UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Introduction to AI

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Contents

1 Introduction

Intelligence derives from the Latin verb *intelligere*, a combination of *intus* (between) and *legere* (to choose), that is, to choose (correctly) between options.

The history of ***artificial intelligence (AI)*** goes back to the Greeks to find the first attempts to ***automatize human intelligence*** [1, 2, 3, 4].

The ***history of AI*** is the history of a computer science branch evolving since 1940 and moving between two philosophical views:

- ***Empiricism / behaviorism:*** the (sensorial) ***experience*** is the main source of knowledge and adaptation of the ***behavior***.
- ***Racionalism / cognitivism:*** the (logic) ***reasoning*** is the main source of knowledge and adaptation of the ***mind***.

2 Artificial intelligence

John McCarthy proposed the term ***Artificial Intelligence (AI)*** for the ***Dartmouth workshop*** entitled *Dartmouth Summer Research Project on Artificial Intelligence* and held the summer of 1956 at the Dartmouth University, triggered by a proposal made in August 1955 ↱:

An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves.

McCarthy's website: `http://www-formal.stanford.edu/jmc`

As some of the participants acknowledge when they got together 50 years later, this workshop sparked the AI as a research field, but "no agreement on a general theory of the field and in particular on a general theory of learning" was reached [5].

3 Turing test

In a paper published in 1950 [6], ***Alan Turing*** proposes to answer the question “Can machine think?”, that is also known as the ***imitation game*** or ***Turing test***: an interrogator asks questions via text messages to both, a machine and a person, and the interrogator has to guess who is who. We would say that a machine thinks, if it tricks the interrogator.

Turing believes that the Q&A method allows to introduce almost all aspects of the human activity:

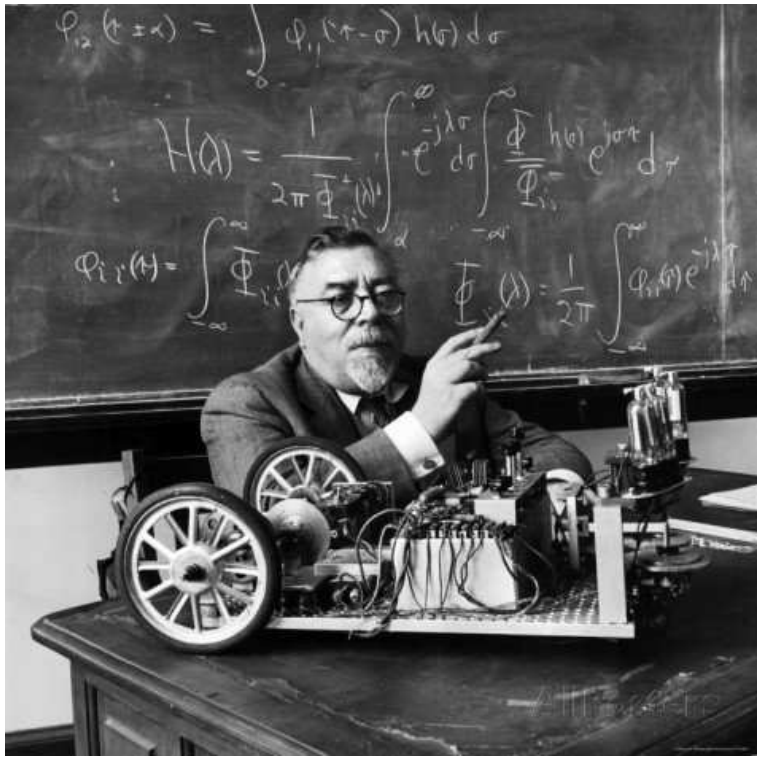
```
Q : Please write me a sonnet on the subject of the Forth Bridge.
A : Count me out on this one. I never could write poetry.
Q : Add 34957 to 70764
A : (Pause about 30 seconds and then give as answer) 105621.
Q : Do you play chess?
A : Yes.
Q : I have K at my K1, and no other pieces. You have only K at K6
    and R at R1. It is your move. What do you play?
A : (After a pause of 15 seconds) R-R8 mate.
```

Turing test is still a subject of controversial debate [7].

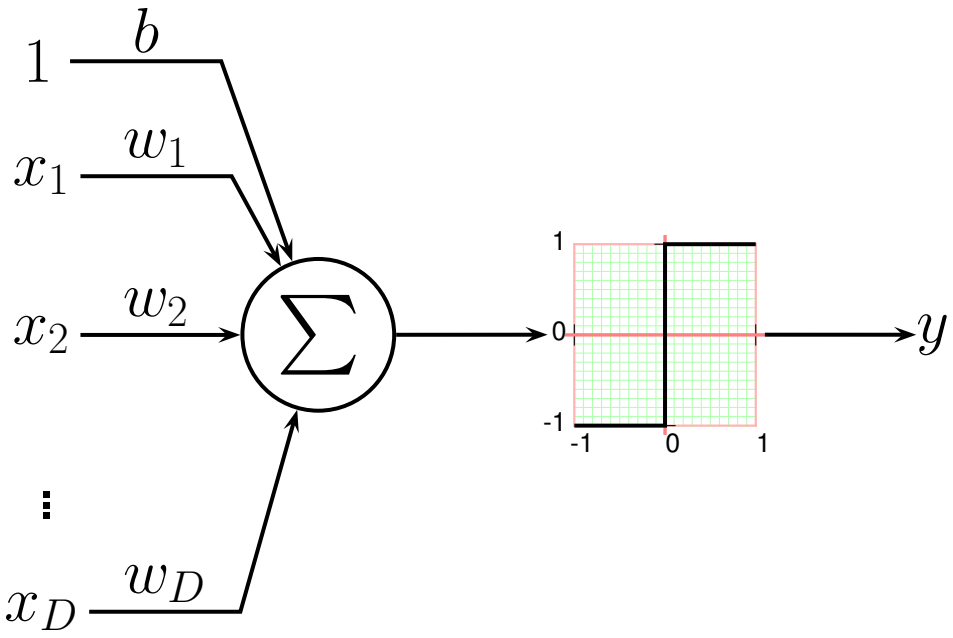
4 Cybernetics

In 1948 ***Norbert Wiener*** defined ***cybernetics*** as the ***control theory*** *and communication between the animal and the machine* [8].

Cybernetics started the study of ***neural networks***.



Norbert Wiener



1943: McCulloch-Pitts neuron [9]

5 Neural networks

- 1943: ***William McCulloch*** and ***Walter Pitts*** proposed the first neural-based computational model [9].
- 1951: ***Marvin Minsky*** implements the "first" artificial neural network, ***SNARC (Stochastic Neural Analog Reinforcement Calculator)***, with 40 analogical (artificial) neurons.
- 1954: ***Belmont Farley*** and ***Wesley Clark*** carry out the first digital simulation of a neural network [10].
- 1958: ***Frank Rosenblatt***, proposes ***Perceptron (Mark 1)***, the first implementation of a neural network (for binary classification of images) able to learn from annotated data [11].
- The ***conexionism*** keeps a modest activity until it comes back at the end of the 80s and above all, in the 2010s.

6 Symbolic AI

Presented at Dartmouth by ***A. Newell***, ***H. Simon*** and ***C. Shaw***, the ***logic theorist (LT)*** was the "first" program of AI [12].

LT is a system for ***automatic reasoning*** in order to *automatically prove theorems* or for *automatic* deduction in ***propositional logic*** that includes three basic key ideas in AI:

- ***Reasoning by searching*** in a tree rooted by the initial hypothesis, each branch adds a derivation and, the path to reach the objective proposition is the proof.
- ***Heuristic functions*** to prune non-promising branches.
- Processing of ***symbolic lists*** for ***knowledge representation***.

The ***symbolic AI*** has been the most ambitious branch, dominating AI until the 90s, when simpler statistical-based ***intelligent agents*** took over ***expert systems***.

7 Machine learning

In 1959 ***Arthur Samuel*** used the term ***machine learning*** for a program that was able to play checkers learning by itself [13].

What is machine learning (ML)?

- ***Arthur Samuel*** (1959) [13]: field of study that gives computers the ability to learn without being explicitly programmed
- ***Tom Mitchell*** (1997) [14]: a system learns from experience E with respect to a class of tasks T and a performance measure R, if its performance on T, as measured by R, improves with E
- ***Kevin Murphy*** (2022) [15]:
  - There are many types of ML according to Mitchell, depending on the nature of T, R and E
  - The usual types of ML can be conveniently treated from a probabilistic (statistical) perspective
  - The probabilistic approach is optimal for decision making under uncertainty and formally frames ML along with many other scientific and engineering areas

The state of AI (and its influences on society) [16]

What are the most important advances in AI?

- Vision
- Speech recognition and generation
- Natural language processing (understanding and generation)
- Image and video generation
- Multi-agent systems, planning and decision-making
- Robotics

The state of AI (and its influences on society) [16]

What are the most inspiring open grand challenge problems?

- Build machines that can cooperate and collaborate seamlessly with humans according to their preferences (how to evaluate?)
- Participation in human competitions: RoboCup, Math Olympiad...
- The AI Scientist challenge: AI systems engage in autonomous scientific research
- Ability to predict how novel interventions might change the world they are interacting with
- More general AI: same system applied to different tasks

The state of AI (and its influences on society) [16]

What are the prospects for more general AI?

- Transfer learning: Transformer architecture + self-supervised train
- Continual and multitask learning
- More general reinforcement learning
  - Reward for exploring new areas of the problem space
  - Data augmentation via synthetic generation
- To imbue machines with common sense abilities

The state of AI (and its influences on society) [16]

What are the most promising opportunities for AI?

- Augmentation of human capabilities
  - Human-AI teams often do not currently outperform AI-only teams
  - Aid in discovering or breaking new ground (drugs)
  - Aid in decision-making (summarisation/prediction complex data)
  - Basic AI aid (translation, healthy diet, car driving, etc.)
- AI software can function autonomously
  - Data dependency
  - Legal restrictions

References

[1] Daniel Crevier. *AI: The Tumultuous Search for Artificial Intelligence*. BasicBooks, 1993.

[2] Pamela McCorduck. *Machines Who Think: A Personal Inquiry into the History and Prospects of AI*. A K Peters, 2004.

[3] Nils J. Nilsson. *The Quest for Artificial Intelligence*. Cambridge University Press, 2009. ai.stanford.edu/~nilsson.

[4] Piero Scaruffi. *Intelligence is not Artificial*. CreateSpace Independent Publishing Platform, 2018. scaruffi.com (/singular/purchase.html) (/mind/ai.html).

[5] James Moor. The Dartmouth College Artificial Intelligence Conference: The Next Fifty Years. *AI Magazine*, 27(4), 2006.

[6] Alan M. Turing. Computing Machinery and Intelligence. *Mind*, 1950.

[7] A. P. Saygin, I. Cicekli, and V. Akman. Turing Test: 50 Years Later. *Minds and Machines*, 10(4):463–518, 2000.

[8] Norbert Wiener. *Cybernetics: Or Control and Communication in the Animal and the Machine*. MIT press, 2nd edition, 1961.

[9] Warren McCulloch and Walter Pitts. A Logical Calculus of Ideas Immanent in Nervous Activity. *Bulletin of Mathematical Biophysics*, 1943.

[10] Belmont G. Farley and Wesley A. Clark. Simulation of self-organizing systems by digital computer. *IEEE Trans. of the IRE Professional Group on Information Theory*, 4(4), 1954.

[11] Frank Rosenblatt. The Perceptron: A probabilistic model for information storage and organization in the brain. *Psychological Review*, 65(6):386–408, 1958.
[12] Allen Newell and Herbert A. Simon. The logic theory machine: A complex information processing system. *IRE Transactions on Information Theory*, 2(3):61–79, 1956.
[13] Arthur L. Samuel. Some Studies in Machine Learning Using the Game of Checkers. *IBM Journal of Research and Development*, 1959.
[14] T. Mitchell. *Machine Learning*. McGraw Hill, 1997.
[15] K. P. Murphy. *Probabilistic Machine Learning: An introduction*. MIT Press, 2022.
[16] Michael L. Littman, Ifeoma Ajunwa, Guy Berger, Craig Boutilier, Morgan Currie, Finale Doshi-Velez, Gillian Hadfield, Michael C. Horowitz, Charles Isbell, Hiroaki Kitano, Karen Levy, Terah Lyons, Melanie Mitchell, Julie Shah, Steven Sloman, Shannon Vallor, and Toby Walsh. Gathering Strength, Gathering Storms: The One Hundred Year Study on Artificial Intelligence (AI100) 2021 Study Panel Report, 2022.