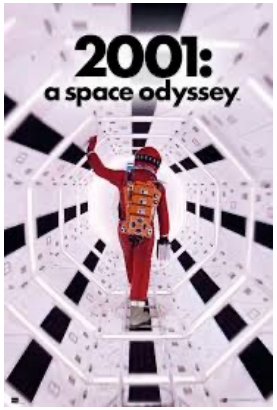
AI and Scientific Research

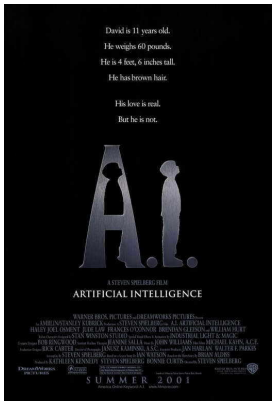
Patrick Valduriez

Popular Imaginary about AI

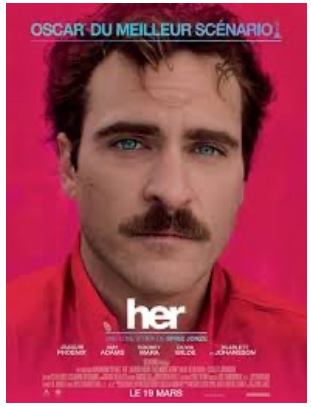


1968

1984



2001



2025

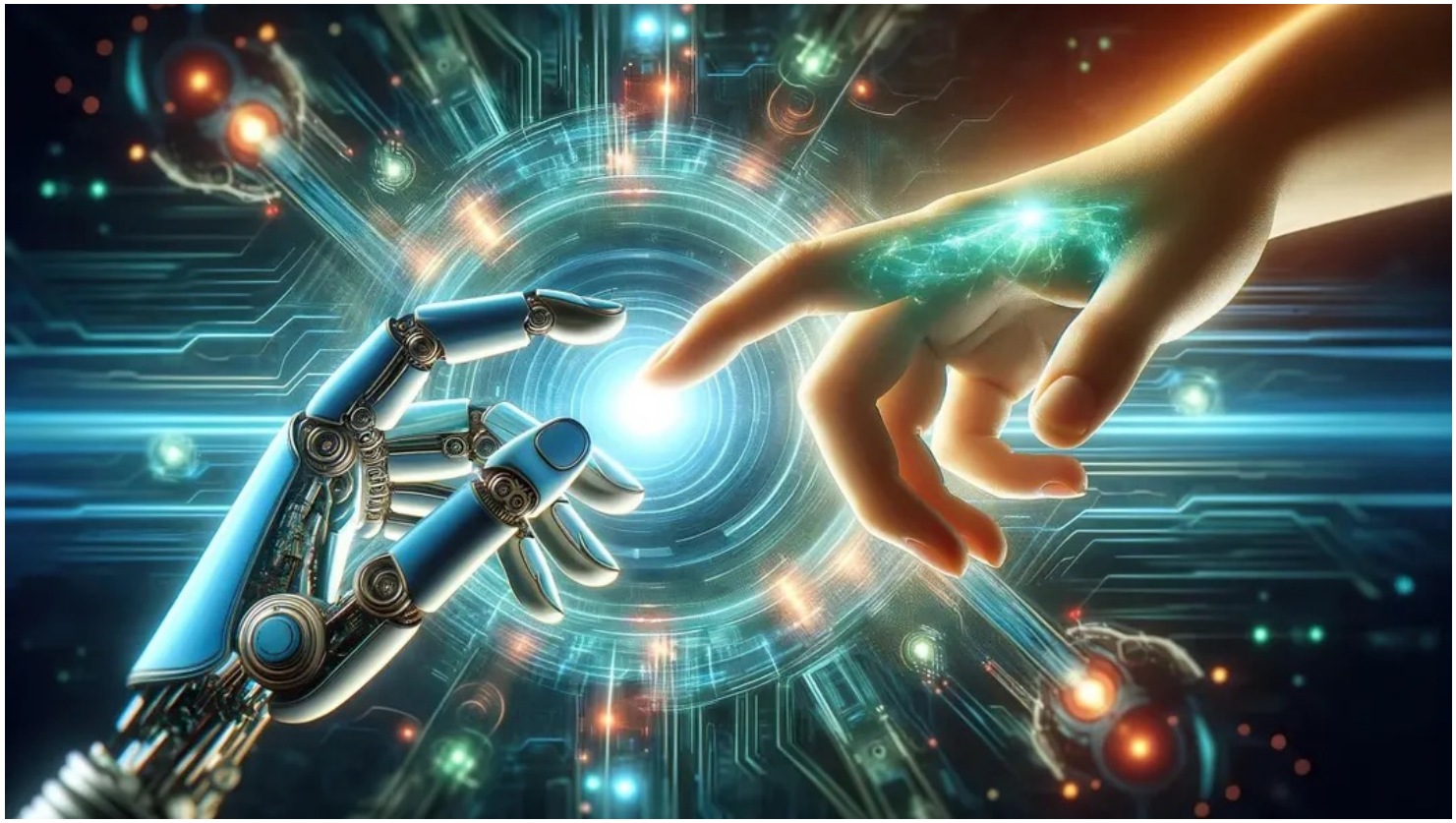
References

- AI and economy
  - The Fourth Industrial Revolution, K. Schwab, 2017
  - AI for Good, United Nations, 2021
  - AI Will Transform the Global Economy. Let's Make Sure It Benefits Humanity. IMF, January 2024
  - Artificial Intelligence and the Future of Work. OECD, 2019
- AI and science
  - The Impact of Artificial Intelligence on Science and Research, European Commission, 2021
  - Artificial Intelligence for Scientific Discovery, DoE, USA, 2020
  - Artificial Intelligence and Life Sciences, NIH, USA, 2020
  - Shaping sustainable agrifood futures: pre-emerging and emerging technologies and innovations for impact. FAO and CIRAD, 2024
- AI and magic
  - (Un)making AI Magic: A Design Taxonomy, Lupetti and Murray-Rust, CHI 2024

Outline

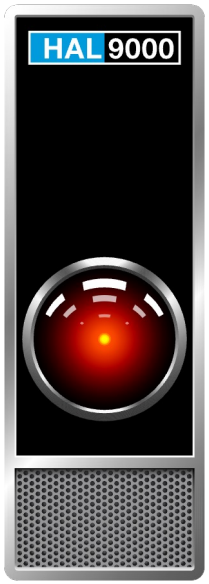
- Artificial intelligence
- Opportunities for science
- Risks for science
- Impact on scientific research

Artificial Intelligence

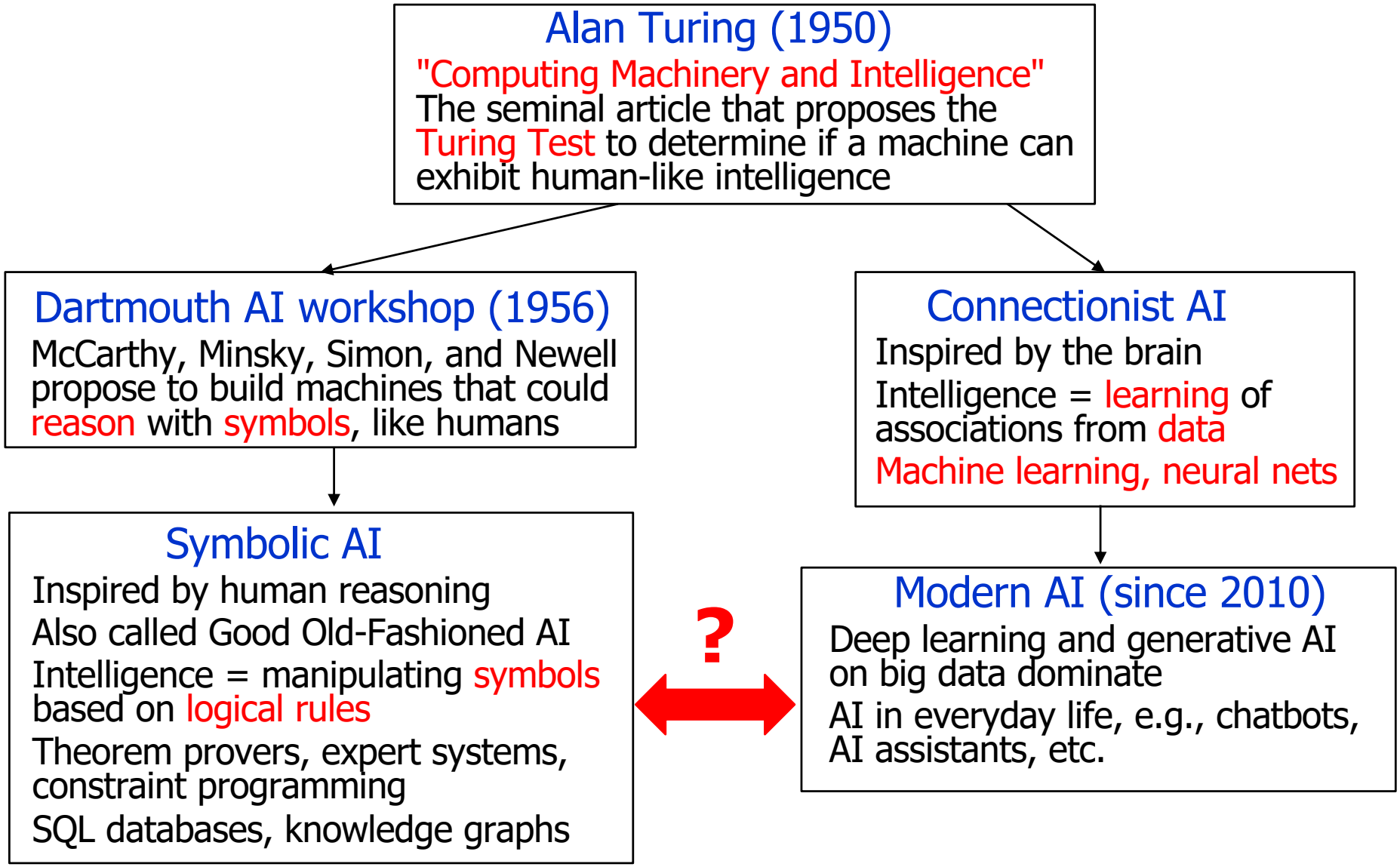


Definitions

- Intelligence
  - The ability to learn and perform suitable functions to solve problems and achieve goals, appropriate to the context in an uncertain, ever-varying world
    - An ape is intelligent
    - A factory robot achieves its goal but is not intelligent
    - What about (some) humans?
- Artificial intelligence (AI)
  - John McCarthy (1955): AI as the science and engineering of making intelligent machines
    - Initially, machines that behave in a clever way, like playing checkers, chess or go
    - Today, the emphasis is on machines that can learn



AI – short history



AI – short history

Alan Turing (1950)

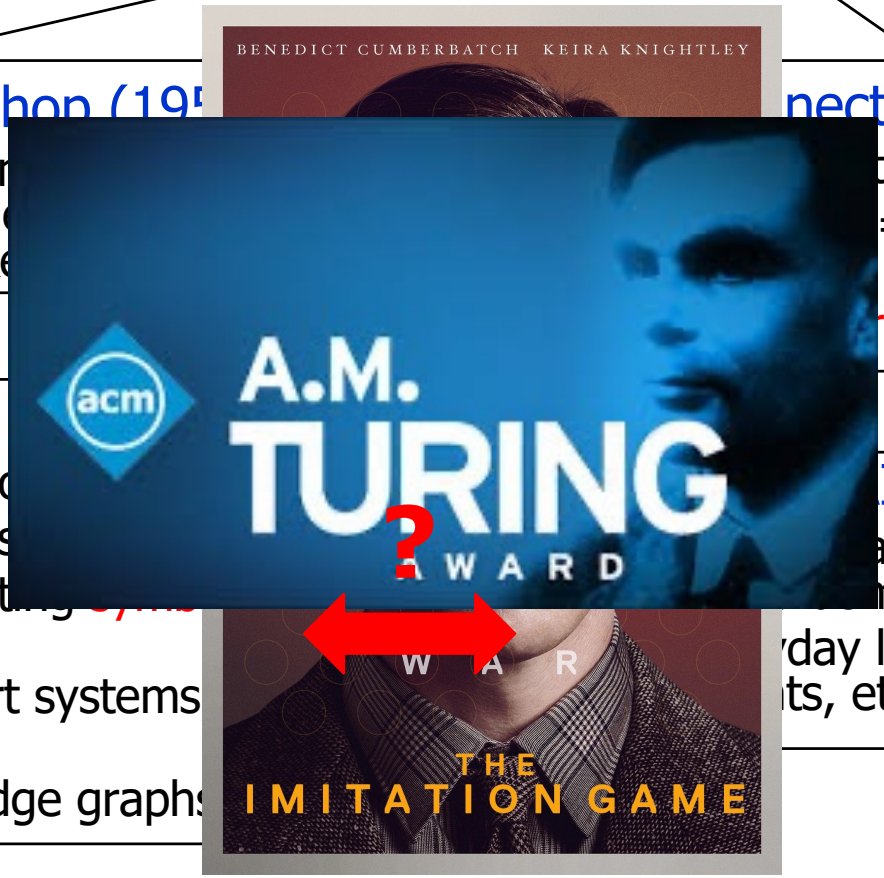
"Computing Machinery and Intelligence"
The seminal article that proposes the Turing Test to determine if a machine can exhibit human-like intelligence

Dartmouth AI workshop (195

McCarthy, Minsky, Simor
propose to build machin
reason with symbols, like

Symbolic AI

Inspired by human reasc
Also called Good Old-Fas
Intelligence = manipulat
based on logical rules
Theorem provers, expert systems
constraint programming
SQL databases, knowledge graph



nectionist AI

he brain
= learning of
from data
rning, neural nets

I (since 2010)

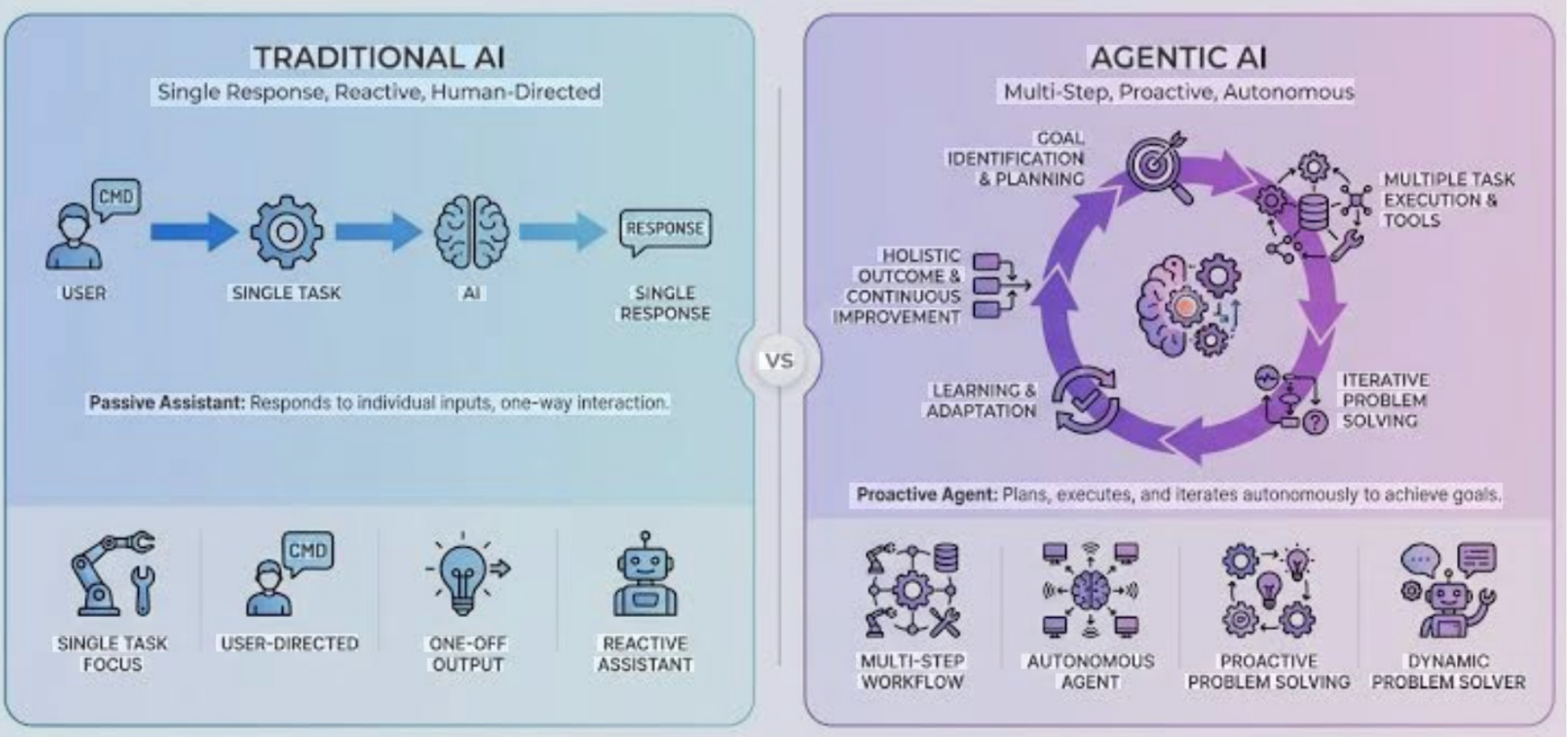
and generative AI
minate
day life, e.g., chatbots,
ts, etc.

Machine Learning – short history

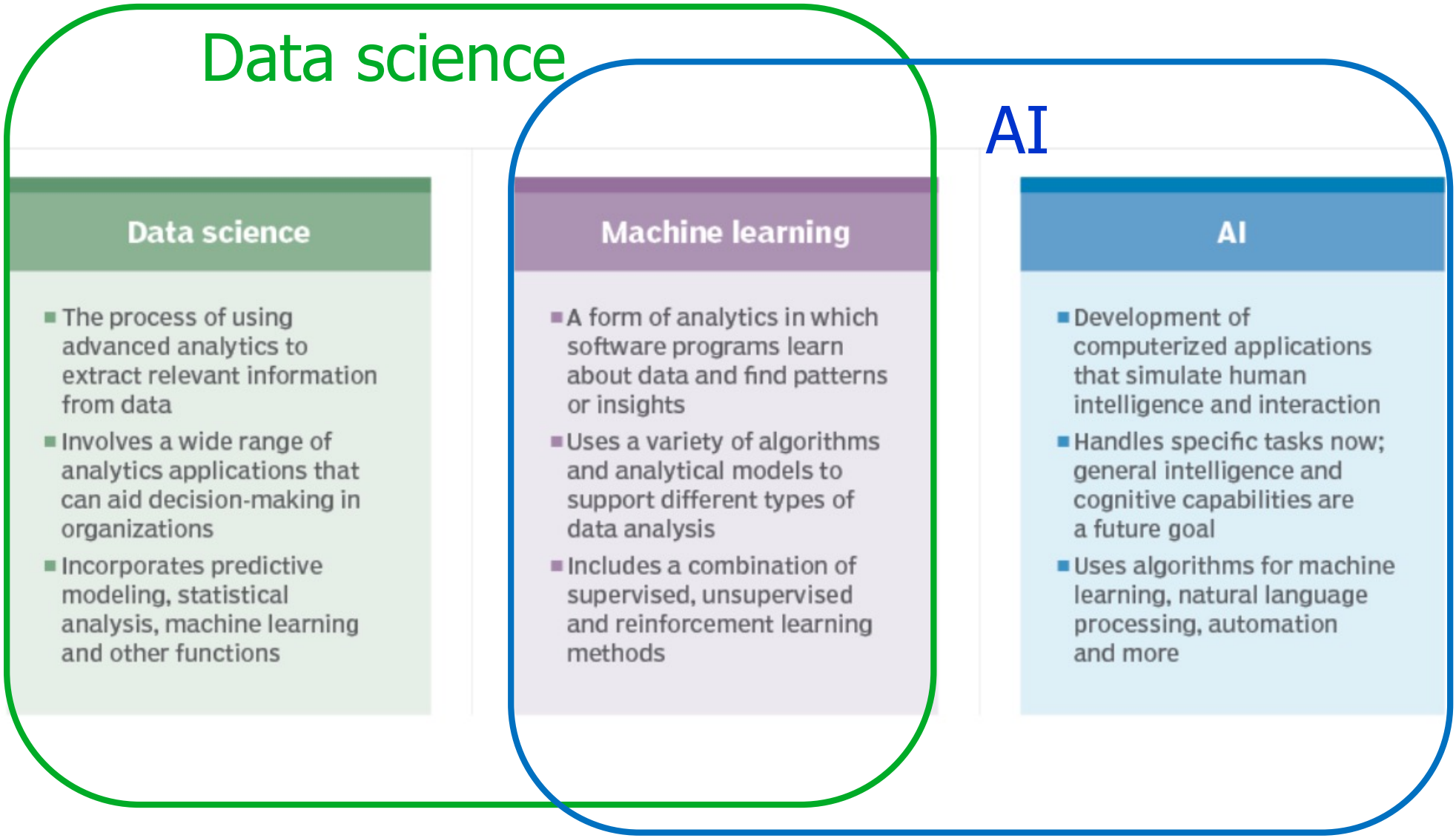
- 1950s: the birth of ML
  - 1952: Arthur Samuel's program to play checkers
  - 1958: Perceptron by Frank Rosenblatt, one of the first NNs
  - Then optimism fades due to limitations
- 1980s: new techniques based on statistical methods
  - Decision trees, support vector machines, and Bayesian methods
  - Backpropagation algorithm (1986) re-ignites interest in NNs
- 2000s: big data
  - ML becomes mainstream (e.g., spam filtering, search engines)
  - Inria Scikit-learn, Meta PyTorch, Google TensorFlow
- 2010s: deep learning
  - Breakthroughs in speech, vision, and language processing
    - 2012: AlexNet wins ImageNet, showcasing the power of convolutional NNs
- 2020s: generative AI at scale
  - Emergence of transformers (BERT and GPT) and LLMs (ChatGPT, Claude, Gemini, Mistral AI)

Agentic AI

- AI focused on decision-making, autonomous action, and collaboration
  - Multi-agent systems, LLMs, AI agents



Data Science versus AI



Dinizia

- A perfect example of data science discovery
  - This giant tree (full scientific name: Dinizia excelsa), almost 90 meters high and 10 meters round, is the biggest ever identified in the Amazon forest in Northern Brazil
  - It was discovered by a satellite in 2019 and, following the analysis of the collected data, eventually reached in 2022 by a group of 30 scientists
- The Dinizia Project (2025-2027)
  - Data science for the natural environment
  - PIs: Eduardo Ogasawara (CEFET) & Esther Pacitti (Inria, U. Montpellier)

CEFET/RJ Inria Université de Montpellier

COPPE UFRJ LNCC Laboratório Nacional de Computação Científica Universidade Federal Fluminense FIOCRUZ cirad NYU

AI as a Transformative Innovation

- Transformative innovation
  - Involves creating radical, large-scale changes that significantly alter existing systems, industries, or even societal structures
- Innovation can be armful
  - 1546: King Edward 6 bans catholic rites and unauthorized "innovations" in worship
  - 2023: citizen and expert movement calling for a pause in AI development

AI in Science

Opportunities

- Acceleration of scientific discovery
  - Processing of big data, creation of models of complex systems, and prediction of phenomena that are difficult to observe directly
- Automation of repetitive tasks
  - Data processing: data cleaning, analysis, visualization, testing and simulation
  - Scientific writing: bibliography study, article writing
  - Scientific evaluation: verification of article quality, fraud detection, reviewer selection, etc.
- Improved decision-making
  - Project prioritization: by analyzing trends and identifying areas with high potential
- Interdisciplinary collaboration
  - Data sharing from different disciplines and sources (lab experiments, models, observational data)

Opportunities

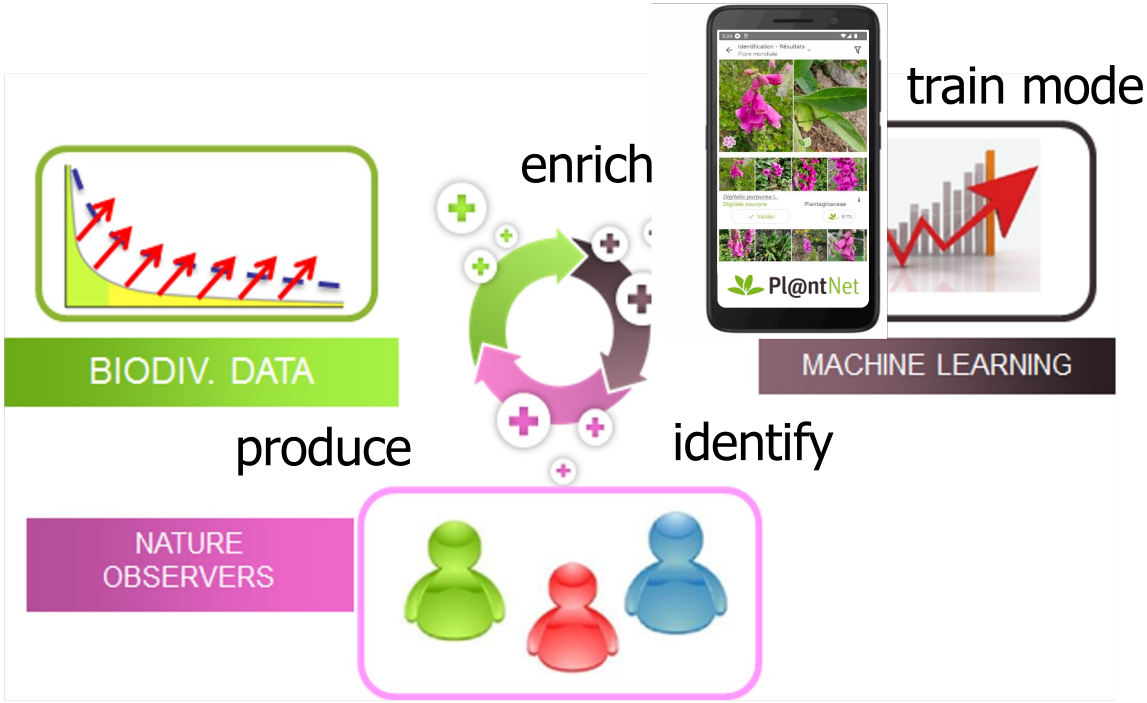
- Open science
  - Federated learning to facilitate broader scientific collaboration
  - Creation of FAIR (Findable, Accessible, Interoperable, and Reusable) data and AutoML models
  - AI models across various scientific problems using OpenML
- Democratizing science
  - Advanced analysis accessible without specialized training
  - Analysis of data contributed by the public

Pl@ntNet

cirad Inria IRD INRAE

A citizen science platform that uses ML to help people identify plants with their mobile phones

- 30 million users worldwide



Download on the App Store

GET IT ON Google Play

Pl@ntNet Online Version

ML-driven Farming in India

Plantix

- The Problem
  - Family farmers (1–2 hectares of land) struggle with
    - Crop diseases they cannot identify early
    - Limited access to trained agronomists
    - Financial losses from reduced yields and expensive chemical treatments
- Solution
  - Farmers use the Plantix app to take pictures of their crops
  - Plantix instantly diagnoses plant diseases, nutrient deficiencies, or pest infestations, and provides treatment recommendations in local language
- Impact
  - Disease detection accuracy: 92%+ for common crops like cotton, groundnut, rice, and chili
  - Farmers treat problems earlier, preventing spread
  - Reduced use of chemical pesticides and fertilizers
  - Yield increase: up to a 20–30% improvement
  - Knowledge sharing among farmers

Risks for Science

Quality Problems

- Poor data quality
  - Garbage in, garbage out: mediocre, incomplete, or biased data can lead to misleading conclusions
  - Reinforcement of existing biases: if past data reflect biases, AI might reproduce or even amplify them
- Lack of interpretability
  - Black-box models: difficult to understand why a ML model made a certain prediction
  - Trust and reproducibility: hard to explain or reproduce AI-generated results
- False discoveries
  - Spurious correlations: AI can find patterns in noise, especially in large datasets, leading to false positives
  - Overfitting: models may perform well on training data but fail in real-world or future scenarios

Example of AI Failure

- Context: biomedical imaging
  - Analysis of biomedical images to assist in disease diagnosis
    - Zech et al.: "Variable Generalization Performance of a Deep Learning Model to Detect Pneumonia in Chest Radiographs: A Cross-Sectional Study," PLOS Medicine, 2018
- Incident
  - Zech et al. found that an AI model trained to detect pneumonia on chest X-rays performed surprisingly well, but only in certain hospitals
  - When tested on data from different hospitals, its performance dropped significantly
- What went wrong: the AI had learned shortcuts
  - In these different hospitals, pneumonia patients were more likely to be scanned with portable X-ray machines, which left distinctive artifacts in the images
  - The AI model picked up on the machine type rather than actual medical features: it was detecting hospital-specific patterns, not pneumonia
- Conclusion
  - This is a clear case of dataset bias: the AI was not generalizing medical knowledge but overfitting to peculiarities in the training data

Ethics

- Integrity
  - Copyright violation: copyrighted books, articles, and websites to train models without permission
  - Fraud: AI tools to make up data or fake scientific results
  - Plagiarism: using automated writing tools and translators
- Overreliance and misuse
  - Automation bias: researchers may trust AI outputs too readily, even when they are flawed
  - Loss of domain knowledge: leading to neglect scientific reasoning
  - Increased cognitive debt when using AI assistants
- Unequal access
  - ML models often require expensive HPC resources, potentially excluding researchers from underfunded institutions or countries

info@anthropiccopyrightsettlement.com

Piratage 1 décembre 2025 à 13:53

Court Notice: Anthropic Copyright Class Action

À : Patrick Valduriez,

Répondre à : info@anthropiccopyrightsettlement.com

Notice of $1.5 Billion Proposed Class Action Settlement Between Authors & Publishers and Anthropic PBC

A federal court authorized this Notice. This is not junk mail, an advertisement, or a solicitation from a lawyer.

Dear PATRICK VALDURIEZ:

A Settlement has been reached in a class action lawsuit claiming that Anthropic infringed protected copyrights by downloading works in two allegedly pirated online datasets called Library Genesis (LibGen) and Pirate Library Mirror (PiLiMi). The current Settlement provides for **approximately $3,000 per work**, prior to the deduction of any costs, fees, and expenses as described below.

Please read this Court-approved notice carefully regarding the Settlement and your options. Your legal rights may be affected whether you act or not.

What's this lawsuit about?

Privacy and Regulation

- Security and privacy concerns
  - Sensitive data: using AI with genomic, medical, or personal data raises privacy concerns
  - Model inversion attacks: AI models can be reverse-engineered to leak sensitive training data
  - Using a generative AI tool, you are providing the AI platform with valuable information about your activities
  - Ability to autonomously identify and exploit software vulnerabilities (Claude Mythos)
- Regulatory and legal uncertainty
  - AI-generated research outputs raise unresolved questions about authorship, intellectual property, liability, and compliance with scientific standards

Impact on Scientific Research

Impact on the Global Economy

- AI will displace many jobs, adding to labor market churn
  - Headline-grabbing reports suggest hundreds of millions of jobs were at risk
  - Creative destruction: AI replaces certain tasks while augmenting others
- Job displacement
  - Entry-level white-collar jobs, routine and clerical jobs involving repetitive tasks
- Job creation
  - High-paid AI specialists, such as data scientists and ML engineers
  - Low-paid AI shadow workers such as annotators/labelers
- Sectors most impacted by AI
  - Information technology, professional services, financial services, healthcare, energy, transportation, etc.
- Impact on workforce
  - Employers: increasingly prioritizing AI-related skills and skills that complement AI, such as digital literacy, creativity, and emotional intelligence
  - Employees: suffer from FOBO (Fear of Becoming Obsolete)

Impact on Research Practices

- Training and skills
  - Scientists will need to acquire skills in AI, machine learning, and data analysis to take full advantage of these tools
  - And collaborate with AI and data science experts
- Ethics and responsibility
  - Scientists must ensure that their AI models do not reinforce existing biases and inequalities
  - Decisions made by AI systems must be understandable and interpretable
- Special care with generative AI
  - Proprietary tools used for sensitive activities could impact individuals or organizations
  - Risk of losing intellectual property for a new method or invention that is not yet protected
  - Opt for open models whenever possible

Final Remarks

- AI is transforming the scientific method in ways we've never seen before by
  - Accelerating discovery, automating data analysis, and generating hypotheses
    - With limited human supervision using agentic AI workflows
  - Challenging our traditions and beliefs
    - AlphaGo's famous move 37 versus Lee Se-dol
- AI pushes current scientific practice to its limits
  - Publish-or-perish and least publishable unit (LPU) models
    - Hurt intellectual curiosity
  - Exponential numbers of journals and papers that humans won't be able to read (only AIs will)
  - Performance indicators of all kinds that may encourage misconduct and short term thinking
- An opportunity for a major reset
  - Scientific method, management, peer review and publication, result repetition and verification, theory building, ethics, …

Questions?

Will AI replace human scientists?