

AI in an nutshell

Manel Martínez-Ramón

Meenu Ajith

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Nobel Prize in Physics 2024



NOBELPRISET I FYSIK 2024 THE NOBEL PRIZE IN PHYSICS 2024



KUNGL.
VETENSKAPS-
AKADEMIEN

THE ROYAL SWEDISH ACADEMY OF SCIENCES



John J. Hopfield

Princeton University, NJ, USA



Geoffrey E. Hinton

University of Toronto, Canada

"för grundläggande upptäckter och uppfinningar som möjliggör maskininlärning med artificiella neuronnätverk"

"for foundational discoveries and inventions that enable machine learning with artificial neural networks"

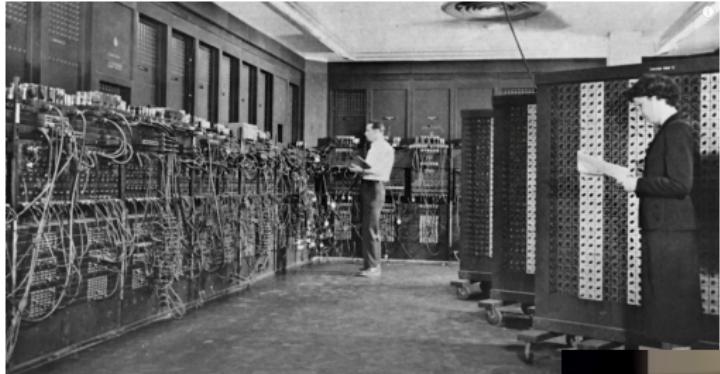
THE
NOBEL
PRIZE

Nobel Prize in Physics 2024

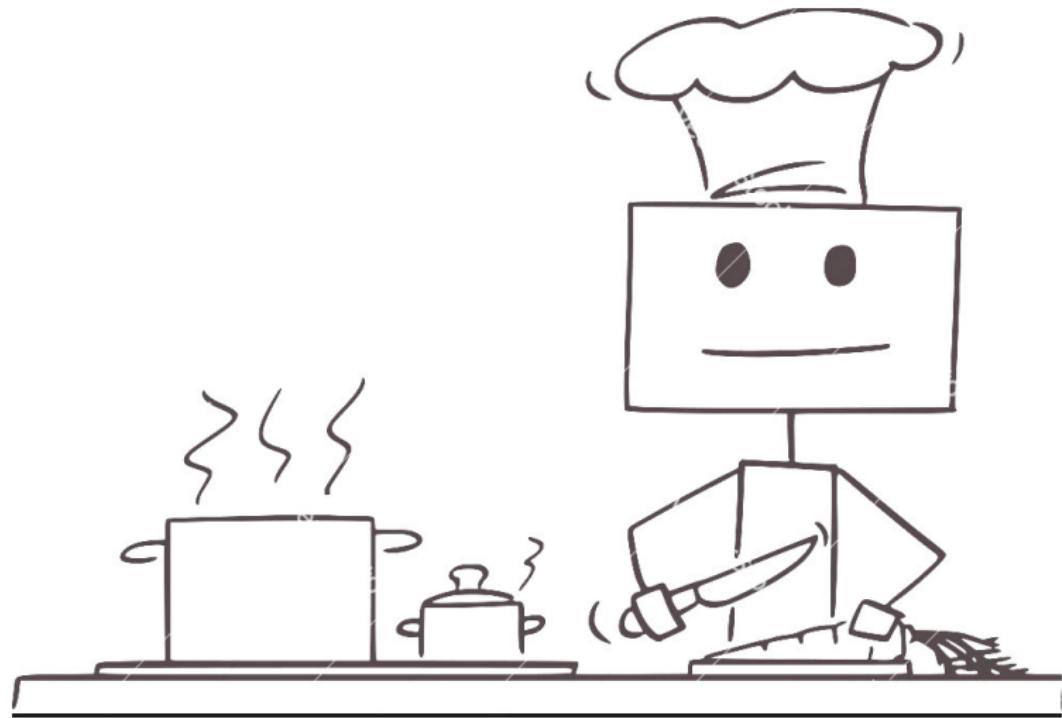
- IA is everywhere.
- What is its relation with physics?
 - ① Developed from models known in physics
 - ② Used to solve problems in physics
 - ③ IA revolutionized the World



From computers to reasoning



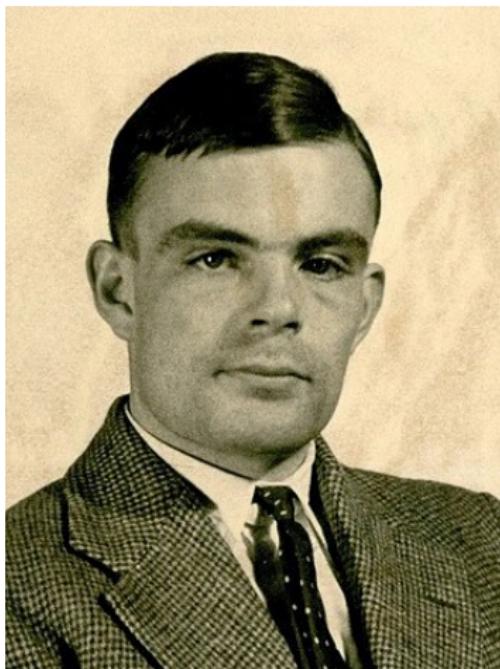
Computers and complex tasks



Hand me a glass



The learning concept



Alan Turing (1912-1954)

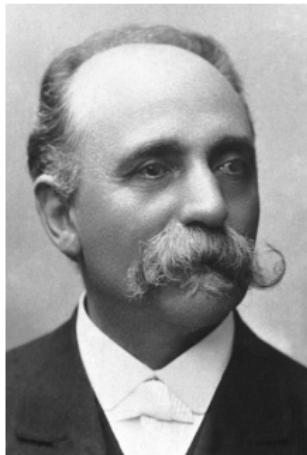
What is Artificial Intelligence?

In 1956, John McCarthy organized a conference in Dartmouth College “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, Minsky, Rochester and Shannon, “*A proposal for the Dartmouth Summer Research Project on Artificial Intelligence*”, 1956.

Sixty seven years and six months later,
we still do not exactly know what it is.

The neuron

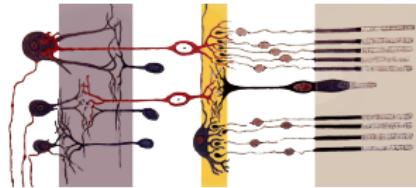


Camilo Golgi
(1843-1926)



Santiago Ramón y
Cajal (1852-1934)

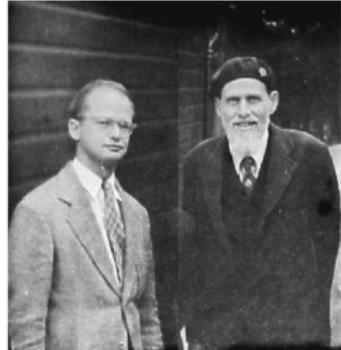
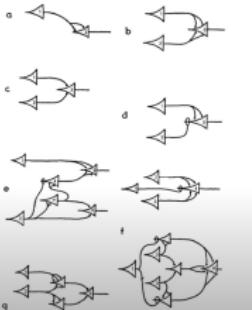
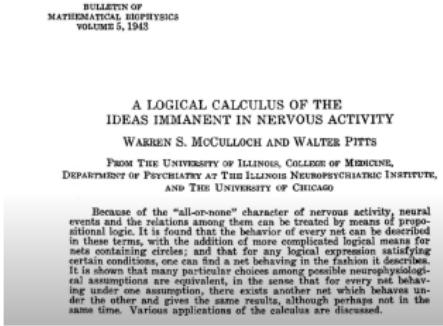
C. Golgi (Italy) and S. Ramón y Cajal (Spain) were awarded the 1906 Nobel Prize in Physiology and Medicine.



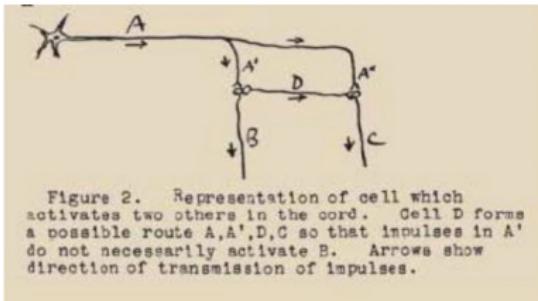
Santiago Ramón y
Cajal, Histologie Du
Système Nerveux de
l'Homme et Des
Vertébrés, Maloine,
Paris, 1911,

Inception of the artificial neuron

- McCulloch and Pitts, 1943

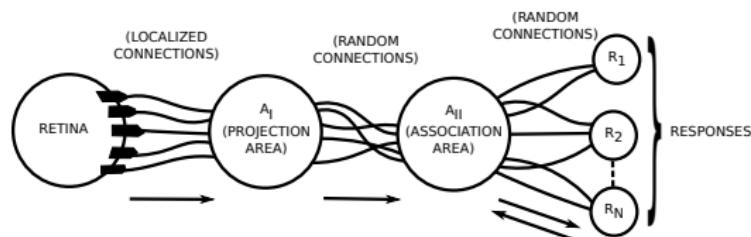


- Hebb, 1949



The perceptron

- Rosenblatt, 1958

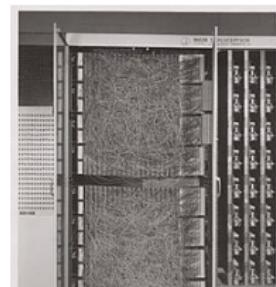


The New York Times.

By The New York Times Company
Times Square, New York 36, N. Y.

NEW YORK, SUNDAY, JULY 13, 1958.

33c beyond 100-mile zone from New York.
Higher in air delivery cities.



Electronic 'Brain' Teaches Itself

The Navy last week demonstrated the embryo of an electronic computer named the Perceptron which, when completed in about a year, is expected to be the first non-living mechanism able to "perceive, recognize, and identify its surroundings."

Martinez, Ajith, Rajendra

recognize the difference between right and left, almost the way a child learns.

When fully developed, the Perceptron will be designed to remember images and information it has

AI in a nutshell

Proc. Natl. Acad. Sci. USA
Vol. 79, pp. 2554–2558, April 1982
Biophysics

Neural networks and physical systems with emergent collective computational abilities

(associative memory/parallel processing/categorization/content-addressable memory/fail-soft devices)

J. J. HOPFIELD

Division of Chemistry and Biology, California Institute of Technology, Pasadena, California 91125; and Bell Laboratories, Murray Hill, New Jersey 07974

Contributed by John J. Hopfield, January 15, 1982

ABSTRACT Computational properties of use to biological organisms or to the construction of computers can emerge as collective properties of systems having a large number of simple equivalent components (or neurons). The physical meaning of content-addressable memory is described by an appropriate phase space flow of the state of a system. A model of such a system is given, based on aspects of neurobiology but readily adapted to in-

calized content-addressable memory or categorizer using extensive asynchronous parallel processing.

The general content-addressable memory of a physical system

Suppose that an item stored in memory is "H. A. Kramers & G. H. Wannier *Phys. Rev.* **60**, 252 (1941)." A general content-

Hopfield uses the collective behavior of matter to generate computational capacity.

**Boltzmann Machines:
Constraint Satisfaction Networks that Learn ***

Geoffrey E. Hinton
Department of Computer Science
Carnegie-Mellon University, Pittsburgh, PA 15213

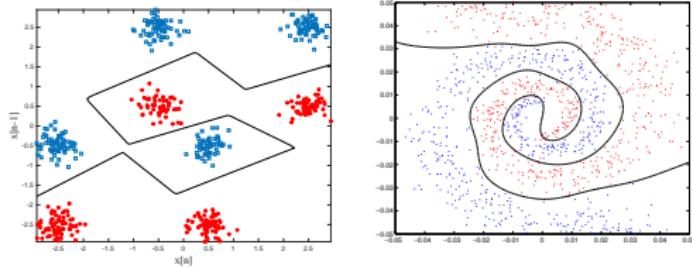
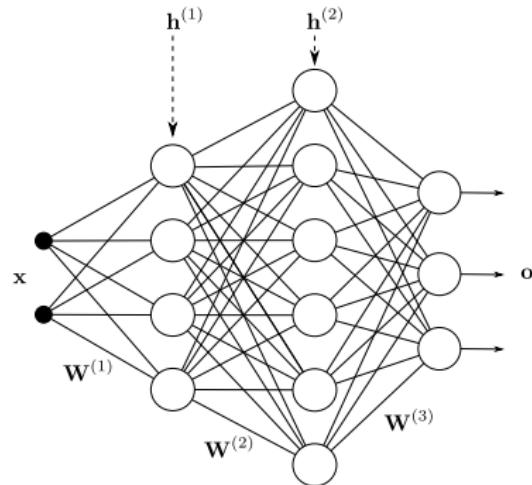
Terrence J. Sejnowski
Department of Biophysics
The Johns Hopkins University, Baltimore, MD 21218

David H. Ackley
Department of Computer Science
Carnegie-Mellon University, Pittsburgh, PA 15213

May, 1984

Hinton uses concepts of thermodynamics to train Hopfield's networks: the Boltzmann distribution. It leads to the concept of collective behavior.

The neural network



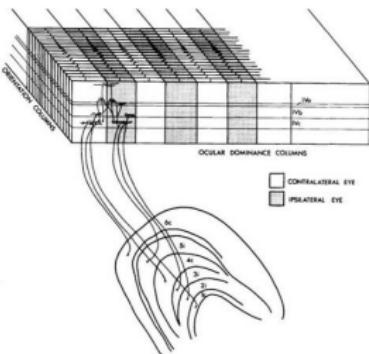
Werbos (1974, 1988); Rumelhart, Hinton & Williams (1986).

Initial difficulties of AI

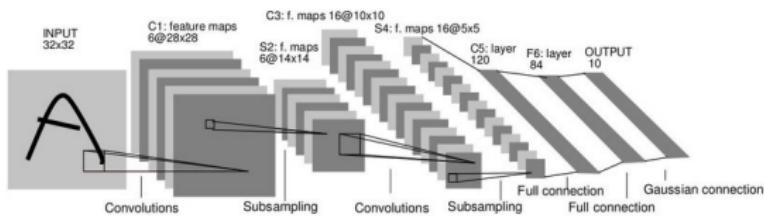


Convolutional neural networks

David Hubel and Torsten Wiesel (1981 Nobel Prize in Medicine), 1958.

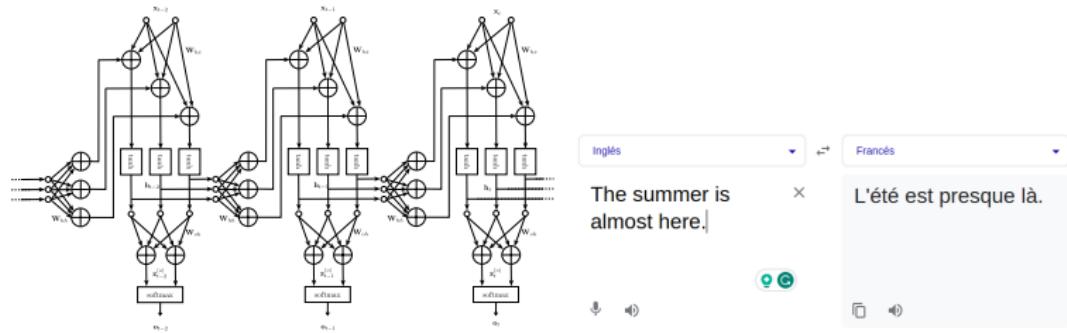


Yan LeCun (2018 Turing Award), 1989

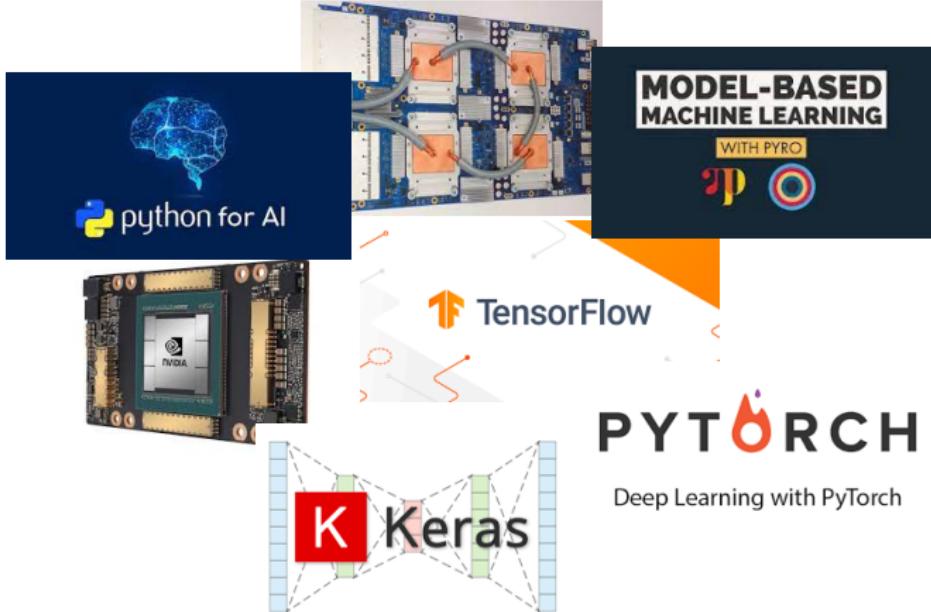


Recurrent Neural Networks

Elman, 1972, Hochreiter, 1997, Sutskever, 2012



AI tools



Self attention and transformers

