

Politecnico di Milano  
Artificial Intelligence

# Artificial Intelligence

## What and When

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What is artificial intelligence?

When has been AI created?

# Are there problems?

- The problem of the **definition**
  - What is the “correct” definition?
- The problem of the **origin**
  - Precursors
  - Long research tradition
- Artificial Intelligence: 1956-today

# The definition problem

- Lack of a unique and universally accepted definition
- Several and **different definitions**
- Definitions organized according to **two dimensions**
  - Thought processes vs. behaviors
  - Human performances vs. rational performances

# Artificial Intelligence: definitions

Systems that think like humans	Systems that think rationally
Systems that act like humans	Systems that act rationally

# Thinking humanly

- The **cognitive modeling approach**
  - Intelligence: how humans think
  - Introspection or psychological experiments to determine human cognitive processes
- Psychological tradition (cognitive science)
- GPS (A. Newell, H. Simon)
  - Human processes simulation



# Acting humanly

- The **conventional approach**
  - Intelligence: realization of a determined performance (previously defined)
- Turing test (1950)
  - **Operational** definition of intelligence
- Extension of the notion of intelligence
  - Not just to think, but also **to act**





# Thinking rationally

- The **“laws of thought”** approach
  - Intelligence: ability to think “in the right way”
- **Rationality** as an ideal concept of intelligence
  - Intelligence without errors
  - Exact definition of rationality
- Logical tradition
  - Programs able to solve any solvable problem described in logical notation

# Acting rationally

- The rational agent approach
  - Intelligence: acting to achieve the best possible outcome
- **Rational agent**
  - Physical system operating in an environment
- Limited rationality
  - Acting **appropriately** (even with short time and insufficient information)

# Artificial Intelligence

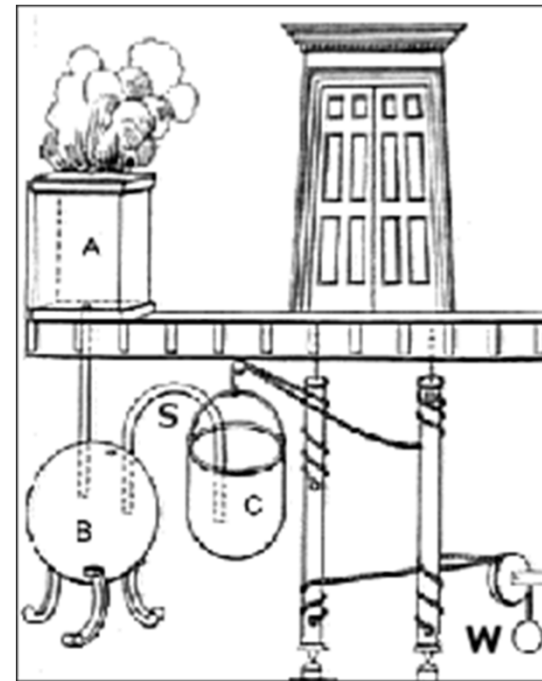
- **Conventional** definition of intelligence
- **Constant extension** of its boundaries  
(depending on scientific and technological achievements)
- Science **and** engineering
  - Understanding intelligence
  - Building intelligence

# The problem of the origin

- Official date of birth (1956)
- Role of **precursors**
  - Computer engineering
  - Cybernetics
- **Research tradition**
  - Tendency of humans to represent themselves
  - Formalistic tradition of enquiry on the mind

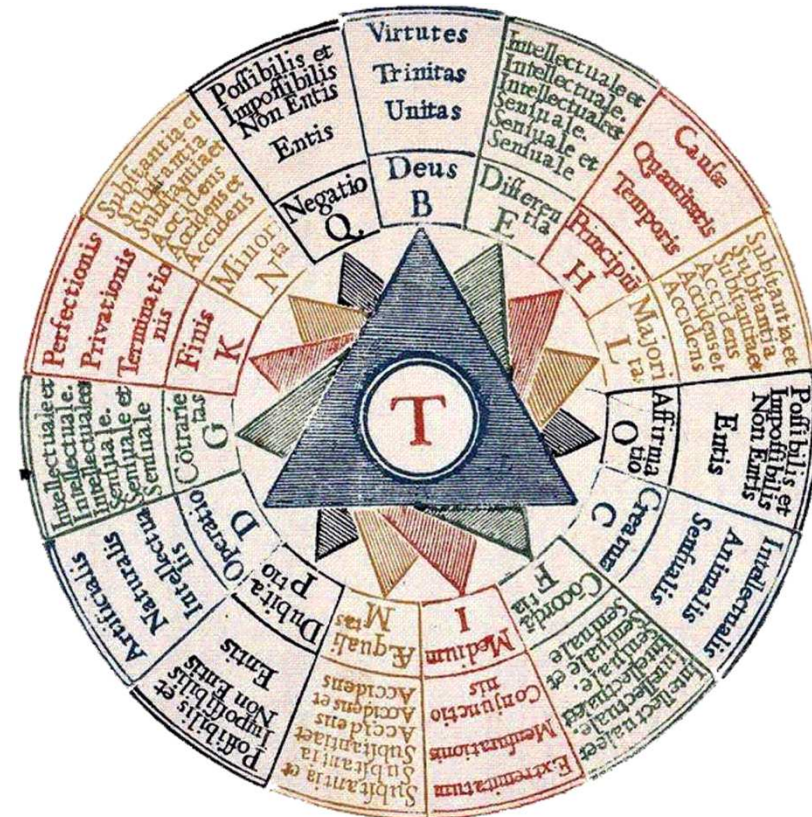
# Research tradition: the ancient world

- Heron of Alexandria (150 AD)
  - **Semiautomatic machines** (*autòmatha*): water-powered and steam-powered



# Research tradition: the ancient and medieval world

- Ramon Lull (1235-1315)
  - *Ars Magna*: general principles of human **knowledge** represented by **numbers** and **symbols** composed to obtain further knowledge
  - *Ars inveniendi veritatem*

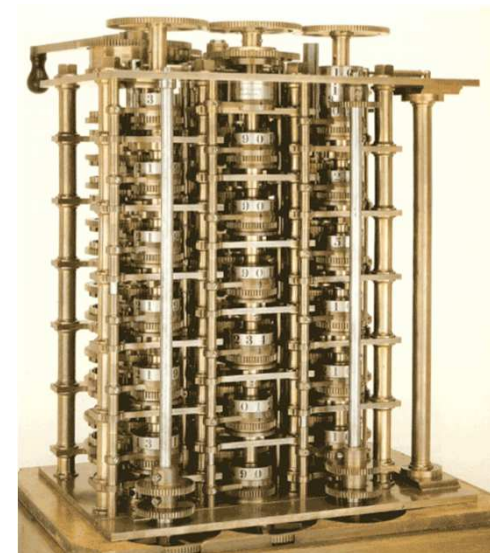


# Research tradition: the scientific revolution

- Descartes (1596-1650)
  - Rational actions and mechanical actions
- La Mettrie (1709-1751)
  - *L'Homme Machine*
- Pascal (1623-1662)
  - Mechanical calculator
- Leibniz (1646-1716)
  - Project of mechanizing rationality (*calculus ratiocinator*)
  - Axiomatic-deductive system

# Research tradition: Charles Babbage (1791-1871)

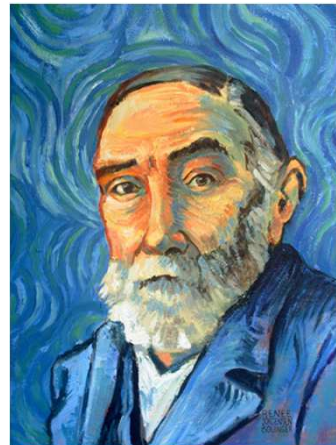
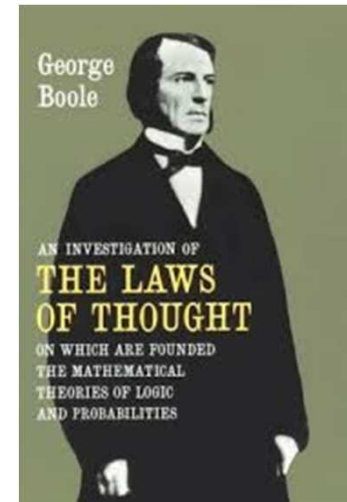
- Numerical tables for **calculation**
- ***Difference Engine***
  - Automatic calculation of logarithmic tables
- ***Analytical Machine***
  - Memory warehouse
  - Control system





# Research tradition: the birth of modern logic

- Boole (1854): **algebrization of logic**
  - Laws constituting the 'mathematics' of human cognition
- Frege
  - **Formal system** (first order logic),  
notion of proof



# Research tradition: Alan Turing (1912-1954)

- Computability theory
  - **Universal machine**
    - Capable of expressing any definite procedure by a finite number of actions
  - **Algorithm**
    - Sequence of operations that can be performed by the universal machine



# The precursors

- **Computer engineering**

- Z3, Eniac



- **Cybernetics**

- Study of the communication and control of regulatory feedback both in living beings and machines
- McCulloch, Pitts (1943)

- First model of artificial neurons



# The birth of Artificial Intelligence

- **Workshop** at Dartmouth (summer 1956)
- J. McCarthy, M. Minsky, C. Shannon, N. Rochester

*"The study is to proceed on the basis of the conjecture that 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."*

(McCarthy 1955)

# Great expectations (1956-1969)

- General **search strategies** (applications to games)
  - GPS (Simon, Newell)
- Progressively **restricted** notion of **intelligence**
  - Microworlds (Minsky)
- *Lisp* (McCarthy)
- Temporal decline of neural network models

# First problems (1966-1973)

- More complex problems
- **Intractability** of many problems
  - No theory of computational complexity
- **Crisis** in the field of **machine translations**
  - Cancellation of government funding
  - Extension of the crisis to the whole field

# Knowledge-based systems (1969-1979)

- **Narrow** areas of **expertise**
- **Expert systems**
  - Centrality of domain knowledge and its adequate description
  - Systems supporting human experts
- **Natural language processing**
  - Syntax + semantics



# AI becoming an industry (1980- today)

- **Commercial** expert systems
- Chip design
- **Human-computer interfaces**





# The revival of neural networks (1986-today)

- **Back-propagation learning algorithm**  
reinvented by four different research groups
- Connectionist models of intelligent systems

# AI becoming a science (1987-today)

- Revolution in **content** and **methods**
  - Experiments
  - Rigorous theorems
- **Probabilistic approach**
  - Bayesian networks: efficient representation and rigorous reasoning with uncertain knowledge

# The emergence of intelligent agents (1995-today)

- From a **single** agent: “whole agent” problem
  - Robotics, artificial vision, learning
- To **groups** of agents: systems of interacting agents (MAS)
  - Positive interaction: cooperation
  - Negative interaction: competition

# Rational agent

- **Rationality:** reasons to act
  - Economic tradition: utility function
  - Qualitative rationality: beliefs, desires, intentions
- **Autonomy:** relatively to other agents
- **Adaptability:** individual learning

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- McCorduck, P. (1979) *Machines Who Think*, A K Peters, Ltd.
- Russell, S., Norvig, P. (2009) *Artificial Intelligence: A Modern Approach*, Prentice Hall