Artificial Intelligence

Christopher Simpkins

Kennesaw State University

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.

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/

What does this mean for us?

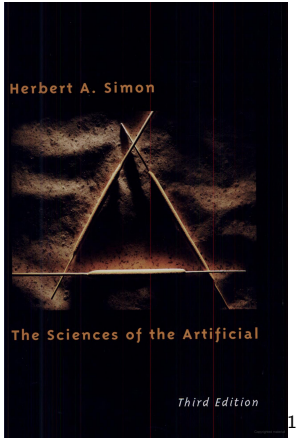
- Many AI courses focus on *the current thing*, e.g., statistical machine learning, and neural networks.
- This course covers the full spectrum of AI so that you're ready to spot and develop promising new directions.
  - We'll spend little time on machine learning, and barely touch on neural networks.
    - We have entire courses for those subjects!

Why does it matter that the aforementioned hypers are wrong?

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

This makes AI exciting!

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 quantitative rationality.

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

Acting humanly

Turing test

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

Total Turing test

- Computer vision
- Robotics

Nobody cares about Turing tests.

Rationality

"Doing the right thing."

- Acting rationally - goal maximizing behavior
  - Choosing actions which reach goals with minimal cost
  - Choosing actions which maximize a payoff relative to other agents
  - Choosing actions which maximize long-term expected reward
- Thinking rationally - "laws of thought"
  - Logic
  - Probabilistic inference

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

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?

- Cognitive modeling
- Behaviorism
  - Operant conditioning
  - "Reinforcement learning"

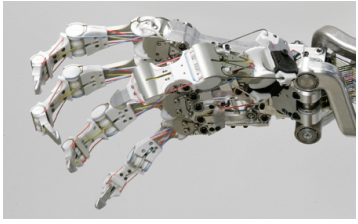
Computer Engineering

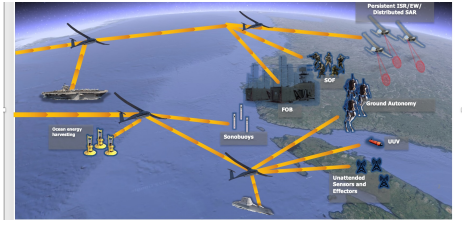
How can we build an efficient computer?

- High performance computing
  - Today's LLMs take years of compute time to train.
- Quantum computing

Control theory and cybernetics

How can artifacts operate under their own control?





DARPA POWER Program

Impact 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)
- Rich Sutton and Andrew Barto (2024)

AI lament: once an AI problem is solved, it's no longer considered AI.

History of AI

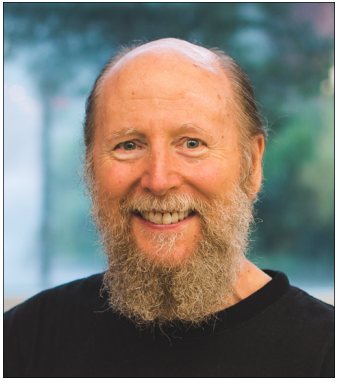
- MucCulloch, Pitts, Hebb (1943-1949)
  - Perceptrons
  - Hebbian learning
- 1956 Dartmouth AI Workshop
  - Organized by John McCarthy, Marvin Minsky, Claude Shannon, Nathaniel Rochester
  - Attended by Allen Newell and Herbert Simon from Carnegie Tech, Trenchard More from Princeton, Arthur Samuel from IBM, and Ray Solomonoff and Oliver Selfridge from MIT
- Symbolic AI (1952-1969) – "clever Lisp programs"
- First AI Winter (1966-1973)
  - Lighthill report (Lighthill, 1973) – British government ended most AI funding
- Expert Systems (1969-1986)
- Second AI Winter (1986)
  - Experts systems failed to deliver on their inventors' promises.
  - Knowledge acquisition bottleneck.
  - Adaptability, brittleness.

Modern AI

- Return of neural networks (1986-present)
  - Symbolism vs Connectionism
  - Geoff Hinton, et. al.
- Probabilistic reasoning and machine learning (1987-present)
  - Neats vs scruffies
  - "Physics envy"
- Big data (2001-present)
  - Large data sets – don't fit on a single machine
- Deep learning (2011-present)
  - You may have heard of it?

Future of AI

Andrew Barto



Rich Sutton

David Silver

The Era of Experience