Artificial Intelligence

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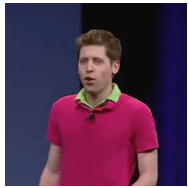
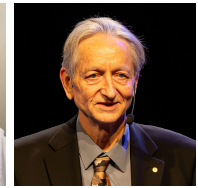
These people are wrong.





To be fair, there are many, many people who are wrong about AI. But you probably recognize these guys.

- The emergence of "human-level AI" has been "just a few years away" since 1956. All of these predictions have been wrong.

Why does it matter that they're wrong?

We are decades, perhaps centuries away from "solving" AI.

- AI is immature.
- Currently, unfortunately, overhyped.

See my advisor's advisor's dated predictions:

https://rodneybrooks.com/my-dated-predictions/

- Most of the truly groundbreaking discoveries in AI are yet to be made.

This makes AI exciting!

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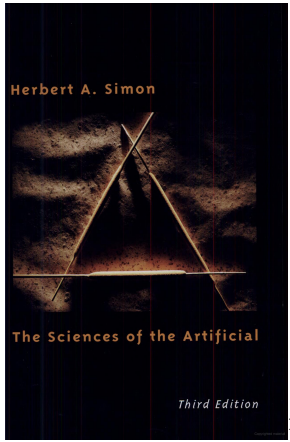
What does this mean for us?

- If most of the breakthroughs are yet to be made, then
  - *we don't even have the right* ***paradigm*** *yet.*
- Many AI courses focus on *the current thing*, focusing on statistical machine learning, and neural networks in particular.
  - This does a disservice to students!
- This course the full spectrum of AI so that you're ready to spot and develop promising new directions.
  - We'll spend little time on machine learning, and barely touch on neural networks.
    - We have entire courses for those subjects!

What is AI?



[1]

Artificial
- Man-made. Syntehetic.

Intelligence
- Problem solving, inference, decision making, learning.

Rationality
- Doing the right thing.

[1] https://mitpress.mit.edu/9780262691918/the-sciences-of-the-artificial/

Four Approaches to AI

Decompose AI into thinking and acting, and define standards of performance as fidelity to humans and quanitative rationality.

		Standard	
		Humanly	Rationally
Mode	Acting	Acting humanly	Acting rationally
	Thinking	Thinking humanly	Thinking rationally

Thinking is nothing more than acting in an imagined space.
– Konrad Lorenz via Bernhard Schölkopf

Acting humanly

Turing test

- Natural language processing
- Knowledge representation
- Automated reasoning
- Machine learning

Total Turing test

- Computer vision
- Robotics

Nobody cares about Turing tests.

Thinking humanly

Cognitive modeling

Acting rationally

Rational agent

Thinking rationally

"Laws of thought"

Beneficial machines

Value alignment

Foundations of AI

- Philosophy
- Mathematics
- Neuroscience
- Psychology
- Computer Engineering
- Control theory and cybernetics
- Linguistics

Such a rich tapestry!

Philosophy

- Can formal rules be used to draw valid conclusions?
- How does the mind arise from a physical brain?
- Where does knowledge come from?
- How does knowledge lead to action?

Mathematics

- What are the formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?
- Logic
- Probability and statistics
- Algorithms, computability and complexity
- Optimization

Economics

Acting rationally

- How should we make decisions in accordance with our preferences?
- How should we do this when others may not go along?
- How should we do this when the payoff may be far in the future?

Neuroscience

How do brains process information?

	Supercomputer	Personal Computer	Human Brain
Computational units	10^6 GPUs + CPUs	8 CPU cores	10^6 columns
	10^{15} transistors	10^{10} transistors	10^{11} neurons
Storage units	10^{16} bytes RAM	10^{10} bytes RAM	10^{11} neurons
	10^{17} bytes disk	10^{12} bytes disk	10^{14} synapses
Cycle time	10^{-9} sec	10^{-9} sec	10^{-3} sec
Operations/sec	10^{18}	10^{10}	10^{17}

Psychology

How do humans and animals think and act?

- Acting humanly

Computer Engineering

How can we build an efficient computer?

- HPC
- Quantum computing

Control theory and cybernetics

How can artifacts operate under their own control?

Linguistics

How does language relate to thought?

History of AI

Turing award winners:

- Marvin Minsky (1969)
- John McCarthy (1971)
- Allen Newell and Herbert Simon (1975)
- Ed Feigenbaum and Raj Reddy (1994)
- Judea Pearl (1994)
- Yoshua Bengio, Geoffrey Hinton, and Yann LeCun (2019)

MucCulloch, Pitts, Hebb (1943-1949)

- Perceptrons
- Hebbian learning

1956 Dartmouth AI Workshop

Organized by John McCarthy, Marvin Minsky, Claude Shannon, Nathaniel Rochester

Attendees:

Allen Newell and Herbert Simon from Carnegie Tech, Trenchard More from Princeton, Arthur Samuel from IBM, and Ray Solomonoff and Oliver Selfridge from MIT

Logic Theorist

Symbolic AI (1952-1969)

- Lisp

First AI Winter (1966-1973)

Lighthill report (Lighthill, 1973) – British government ended most AI funding

Expert Systems (1969-1986)

DENDRAL MYCIN SHRDLU Frames

Second AI Winter (1986)

Experts systems failed to deliver on their inventors' promises.

Knowledge acquisition bottleneck.

Adaptability, brittleness.

Return of neural networks (1986-present)

Symolism vs Connectionism

Geoff Hinton, et. al.

Probabilistic reasoning and machine learning (1987-present)

Neats vs scruffies

Big data (2001-present)

Large data sets – don't fit on a single machine

Deep learning (2011-present)

CNN DRL (AlphaGo)

The State of the Art

AI Index Highlights from 2019:

- Publications: AI papers increased 20-fold between 2010 and 2019 to about 20,000 a year. The most popular category was machine learning. (Machine learning papers in arXiv.org doubled every year from 2009 to 2017.) Computer vision and natural language processing were the next most popular.
- Sentiment: About 70% of news articles on AI are neutral, but articles with positive tone increased from 12% in 2016 to 30% in 2018. The most common issues are ethical: data privacy and algorithm bias.
- Students: Course enrollment increased 5-fold in the U.S. and 16-fold internationally from a 2010 baseline. AI is the most popular specialization in Computer Science.
- Diversity: AI Professors worldwide are about 80% male, 20% female. Similar numbers hold for Ph.D. students and industry hires.
- Conferences: Attendance at NeurIPS increased 800% since 2012 to 13,500 attendees. Other conferences are seeing annual growth of about 30%.
- Industry: AI startups in the U.S. increased 20-fold to over 800.
- Internationalization: China publishes more papers per year than the U.S. and about as many as all of Europe. However, in citation-weighted impact, U.S. authors are 50% ahead of Chinese authors. Singapore, Brazil, Australia, Canada, and India are the fastest growing countries in terms of the number of AI hires.
- Vision: Error rates for object detection (as achieved in LSVRC, the Large-Scale Visual Recognition Challenge) improved from 28% in 2010 to 2% in 2017, exceeding human

Robotic Vehicles

Legged Locomotion

Autonomous planning and scheduling

Machine Translation

Speech Recognition

Recommendations

Game Playing

Image Understanding

Medicine

Climate Science

Cambrian Intelligence

Rodney Brooks
https://www.amazon.com/Cambrian-Intelligence-Early-History-New/dp/0262522632/