



Introduction to Artificial Intelligence

CS4881 Jay Urbain

Outline

- Course overview
- What is AI?
- A brief history
- The state of the art

CS4881

Format:

- Two lectures per week + one 2-hour lab per week.
- Reserve right to schedule lecture and lab time during any period to best meet the needs of the class.
- Will be out of town week 3.

Course Topics

<https://github.com/jayurbain/artificial-intelligence>

What is AI?

What is AI?

Colloquial Definition

- Intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and other animals.
- When a machine mimics "cognitive" functions that humans associate with other human minds, such as "learning" and "problem solving."

What is AI?

Computer Science Definition

- AI - research as the study of *intelligent agents*:
 - Any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals.

What is AI?

Views of AI?

What is AI?

Views of AI fall into four categories:

Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

What is AI?

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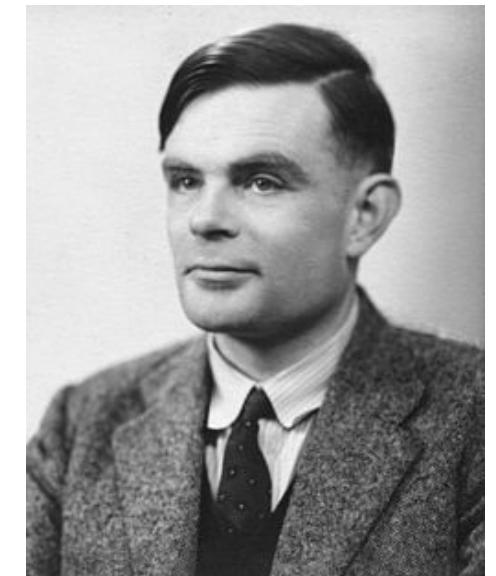
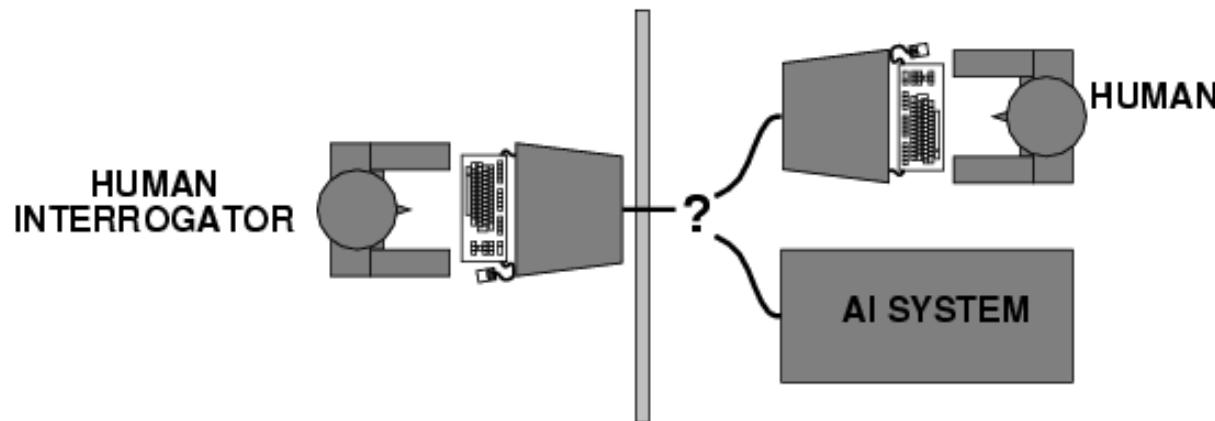
Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

Advocate an agent-based approach where agents act rationally

Acting humanly: Turing Test

- Turing (1950) "Computing machinery and intelligence": "Can machines think?" → "Can machines behave intelligently?"
- Operational test for intelligent behavior:
 - **Imitation Game (Turing Test).**

Alan Turing



Acting humanly: Turing Test

- Turing predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes.
- Turing anticipated most major arguments against AI in following **50 years**.
- Suggested major components of AI:
 - natural language understanding
 - knowledge representation
 - automated reasoning
 - machine learning

Thinking humanly: cognitive modeling

- 1960s "cognitive revolution": information-processing psychology.
- Requires scientific theories of internal activities of the brain.



- How to validate? Requires:
 - 1) Predicting and testing behavior of human subjects (top-down)
or
 - 2) Direct identification from neurological data (bottom-up).
- Both approaches (Cognitive Science and Cognitive Neuroscience) can be thought of as distinct from AI – however there is a growing interdependence.

Thinking rationally: "laws of thought"

- Aristotle: what are correct arguments/thought processes?
- Syllogisms:
 - Several Greek schools developed various forms of *logic: notation and rules of derivation for thoughts.*
 - May or may not have proceeded to the idea of mechanization.
- Direct line through mathematics and philosophy to computer science and modern AI. Problems:
 1. Not all intelligent behavior is mediated by logical deliberation.
 2. What is the purpose of thinking? What thoughts should I have?

Syllogism: form of reasoning in which a conclusion is drawn

Acting rationally: rational agent

- **Rational behavior:** ??

Acting rationally: rational agent

- **Rational behavior**: doing the right thing.
- **The right thing**: that which is expected to *maximize goal achievement*, given the available information.
- Doesn't necessarily involve thinking – e.g., blinking reflex – but thinking should be in the service of *rational* action.

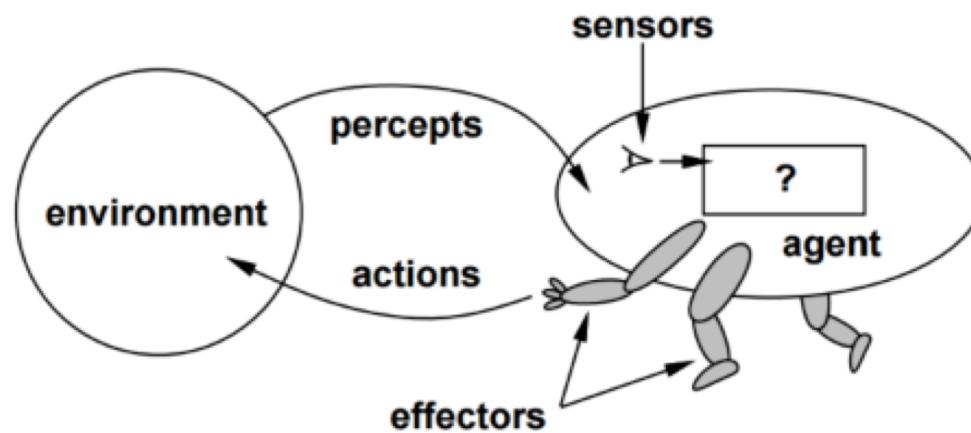
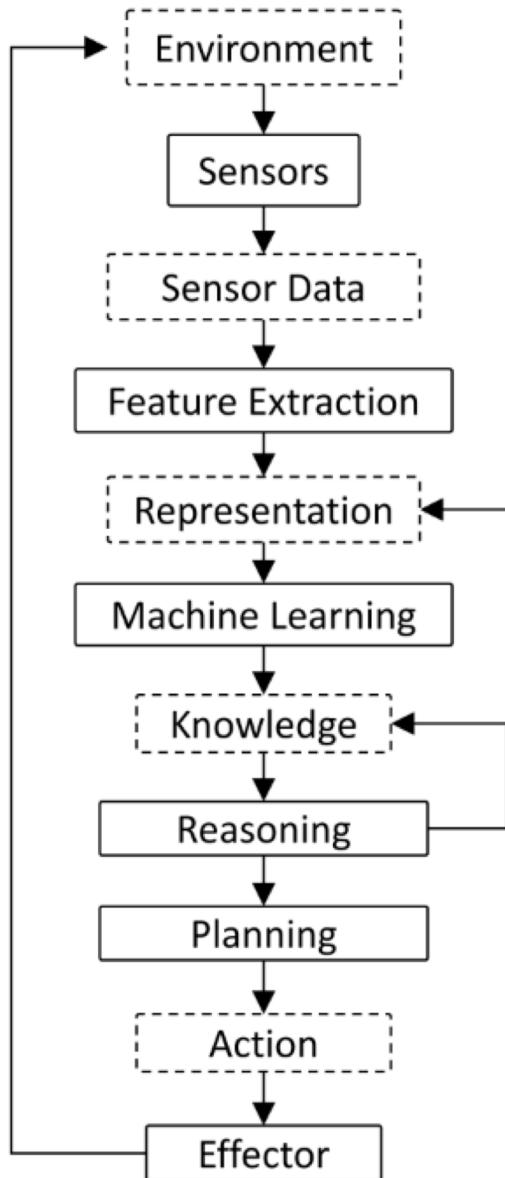
Rational agents

- An *agent* is an entity that perceives and acts.
- This course is about designing *rational* agents.
- Abstractly, an agent is a *function mapping percept histories to actions*:

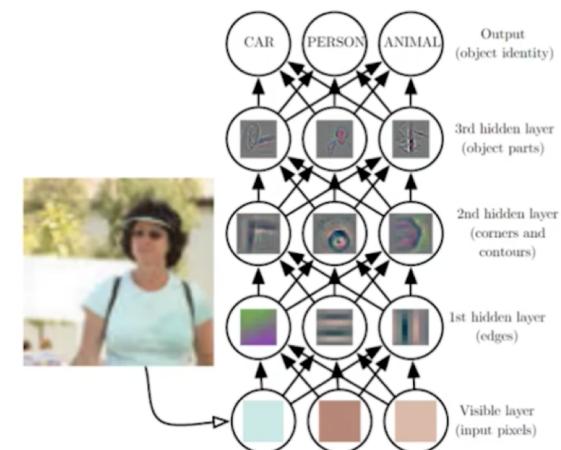
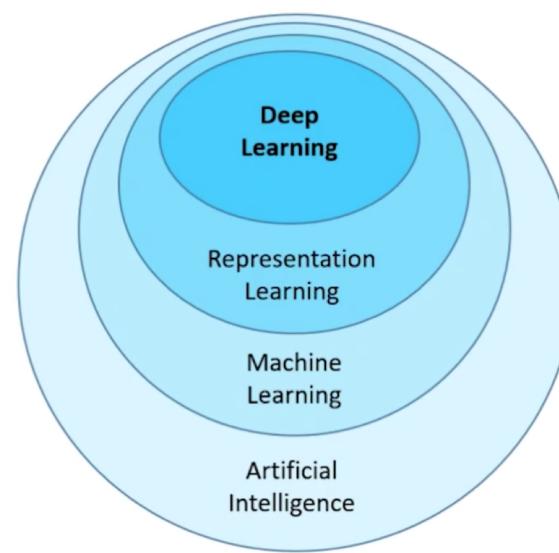
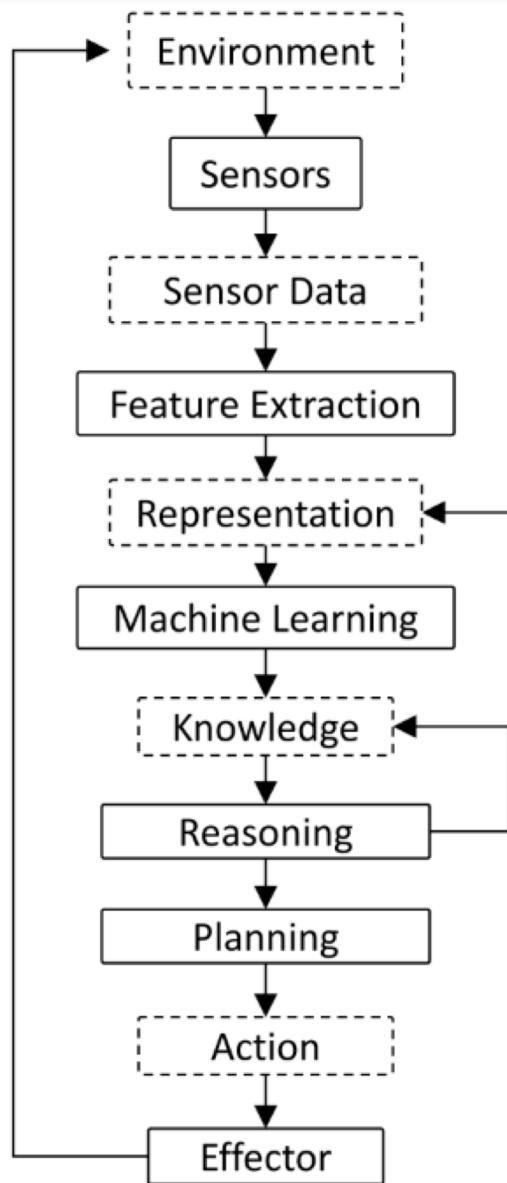
$$[f: \mathcal{P}^* \rightarrow \mathcal{A}]$$

- For any given class of environments and tasks, we seek the agent (or class of agents) with the *best performance*.
- Caveat: computational limitations make perfect rationality unachievable!
 - design best *program* for given machine resources.
 - ... and what is *best*?

Engineering Intelligence – What can be learned by interacting with your environment?



Engineering Intelligence



Definitions of AI

- The term "Artificial Intelligence" was first coined by Prof. John McCarthy for a Conference on the subject held at Dartmouth in 1956.
- McCarthy defines the subject as the "*science and engineering of making intelligent machines*, especially intelligent computer programs".

John McCarthy



Definitions of AI

- Q. What is artificial intelligence?
- A. It is the science and engineering of ***making intelligent machines***, especially intelligent computer programs. It is related to the similar task of ***using computers to understand human intelligence***, but AI does not have to confine itself to methods that are biologically observable.
- Q. Yes, but what is intelligence?
- A. ***Intelligence is the computational part of the ability to achieve goals in the world.*** Varying kinds and degrees of intelligence occur in people, many animals and some machines.

John McCarthy



Definitions of AI

- Exactly what the computer provides is the ability not to be rigid and unthinking , but rather to ***behave conditionally***. That is what it means to ***apply knowledge to action***: It means to ***let the action taken reflect knowledge of the situation***, to be sometimes this way, sometimes that, as appropriate. . . .
- In sum, technology can be controlled especially if it is saturated with intelligence to watch over how it goes, to keep accounts, to prevent errors, and to provide wisdom to each decision.
- - Allen Newell, from *Fairy Tales*

Allen Newell



Definitions of AI

- "AI can be defined as the attempt to get real machines to behave like the ones in the movies."
- This may give an inkling of what a lot of AI research involves, but it *leaves out important facets of AI*, especially its scientific aspects.
- No short definition adequately captures the variety of research goals and topics covered by AI.
- Aaron Sloman
School of Computer Science, The University of Birmingham

AI prehistory

Grounded in computer science, but has drawn from many fields:

- ▶ Philosophy Logic, methods of reasoning, mind as physical system, foundations of learning, language, rationality.
- ▶ Mathematics Formal representation and proof algorithms, computation, (un) decidability, (in) tractability, probability.
- ▶ Economics How people make choices that lead to preferred outcomes = utility, decision theory, game theory.
- ▶ Neuroscience Physical substrate for mental activity.
- ▶ Psychology Phenomena of perception and motor control, experimental techniques.
- ▶ Computer engineering Building fast computers.
- ▶ Control theory Systems that maximize an objective function over time.
- ▶ Linguistics/NLP Knowledge representation, grammar.

Abridged history of AI

- 1943 McCulloch & Pitts: Boolean circuit model of brain.
- 1950 Turing's "Computing Machinery and Intelligence."
- 1951 Minsky & Edmonds build first neural computer SNARC.
- **1956** Dartmouth meeting: McCarthy, Minsky, Shanon, etc. –
"Artificial Intelligence" adopted.
- 1950s Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine, GPS(59), Lisp(58).
- 1952-69 Early enthusiasm “Look Mom no hands era.”
- 1965 Robinson's complete algorithm for logical reasoning.
- 1966-73 AI discovers computational complexity.
Neural network research almost disappears.
- 1969-79 Early development of knowledge-based systems.
- 1980- AI becomes an industry, AI Winter.
- 1986- Neural networks return to popularity
- 1987- AI becomes a science.
- 1995- The emergence of intelligent agents.
- 2000- Biologically inspired algorithms gain popularity, deep learning, probabilistic models
Internet -> Big data, Deep Learning, search, NLP.

The Singularity is Near: When machines transcend humans, Ray Kurzweil, 2005.

- ▶ That a technological-evolutionary point known as "the singularity" exists as an achievable goal for humanity. Kurzweil predicts 2045.
- ▶ Exact nature of the point is an arbitrarily high level of technology where **machines exceed the intelligence capability of humans**.
- ▶ Through the law of accelerating returns, technology is progressing toward the singularity at an exponential rate.
- ▶ That the functionality of the human brain is quantifiable in terms of technology something we can build in the near future.
- ▶ That medical advancements could keep a significant number of his generation (Baby Boomers) alive long enough for the exponential growth of technology to intersect and surpass the processing of the human brain.

The Singularity is Near

All four of Kurzweil's primary postulates must be correct in order for his conclusion to be true.

1. Acceptance and striving for the idea of living forever
2. The law of accelerating returns
3. An objective measurement of cerebral processing power
4. Sufficient medical advancements
 - [nanobots](#) will eventually be able to repair and replace any part of the body that wears out, relies on other methods of medical technology to prolong our lives long enough to reach the singularity.
 - Possibility of quantum brain processing in many recent books, such as [Roger Penrose's *The Road to Reality: A Complete Guide to the Laws of the Universe*](#), cast doubt.

Singularity Epochs

- Epoch 1. Physics and Chemistry
- Epoch 2. Biology and DNA
- Epoch 3. Brains
- Epoch 4. Technology
- Epoch 5. The Merger of Human Technology with Human Intelligence
- Epoch 6. The Universe Wakes Up

The Universe Wakes Up

- After mastering the methods of technology and biology, Kurzweil predicts that human/machine civilization will expand its frontiers into the universe, gradually (or perhaps explosively) consuming the contents of the cosmos until *the universe reaches a 'saturated' state where all inanimate matter has been converted to substrates for computation and intelligence*, and a truly universal super-intelligence takes form.

The Singularity is Near

Vinge Video

- http://www.spectrum.ieee.org/sing_vinge

Major AI related milestones

- 1956 – The Dartmouth Conference
- 1966 – ELIZA gives computers a voice
- 1980 – XCON and the rise of useful AI
- 1988 – A statistical approach to language translation
- 1991 – The birth of the Internet
- 1997 – Deep Blue defeats world chess champion Garry Kasparov
- 2005 – The DARPA Grand Challenge
- 2011 – IBM Watson’s Jeopardy! Victory
- 2012 – The true power of deep learning is unveiled to the world – computers learn to identify cats
- 2015 – Machines “see” better than humans
- 2016 – AlphaGo goes where no machine has gone before
- 2018 – Self-driving cars hit the roads
- 2018 – Deep learning outperforms humans in several NLP tasks

DARPA Grand Challenge



On October 8, 2005, the Stanford Racing Team's Autonomous Robotic Car, Stanley, Won the Defense Advanced Research Projects Agency's (DARPA) Grand Challenge.

Photo courtesy, DARPA.

The car traversed the off-road desert course southwest of Las Vegas in a little less than seven hours.

Mars Rover



Mars Rover.

Photo Courtesy, NASA

Current topics

- **IBM Watson (2010)**
- IBM conducted a series of sparring matches to help prepare Watson for the *Jeopardy!* challenge. These began with the system facing average players and evolved into a 55 match series against Tournament of Champions-level contestants.
- http://www-03.ibm.com/innovation/us/watson/?cn=agus_watson-20100712&cm=k&csr=google&cr=ibm_watson&ct=USJWK002&S_TACT=USJWK002&ck=ibm_watson&cmp=00000&mwid=s2pC4IYkl_15714889053_432n0d3749

Current topics

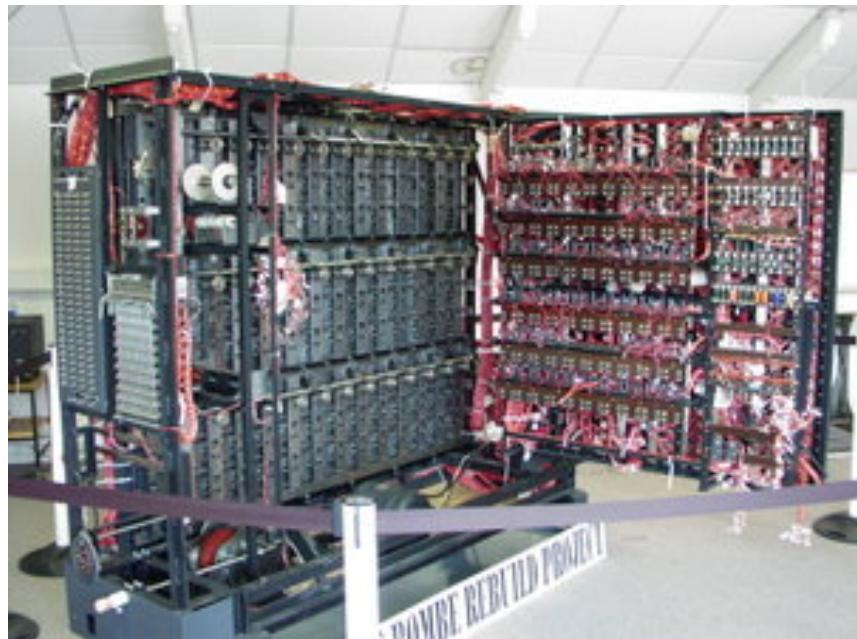
- Scientists See Promise in Deep-Learning Programs
- *(11/23/2013) John Markov, NY Times*

Using an artificial intelligence technique inspired by theories about how the brain recognizes patterns, technology companies are reporting startling gains in fields as diverse as computer vision, speech recognition and the identification of promising new molecules for designing drugs.

- http://www.nytimes.com/2012/11/24/science/scientists-see-advances-in-deep-learning-a-part-of-artificial-intelligence.html?hp&_r=0



AI Pioneers – Alan Turing



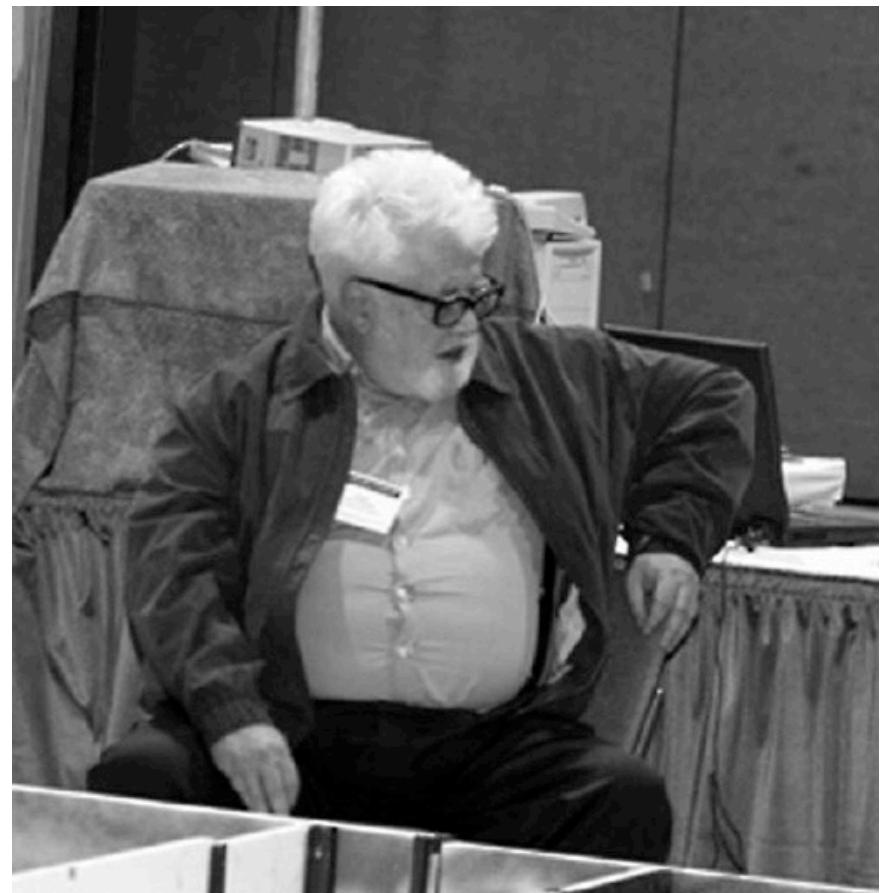
Bombe machine used to crack
German WWII Enigma



AI Pioneers

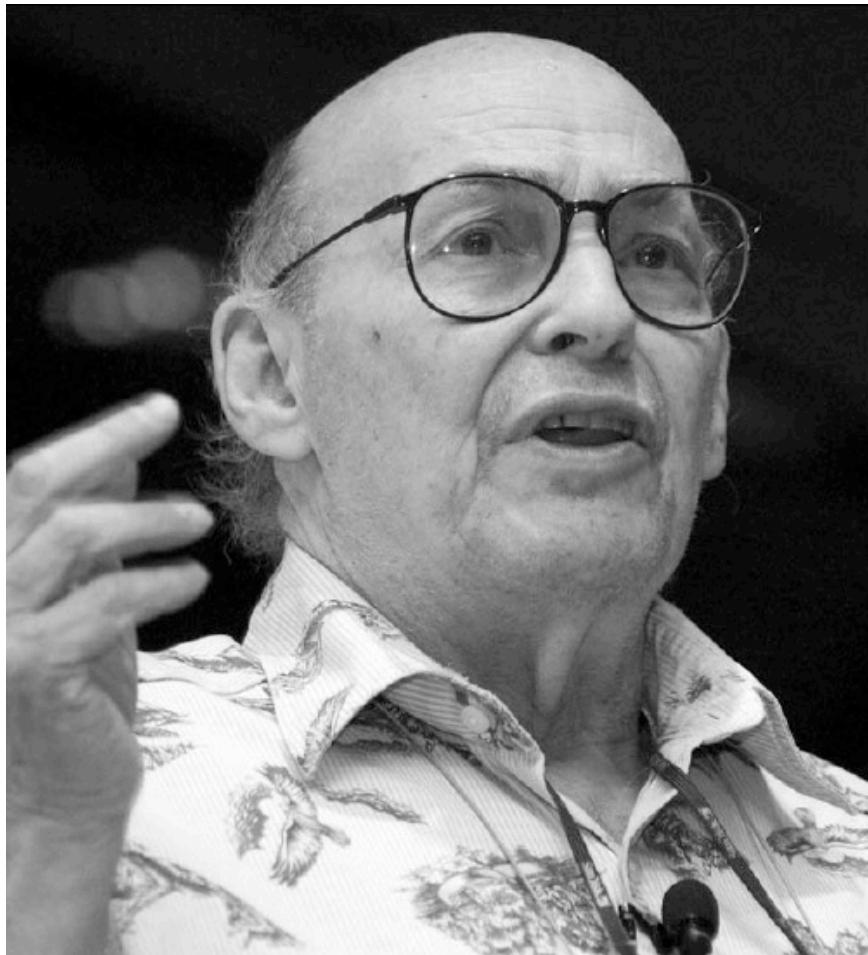


Herb Simon.

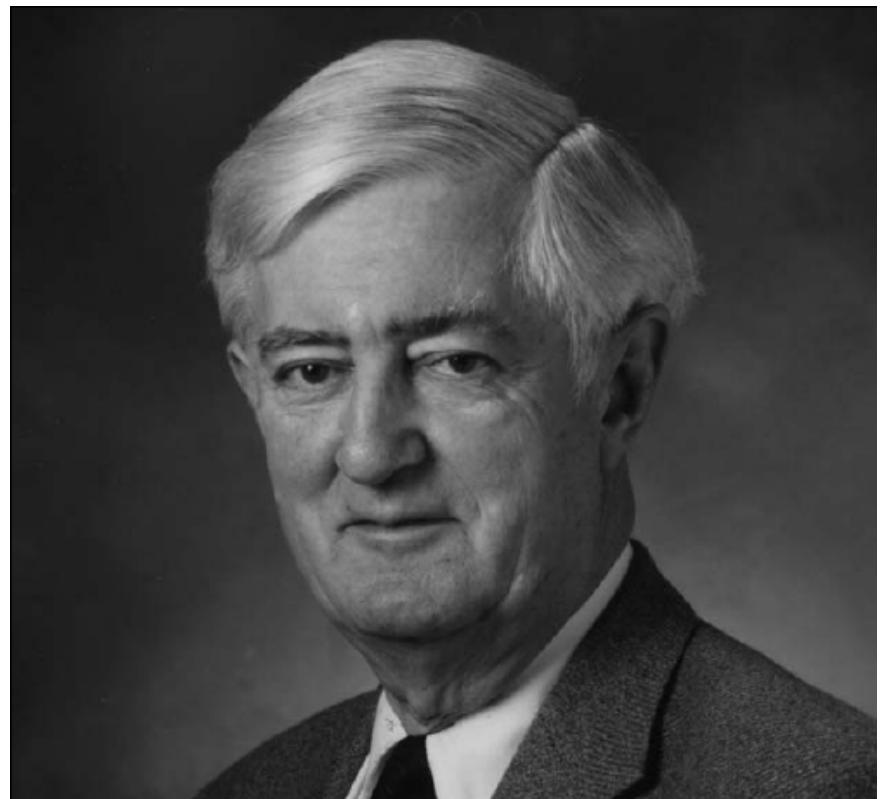


John McCarthy.

AI Pioneers



Marvin Minsky.



Oliver Selfridge.

AI Pioneers



*Photograph Courtesy, National Library of Medicine
The Original Dendral Team, Twenty-Five Years Later.*



Donald Michie.