Artificial Intelligence

Past and Present

Moshe Y. Vardi

Rice University

vardi@cs.rice.edu

The lesson of the lily pond

◆ You plant a lily plant in a pond. The lily doubles every day. After 30 days the pond is fully covered. How long did it take the pond to get half covered?

Leibniz's Dream

◆ Gottfried Wilhelm Leibniz (1646-1716) taught himself Latin at age 8; read Aristotle at age 12, wrote a thesis at age 20 on Aristotelian metaphysics, followed by another thesis on logic in law.

◆ **The Impossible Dream**: a universal mathematical language--*lingua characteristica universalis*--in which all human knowledge can be expressed, and calculational rules--*calculus ratiocinator*--carried out by machines, to derive all logical relationships.

A Man of Acutist Intellect and Manifold Learning

◆ George Boole, 1815-1864: Aristotle's syllogisms are about classes of objects, which can be treated *algebraically*:
   - Conjunction is product
   - Disjunction is addition

◆ The Mathematical Analysis of Logic, 1847:
   - "The design of the following treatise is to investigate the fundamental laws of the operations of the mind."

The First Programmer

Ada Lovelace, 1815-1852: "The Analytical Engine has no pretensions whatever to originate anything. It can do whatever we know how to order it to perform. It can follow analysis; but it has no power of anticipating any analytical relations or truths."

"A Figure of Mysterious Greatness"

Chalres S. Peirce, 1839-1914

◆ 1889: "A logical machine is a machine which, being fed with premises produces the necessary conclusions from them. The value of logical machines seems to lie in their showing how far reasoning is a mechanical process."

◆ 1887: "Precisely how much the business of thinking a machine could possibly be made to perform and what part of it must be left to the living mind is a question not without conceivable practical importance."

The First Manifesto of Artificial Intelligence

Alan M. Turing, 1912-1954

- ◆ 1948: *Intelligent Machinery*
  - ■ "I propose to investigate the question as to whether it is possible for machinery to show intelligent behaviour."
  - ■ Early connectionism – computing with networks: "unorganised machines", e.g., networks of neuron-like elements connected together in a largely random manner.
  - ■ No reference to McCulloch and Pitts, 1943.

"Computing Machinery and Intelligence"

◆ <u>Turing</u>, 1950: " I believe that at the end of the century the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted."

Crux of paper: A ***compelling*** philosophical analysis for the feasibility of intelligent machines + ***Imitation Game***

The Turing Gap

◆ Turing, 1950: "Computing Machinery and Intelligence"

- ■ "I believe that at the end of the century ... one will be able to speak of machines thinking without expecting to be contradicted."
- ■ "We may hope that machines will eventually compete with men in all purely intellectual fields."
- ■ "We can see plenty there that needs to be done."

◆ No discussion: What are the societal consequences of machine intelligence?

- ■ "Could" does not imply "should"!

Walter Pitts, 1923-1969

- **1935**: Read Principia Mathematica in three days, sent a letter to Russell pointing out what he considered serious problems with the first half of the first volume.

- **1941**: Started working with Warren McCulloch on Leibniz dream.

- **1943**: "A Logical Calculus of Ideas Immanent in Nervous Activity" – network of *perceptrons.*

- **1959**: "What the Frog's Eye Tells the Frog's Brain" -- analog processes in the eye were doing at least part of the interpretive work.

- **1969**: Died from alcoholism

Birth of AI Research

- Sept. 2, 1955: proposal by McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon.
    - "We propose that a 2-month, 10-man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College."
    - "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."
    - "We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer."

1958: The First AI Hype Cycle

◆ Frank Rosenblatt implements a single-layer network of perceptrons for image recognition (in SW and then in HW)

- ■ NYT: "the embryo of an electronic computer that [the Navy] expects will be able to walk, talk, see, write, reproduce itself and be conscious of its existence."

◆ **But**: single-layer networks were shown to be of *limited power*

◆ **Outcome**: First AI-Winter

Turing Awards

◆ 1969, Marvin Minsky – "For his central role in creating, shaping, promoting, and advancing the field of artificial intelligence"

◆ 1971, John McCarthy – "The Present State of Research on Artificial Intelligence" is a topic that covers the area in which he has achieved considerable recognition

◆ 1975: Allen Newell and Herbert A. Simon – "they have made basic contributions to artificial intelligence, the psychology of human cognition, and list processing"

Rise and Fall of Symbolic AI, 1960-1990

◆ LISP (McCarthy): 1960

◆ ELIZA (Weizenbaum): 1966

◆ SHRDLU (Winograd): 1969

◆ Shaky the Robot, Prospector (SRI): 1966-1972

◆ MYCIN (Shortliffe and Buchanan): 1975

◆ Nonmonotonic Reasoning (McCarthy): 1980

Fifth Generation Computer Systems

◆ 10-year initiative begun in 1982 by Japan's MITI to create computers using massively parallel computing and logic programming
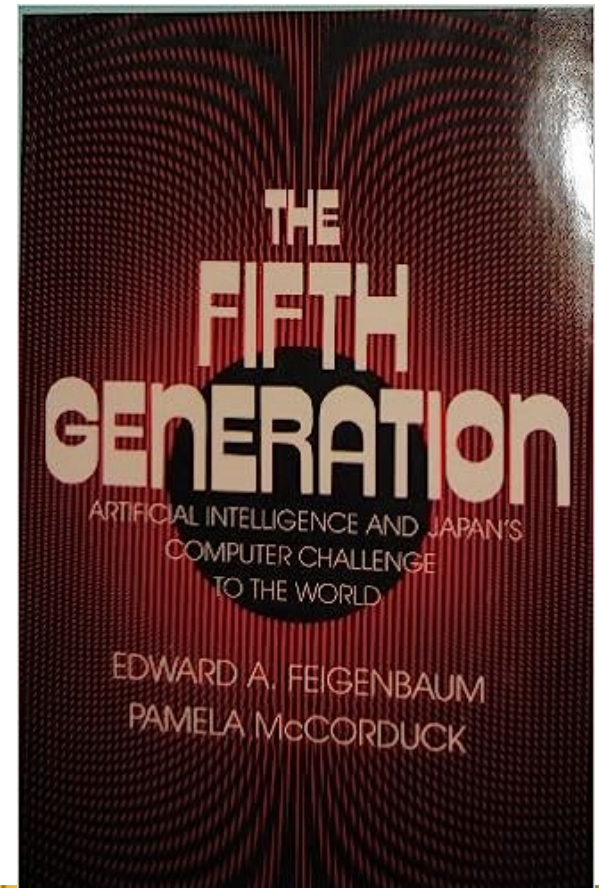
1980s: Revival of Neural Networks

Focus: not modeling brains, but creating useful devices.

◆ Hopfield, PNAS 1982: Neural networks and physical systems with emergent collective computational abilities.

◆ Hopfield, PNAS 1984: Neurons with graded response have collective computational properties like those of two-state neurons.

◆ 1987: Annual Conference on Neural Information Processing System (NeurIPS)

1990-2000s: The 2nd AI Winter

◆ Neural nets did not yet deliver

◆ 5th Generation project did not deliver.

◆ 1994 – **Turing Award**: Edward Feigenbaum and Raj Reddy for "pioneering the design and construction of large scale artificial intelligence systems"

◆ Continuing development of Machine Learning

◆ 2011 – **Turing Award**: Judea Pearl for "fundamental contributions to artificial intelligence through the development of a calculus for probabilistic and causal reasoning"

The Deep-Learning Revolution

◆ **Around 2010**: ANNs achieve superhuman performance on some tasks

◆ What happened?
  - Improved training algorithms
  - Improved architectures
  - Improved hardware (GPUs)
  - Larger datasets (i.e., social media)

◆ 2018: **Turing Award –** Bengio+Hinton+LeCun, "for conceptual and engineering breakthroughs that have made deep neural networks a critical component of computing"

The Generative-AI Revolution

◆ **Generative AI**: AI systems capable of generating text, images, or other media in response to prompts

◆ Driven by DL revolution
- 2017: **Transformer** model
- 2018: GPT
- 2019: GPT-2
- 2021: DALL-E
- 2022: ChatGPT (baed on GPT-3)
- 2023: GPT-4
- …

What is the purpose of AI?

◆ Leibniz: "Mankind will then posses a new instrument that will enhance the capabilities of the mind to a far greater extent than optical instruments strengthen the eyes." – **Intelligence Augmentation**

◆ Turing: Let's create machine that are indistinguishable from people – **Artificial Intelligence**

◆ Daniel Dennett, 2023: "Companies using AI to generate fake people are committing an immoral act of vandalism, and should be held liable."

Calvin and Hobbes