

Computational Intelligence



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Computational Intelligence

<https://github.com/squillero/10k/>

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version 2022.09



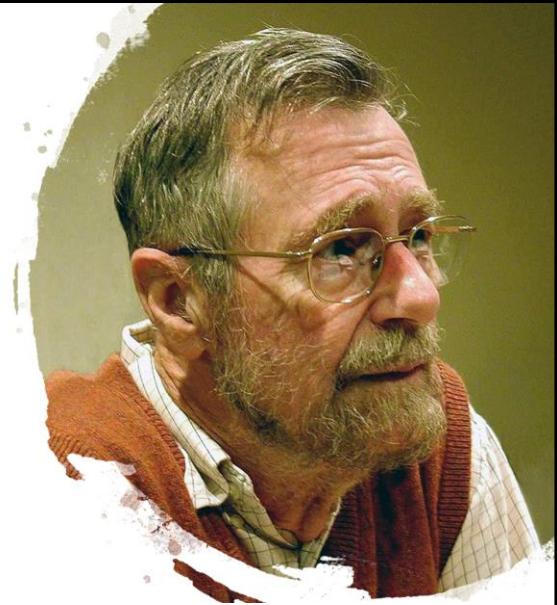
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Artificial Intelligence

- Artificial → Not natural, made as *a copy* of something natural
- Intelligence → ???
... but related to the ability to acquire, understand, and use knowledge
- Note: Humans are not intelligent because they solve problems, they solve problems because they are intelligent
- Intelligence requires **thinking** → AI requires *a copy* of thinking?

**The question of
whether a computer
can think is no more
interesting than the
question of whether a
submarine can swim**

— Edsger Wybe Dijkstra (1930-2002)



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Artificial Intelligence ≠ Artificial + Intelligence

- AI is a **non-compositional compound**
(or “non-compositional phraseme” or “idiom”)
- The meaning is not the predictable sum of the meanings of the component
- Other examples of NCC
 - “red herring”: something that distracts from a relevant question
 - “bull session”: an informal group discussion

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THINKING HUMANLY	THINKING RATIONALLY
ACTING HUMANLY	ACTING RATIONALLY

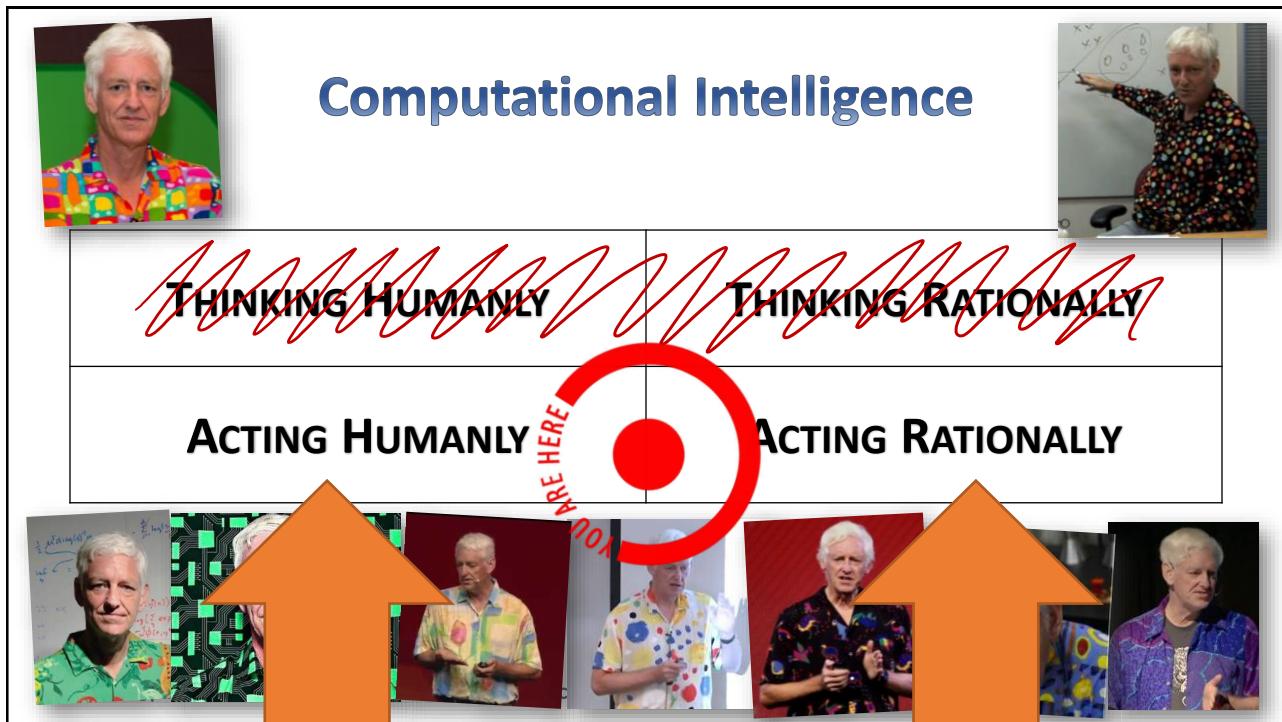
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THINKING HUMANLY	THINKING RATIONALLY
ACTING HUMANLY	ACTING RATIONALLY

The Society of Mind by Marvin Minsky

The Turing Option by Harry Harrison and Marvin Minsky

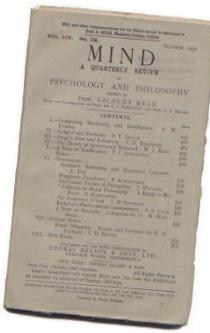
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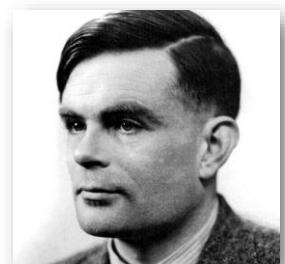
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Acting Humanly

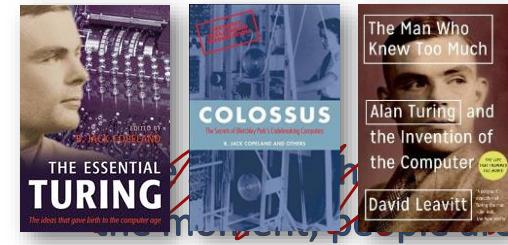
- “The study of how to make computers do things at which, at the moment, people are better” (Rich and Knight, 1991)
- “The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweil, 1990)
- Turing Test



“Computing Machinery and Intelligence”
A. M. Turing (1950), *Mind* 49: 433-460.



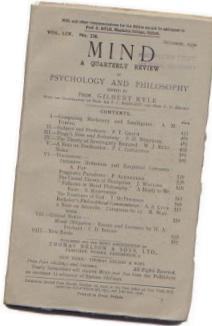
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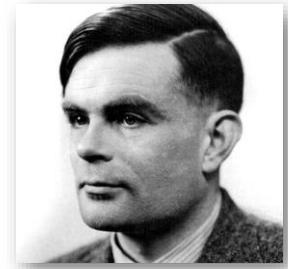
ing Humanly

~~"make computers do things at which, at the moment, people do better" (Rich and Knight, 1991)~~

- “The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweil, 1990)
- Turing Test



“Computing Machinery and Intelligence”
A. M. Turing (1950), *Mind* 49: 433-460.



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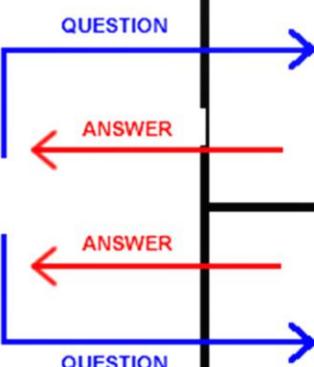
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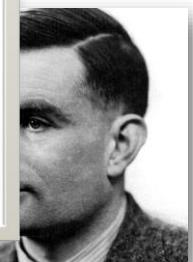


ROOM 1



ROOM 2

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)
hat
veil,



- “The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweil, 1990)
- Turing Test

A. M. Turing (1950), *Mind* 49: 433-460.

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Acting Humanly

- “The study of how to make computers do things at which, at the moment, people are better” (Rich and Knight, 1991)
- “The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweil, 1990)

Deep Blue 1996



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Watson 2011



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AlphaGo 2016



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Acting Rationally

- Norvig's *rational agents*
- “Computational Intelligence is the study of the design of intelligent agents” (Poole et al., 1998)
- Multi-agent systems



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Strong AI

VS.

Weak AI
Narrow AI



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- Solve problems by **searching**
 - Machine Learning
- **Human Learning**
 - Trial & Error
 - Evolution



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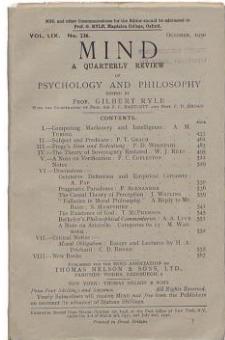
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Learning & Evolution

- Hereditary material → Structure of the child machine
- Mutation → Changes of the child machine
- Natural selection → Judgment of the experimenter



"Computing Machinery and Intelligence"
A. M. Turing (1950), *Mind* 49: 433-460.

There is an obvious connection between the learning process and evolution



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From Biology to Computer Science

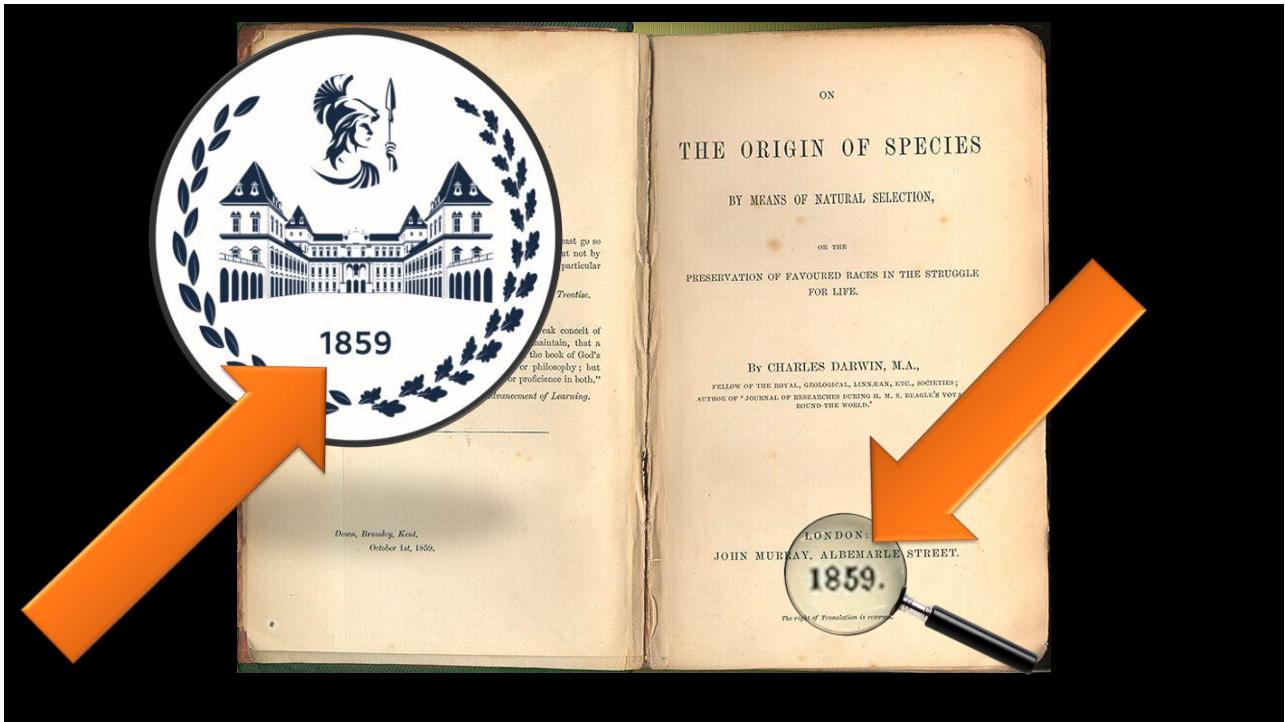


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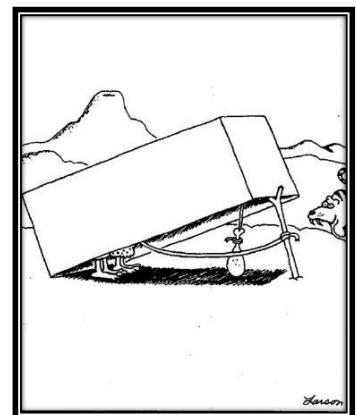
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Bio-Inspired & Population-Based Metaheuristics

- Evolution is **not** an **optimization** process
 - Evolution does **not** have a **goal**
 - Evolution does **not** favor **strength**
 - Evolution does **not** favor **intelligence**
- However,
- When all variations are accumulated in **one** specific **direction** the final outcome may look like the product of an **intelligent design!**

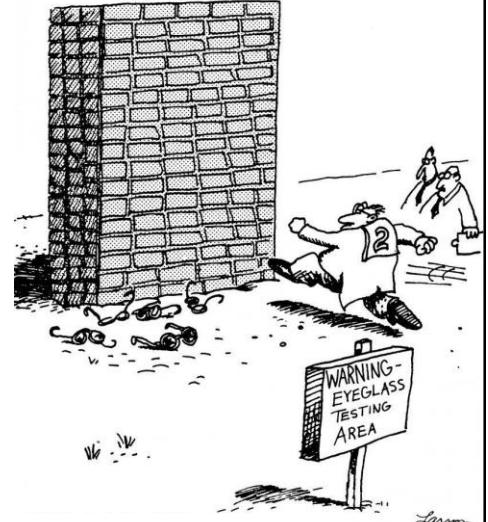


Computational Intelligence (01URROV)

- Single-State methods
 - E.g., Simulated Annealing
- Population methods
 - E.g., Genetic Algorithms
- Policy optimization
 - E.g., Q-Learning
- Representation problem
 - E.g., Fuzzy logic
- Multi agent systems

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Pop Quiz

- Picture yourself running in a street carrying a handful of hamsters
 - What problems do you expect?
 - How would you solve them?
 - Did you ever do it?
 - Did someone tell it to you?



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Ada Countess of Lovelace (1815–1852)

- Only child of Lord Byron
- First programmer in history

1842

The “computer” 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. Its province is to assist us in making available what we are already acquainted with...



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a bit of
HISTORY

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1943–1956: The Inception of AI

- Warren McCulloch and Walter Pitts
- Propositional logic (Russell & Whitehead)
- First network structures able to learn (Donald Hebb)
- Marvin Minsky & Dean Edmonds build a NN computer in 1950
- Alan Turing publish “Computing Machinery and Intelligence” in 1950
 - Credited for coining the term Artificial Intelligence
- 20 May on AI at in Hanover in 1956
 - McCarthy, Minsky, Shannon, Rochester, Newell, Simon, Samuel, Solomonoff, Selfridge...

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1952–1959: Early Enthusiasm

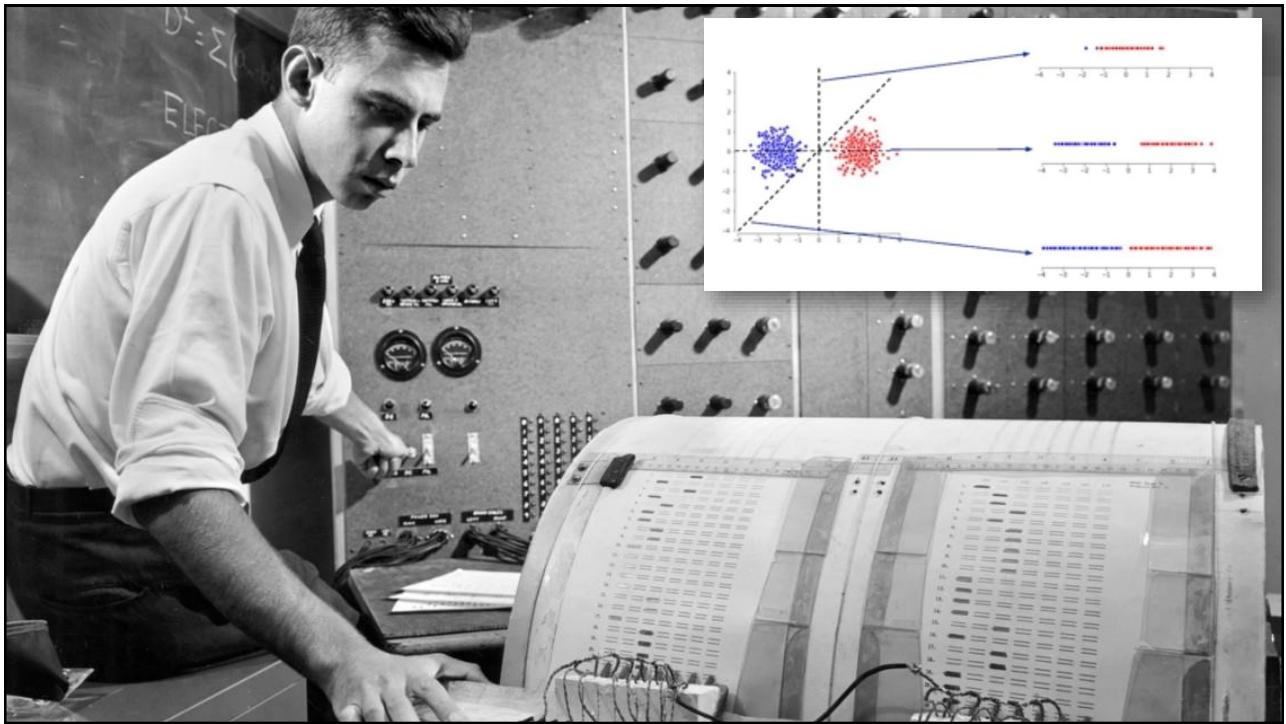
- Focus on tasks that would require intelligence in humans (games, puzzles, IQ tests)
 - The “Look, Ma, no hands!” era (John McCarthy)
- Newell & Simon’s
 - Logic Theorist: Theorem-proving system
 - General Problem Solver (GPS): Solver for a limited class of puzzles, but Machine Learning (1959)
 - Credited for coining the term GPS
- Arthur Samuel’s checkers in 1956
 - Embryonic RL
- Herbert Gelernter’s theorem prover in 1959

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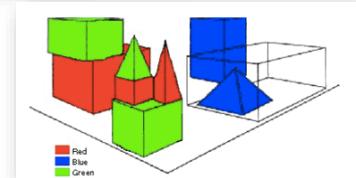


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1952–1959: Early Enthusiasm

- John McCarthy created Lisp in 1958
 - Try Scheme on Replit!
- McCarthy vs. Minsky
- Minsky's "microworld" (e.g., blocks world)

```
1 (display "Hello World")
2 (newline)
```



1960–1973: Back to Reality

The Spirit is willing
but the Flesh is weak



The Vodka is good
but meat is rotten

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1960–1973: Back to Reality

- Minksy publishes “Steps toward artificial intelligence” in 1961
- Failure to solve practical tasks
- Failure to tackle the “combinatorial explosion”
- XOR problem (“Evolutionary Computation” ; book “Perceptrons”, 1969)
- Birth of “Machine Evolution”

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1969–1986: Expert Systems

- General-purpose vs. “Weak” methods
- Bruce Buchanan and friend’s DENDRAL in 1969
 - Able to infer molecular structures from mass spectra
 - Not simple brute force, first *knowledge-intensive system*
- Minsky’s frames (1975)

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1986–now: The Return of NN

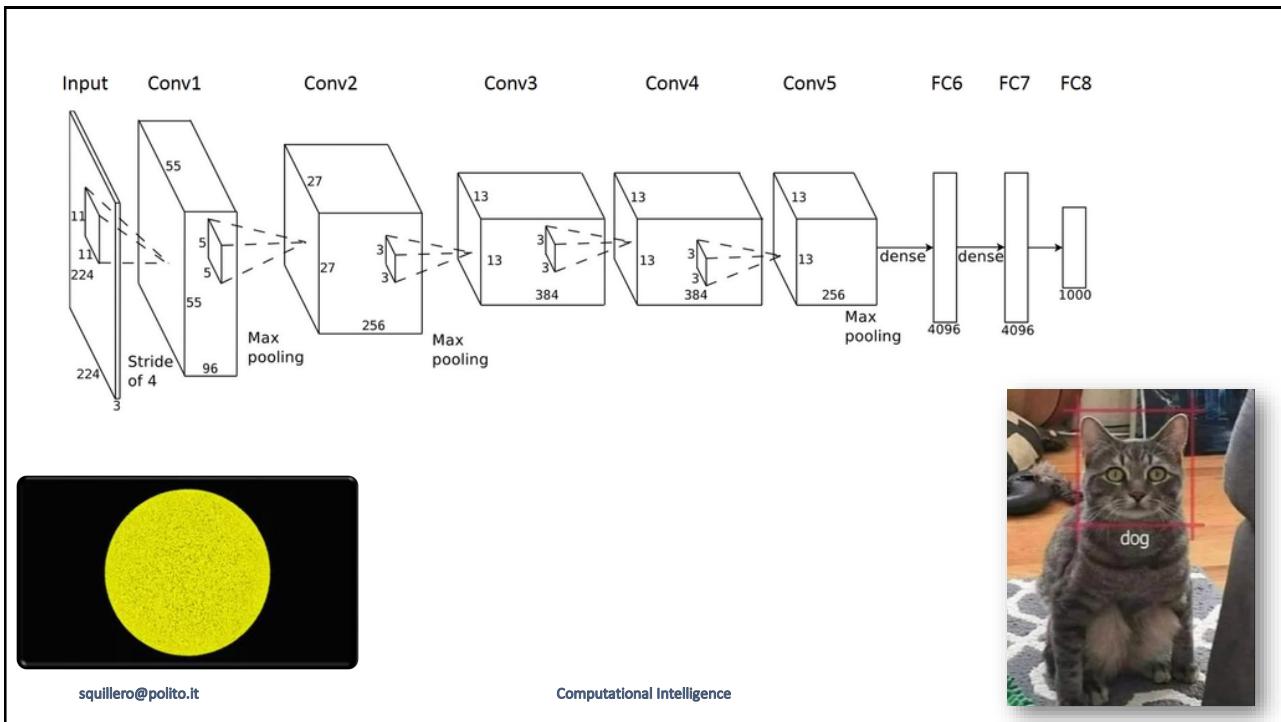
- The re-invention of back-propagation (Leibniz, 1676; Kelley, 1960; Bryson, 1961; Dreyfus, 1962; Linnainmaa, 1970)
- Big data (since 2001?)
- Deep Learning (since 201?)

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?-now: Probabilistic Reasoning

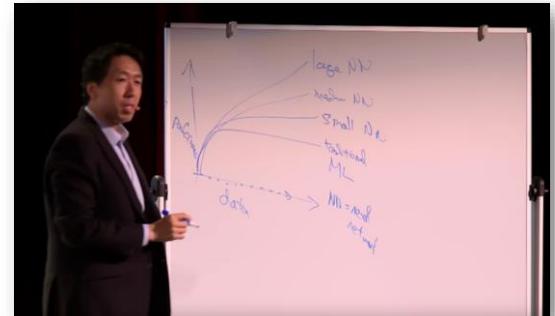
- Mostly ML's topics
- Lotfi Zadeh's Fuzzy Logic in 1965
- Leonard Baum's Hidden Markov Models in late 1960s
- Judea Pearl coined the term “Bayesian Networks” in 1985

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1996–now: Crunching data

- Deep Blue defeated Garry Kasparov in 1996
- “Probably we can now (or we will soon be able to) automate almost everything that a human can do in less than a second of thought”

— Andrew Ng (2018)



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Deep Blue was intelligent the way your programmable alarm clock is intelligent.

— Gary Kasparov, *Deep Thinking: Where Machine Intelligence Ends and Human Creativity Begins*, 2017

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Artificial Intelligence

- My programmable alarm clock **understood** that it should wake me up at 6:30 this morning !?





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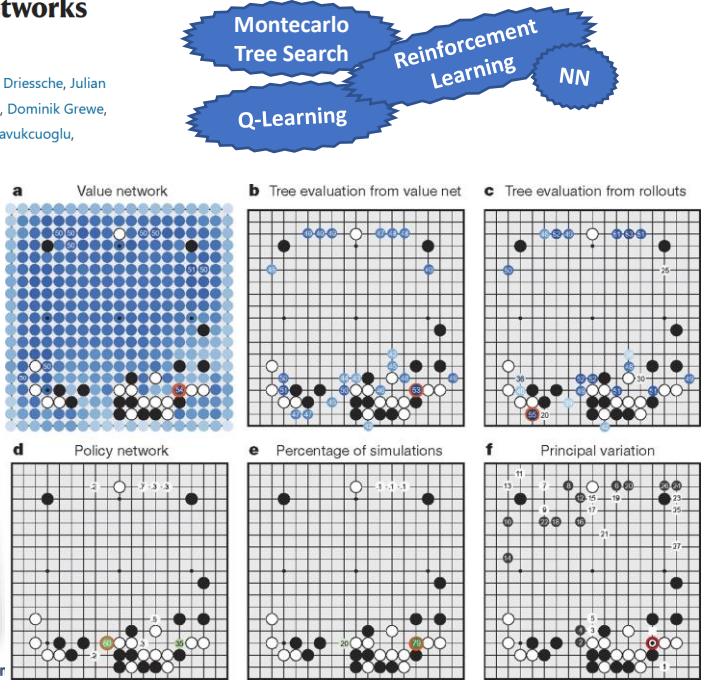
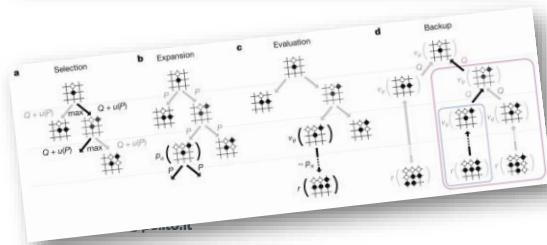
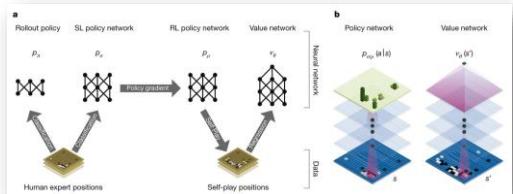


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Mastering the game of Go with deep neural networks and tree search

David Silver Aja Huang, Chris J. Maddison, Arthur Guez, Laurent Sifre, George van den Driessche, Julian Schrittwieser, Ioannis Antonoglou, Veda Panneershelvam, Marc Lanctot, Sander Dieleman, Dominik Grewe, John Nham, Nal Kalchbrenner, Ilya Sutskever, Timothy Lillicrap, Madeleine Leach, Koray Kavukcuoglu, Thore Graepel & Demis Hassabis

Nature 529, 484–489 (2016)



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Complex ≠ Intelligent

- **The Game of Life**, created by John Horton Conway (1970)
 - Repeated applications of simple rules may lead to unforeseeable results
 - Complex properties arise from simple laws



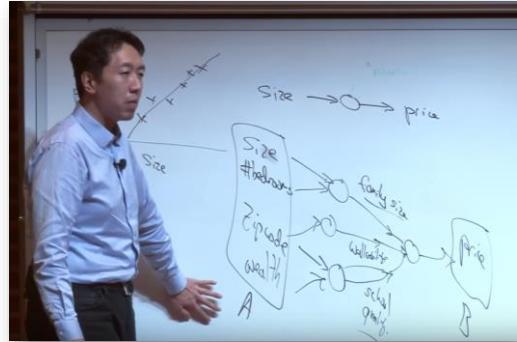
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- AI winter is coming



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- AI is the new electricity



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