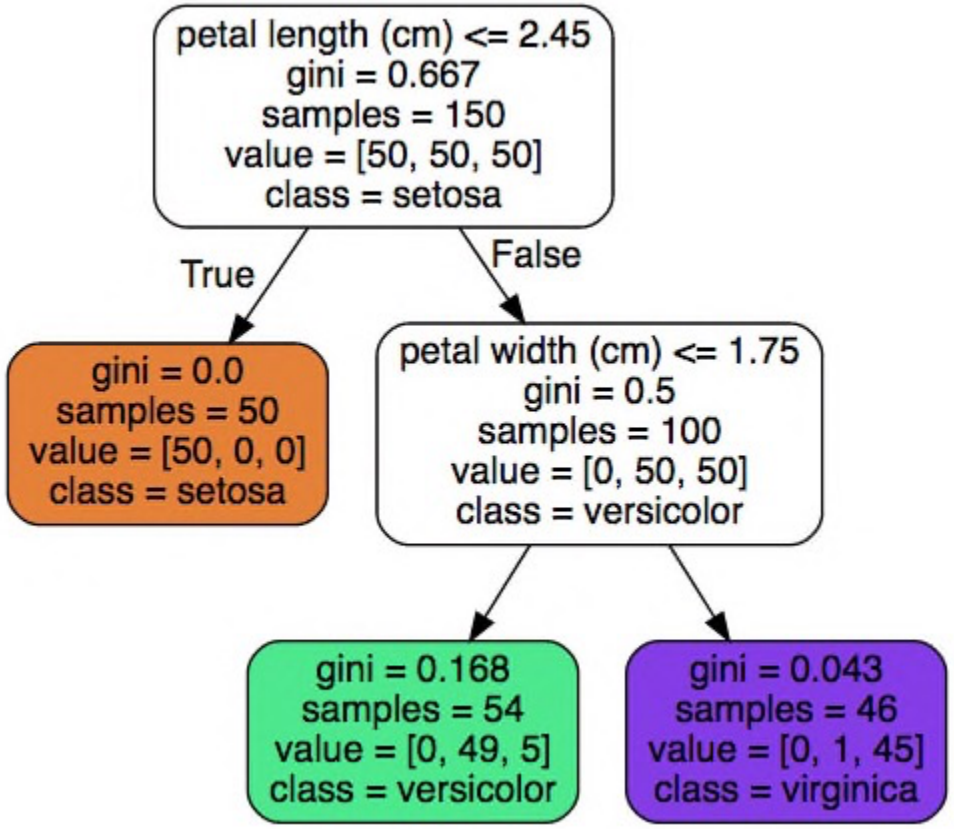
Algorithm #1: K-Nearest Neighbors

Prediction is based on the k nearest neighbors of a data sample.



Algorithm #2: Decision Trees

Build a **tree-like structure** based on a series of learned questions on the data.



Algorithm #3: Artificial Neural Networks

Layers of **loosely neuron-inspired computation units** that can approximate any continuous function.

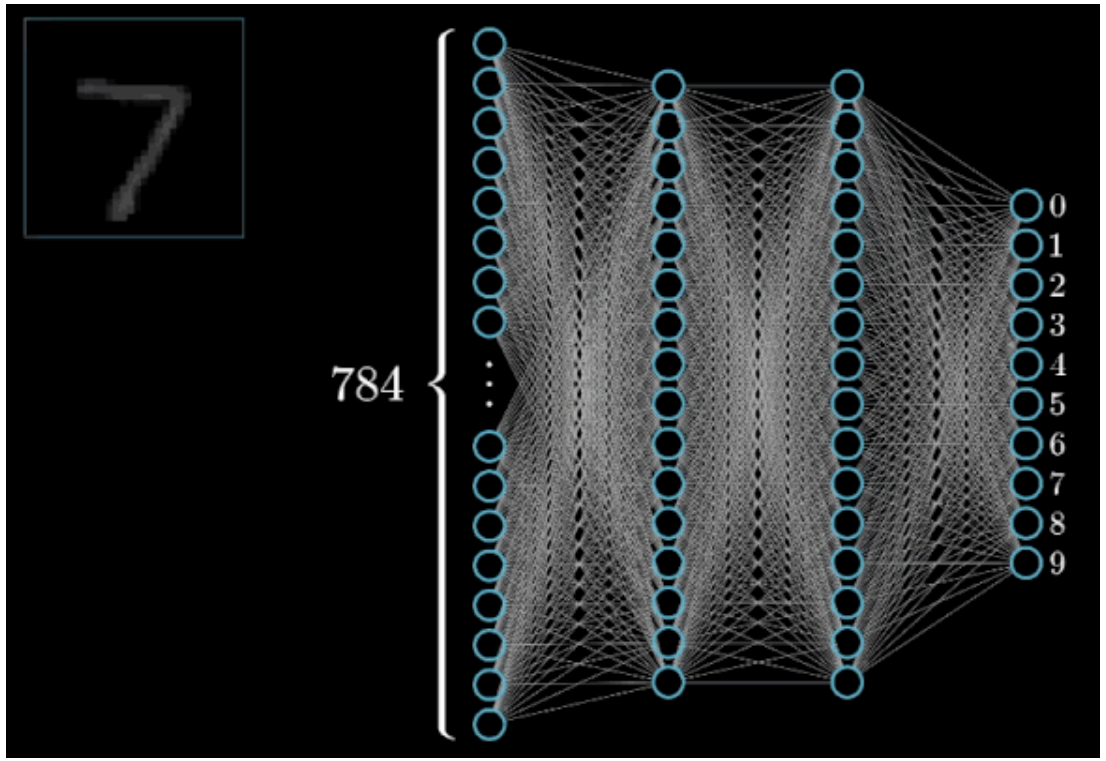


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The Deep Learning tsunami

Subfield of Machine Learning consisting of **multilayered neural networks** trained on vast amounts of **data**.

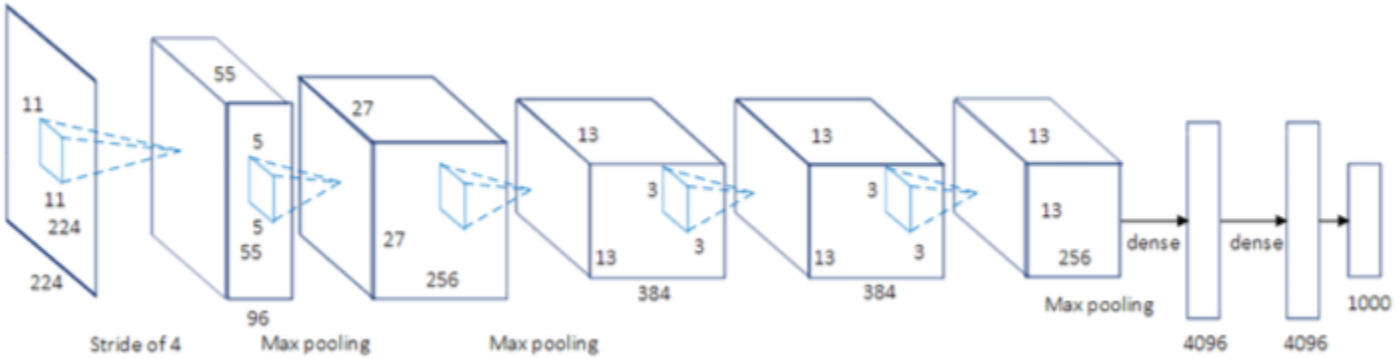


Image credits: [Krizhevsky et al., 2012]

In a decade, outperformed previous SOTA approaches in many fields (computer vision, language processing, and much more).

From labs to everyday life in 25 years

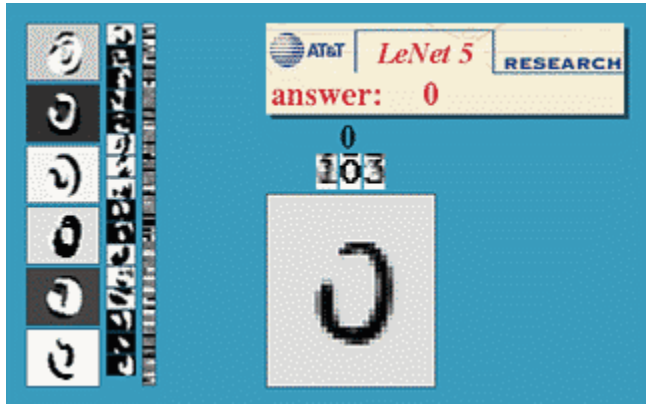


Image credits: *Yann LeCun*



Image credits: *Matthew Brennan*

Reasons for success



Image credits: DeepMind

Case study: Large Language Models



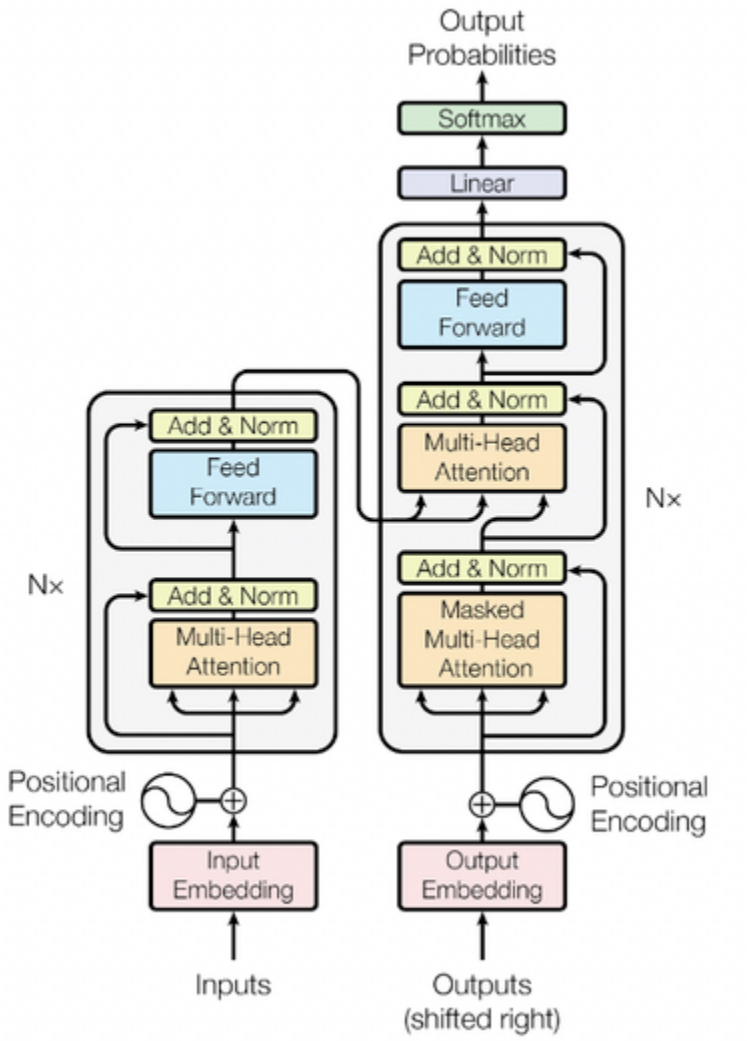
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- **Model**: a function f defining the relationship between inputs (data) and outputs (results).

$$f(inputs) = outputs$$

- LLM: a (very) large model designed for language processing tasks.
- Kickoff: ChatGPT, November 2022.

T for *Transformer*...



- Neural network architecture designed to handle **sequential data**.
- Cheaper to train and easier to parallelize than previous approaches.

Image credits: [Vaswani et al., 2017]

G for *Generative*...

- The next word is predicted via an **attention**-powered statistical analysis of the other words.
- This process can be repeated to produce entire texts.



Image credits: Welch Labs



Image credits: Peyo

P for *Pretrained*

- Models like ChatGPT contain **billions** of internal parameters.
- They are trained on humongous amounts of data (whole parts of the Internet).
- These processes have **huge energy costs**.



Image credits: Getty

The uncertain future(s) of AI

AI's growing impact on individuals and society

AI has more and more social and societal implications:

- Job market transformation.
- Human/machine interactions.
- Trust and acceptability.
- Legal aspects and regulation (AI hallucination cases).
- Fairness.
- Ethics.
- Privacy and usage of personal data.
- ...

Which AI will prevail?

- **Substitutive intelligence**: replacement of men by machines.
- **Augmented intelligence**: human-centered AI for performance augmentation & autonomy enhancement.
- **Hybrid intelligence**: human-machine collaboration on complex tasks.

The AGI debate

- AGI = **Artificial General Intelligence**
  - The ability to perform any task as well as a human.
- Related concept: **strong AI** (intentionality and consciousness).
- Are recent models *sparks of AGI* [Bubeck et al., 2023] or merely *stochastic parrots* [Bender et al., 2021]?

The technological singularity

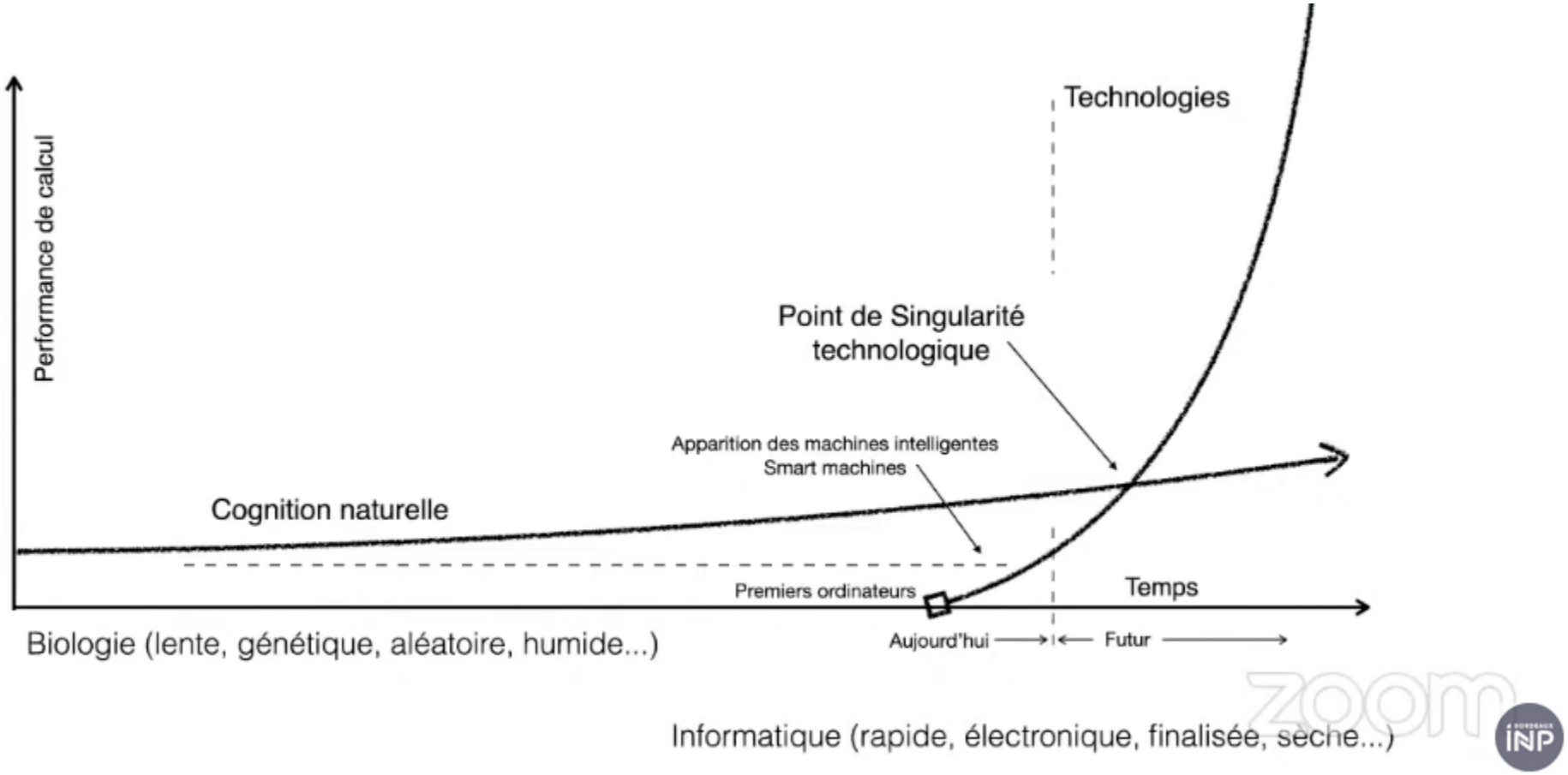


Image credits: *Bernard Claverie*

The Chinese room argument

Is showing intelligent behavior the same as being intelligent? [Searle, 1980s]

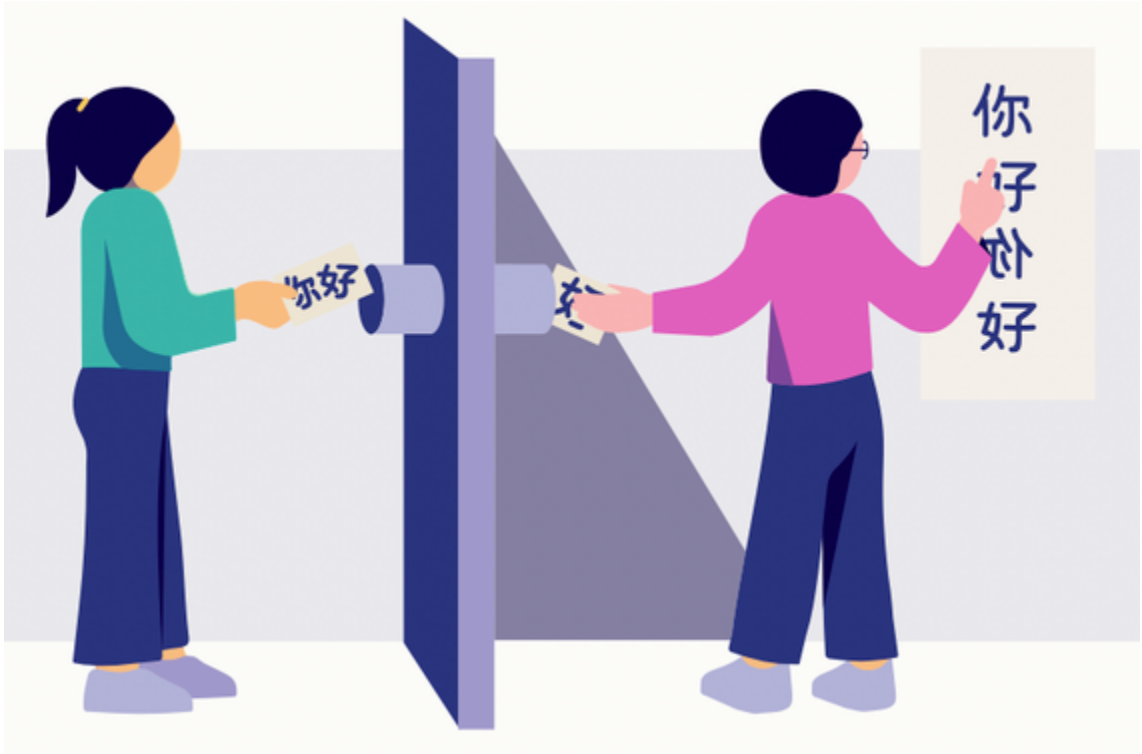


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The human brain: a masterpiece of evolution

- Approx. **86 billion neurons** in 1.4 kg.
- Typical energy consumption: *20 W (!)*
- So much of it is still unknown.



Babies are outstanding learners

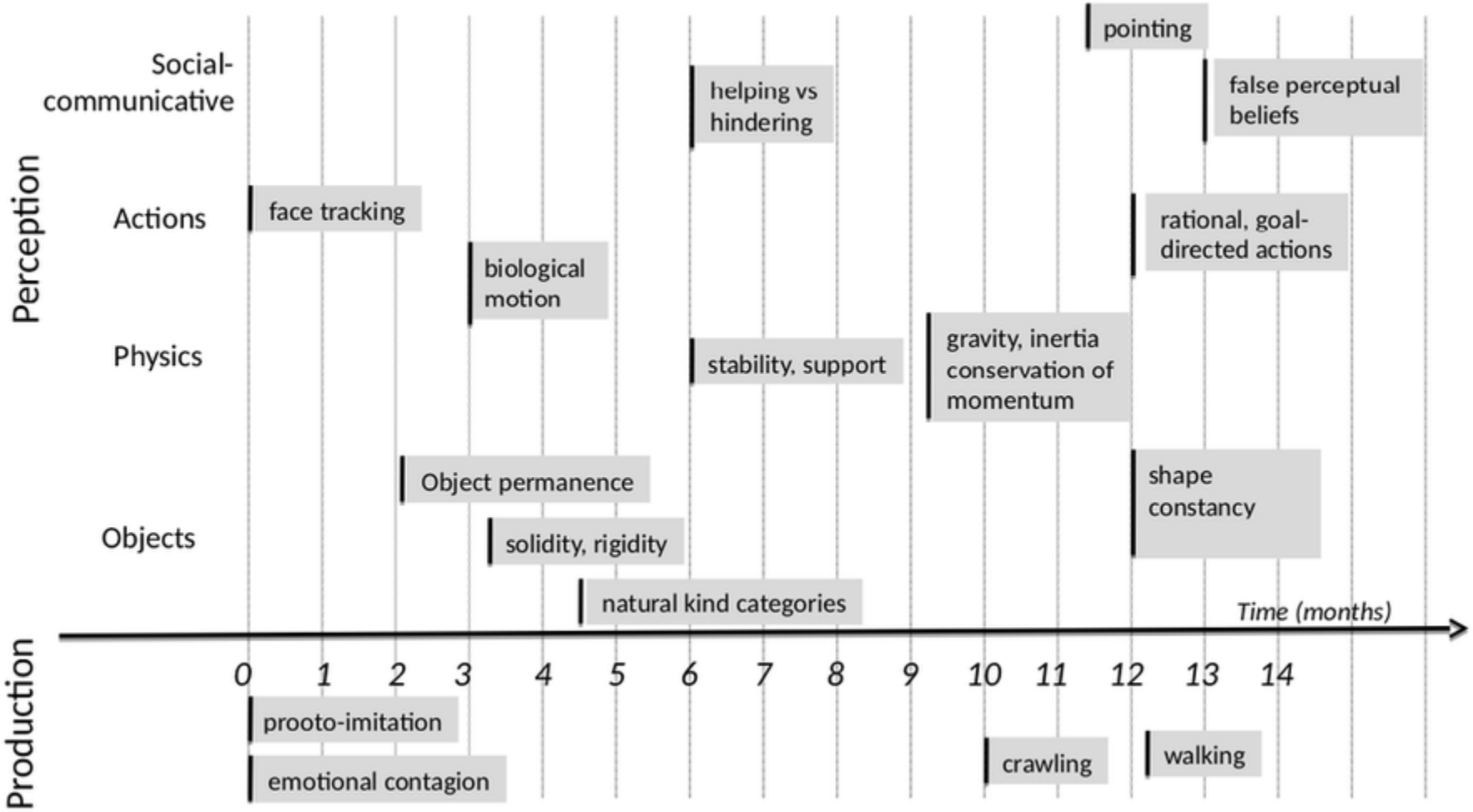


Image credits: Emmanuel Dupoux

Thanks for your attention!

Any questions?



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