Introduction to Artificial Intelligence

CS4881 Jay Urbain

Outline

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

CS4881

Format:

- Two 1-hour lectures per week + one 2-hour lab period.
- Reserve right to schedule lecture and lab time during any period to best meet the needs of the class.

Course Topics

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

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?

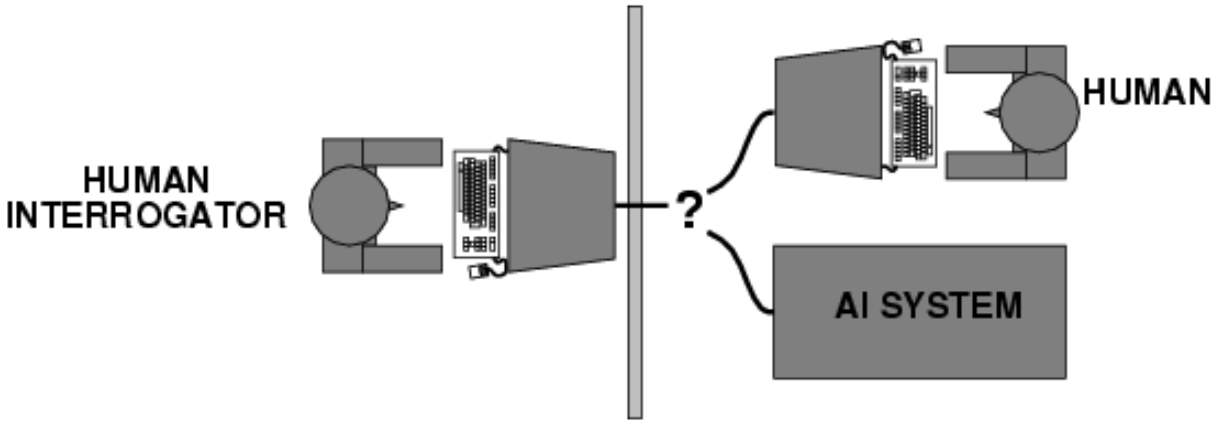
Views of AI fall into four categories:

Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

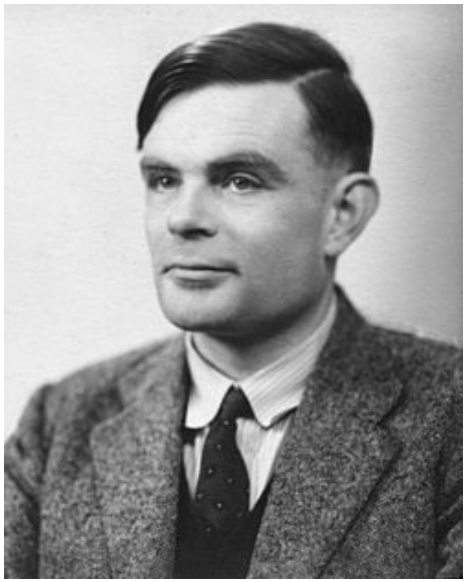
Advocate an agent-based approach where agents act rationally

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 all 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?

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*:

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

- 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*?

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, probabilistic models
	Internet -> Big data,, 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

State of the art milestones

- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997.
- Proved a mathematical conjecture (Robbins conjecture) unsolved for decades. $\neg(\neg(a \vee b) \vee \neg(a \vee \neg b)) = a$
- No hands across America (driving autonomously 98% of the time from Pittsburgh to San Diego).
- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people.
- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft.
- Proverb solves crossword puzzles better than most humans.
- DARPA Grand Challenge won by Stanford 2005.
- Mars Lunar Rover.
- IBM Watson 2010.

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&mkwid=s2pC4IYkI_15714889053_432n0d3749

Current topics

- **A First in Online Gaming: Humans Team Up With AI Software**
  Northwestern University News Center (11/18/08) Leopold, Wendy

  Northwestern University researchers have released an online game in which human players partner with artificial intelligence (AI) software as part of an effort to help computers learn to use language more naturally. At the Web site give-challenge.org, players can team up with one of four AI software systems in a treasure hunt, and provide feedback on how well the systems give instructions for solving puzzles as part of the "GIVE: Generating Instructions in Virtual Environments" project.

- View Full Article

Current topics

- **Read the Web -** NELL: Never-Ending Language Learning
- *CMU (2010->…)*

- Can computers learn to read? We think so. "Read the Web" is a research project that attempts to create a computer system that learns over time to read the web.
- Since January 2010, our computer system called NELL (Never-Ending Language Learner) has been running continuously, attempting to perform two tasks each day:
  - First, it attempts to "read," or extract facts from text found in hundreds of millions of web pages (e.g., playsInstrument(George_Harrison, guitar)).
  - Second, it attempts to improve its reading competence, so that tomorrow it can extract more facts from the web, more accurately.

- http://rtw.ml.cmu.edu/rtw/

Current topics

- **A Future Without Programming**
  IDG News Service (11/20/08) Kaneshige, Tom

  Do-it-yourself applications development is on the rise as business users increasingly turn to codeless programming tools to create applications. "We also have a whole new wave of business users that are not intimidated by the notion of application development," says Forrester analyst Mike Gualtieri. Consultant Kevin Smith says applications and tools such as Coghead, a Web application for code-free development of other Web applications, makes him wonder how traditional developers who have to go through the process of coding from scratch stay in business.

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Current topics

- **Carnegie Mellon Theory of Visual Computation Reveals How Brain Makes Sense of Natural Scenes**
  Carnegie Mellon News (11/19/08) Spice, Byron; Watzman, Anne

  A new computational model from researchers at Carnegie Mellon University helps explain how the brain processes images in the foreground and the background to interpret natural scenes. "Our model takes a statistical approach to making these generalizations about each patch in the image," says Lewicki, a computational neuroscientist.

- View Full Article .

Current topics

- **Real-Time Beethoven**
  Norwegian University of Science and Technology (11/21/08) Oksholen, Tore

  A student at the Norwegian University of Science and Technology has developed a computer instrument that takes the skills of jazz musicians to the next level. Oyvind Brandtsegg has developed a computer program and a musical instrument for improvisation and variation for his Ph.D. research. The computer instrument is capable of taking recorded music and splitting the sound into sound particles that last between one and 10 milliseconds, infinitely reshuffling the fragments, and making it possible to vary the music without changing its fundamental theme.

- View Full Article

Current topics

- **How Google's Ear Hears**
  Technology Review (11/20/08) Greene, Kate

- Google recently announced the addition of voice search capabilities to its iPhone mobile application, which will allow people to speak search terms to their phones.
- To make a voice-operated search engine, Google relied on the massive amount of data it has on how people use search, training its algorithms so that if the system has trouble understanding a word used in a search, it can look at the data and see which terms are regularly grouped together.
- View Full Article

Current topics

- **IBM Tries to Bring Brain Power to Computers**
  IDG News Service (11/19/08) Shah, Agam

  IBM Research has been working on a project to give computers the same processing capabilities as the human brain. The goal is to integrate brain-related senses such as perception and interaction into hardware and software to enable computers to process and understand data faster while consuming less power, says IBM researcher Dharmendra Modha. Modha says neuroscience, nanotechnology, and supercomputing are all being combined as part of the effort to create a new computing platform.

- View Full Article

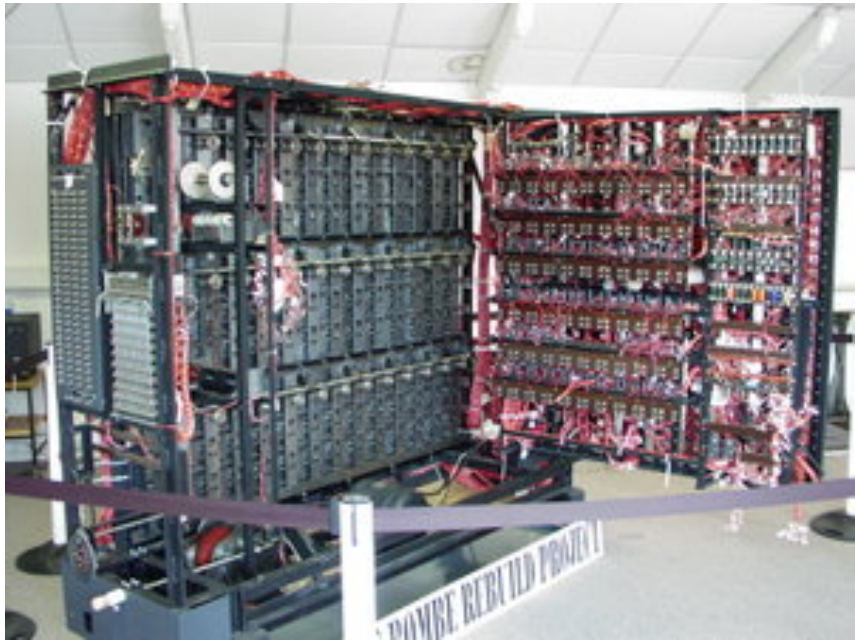
Current topics

- 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

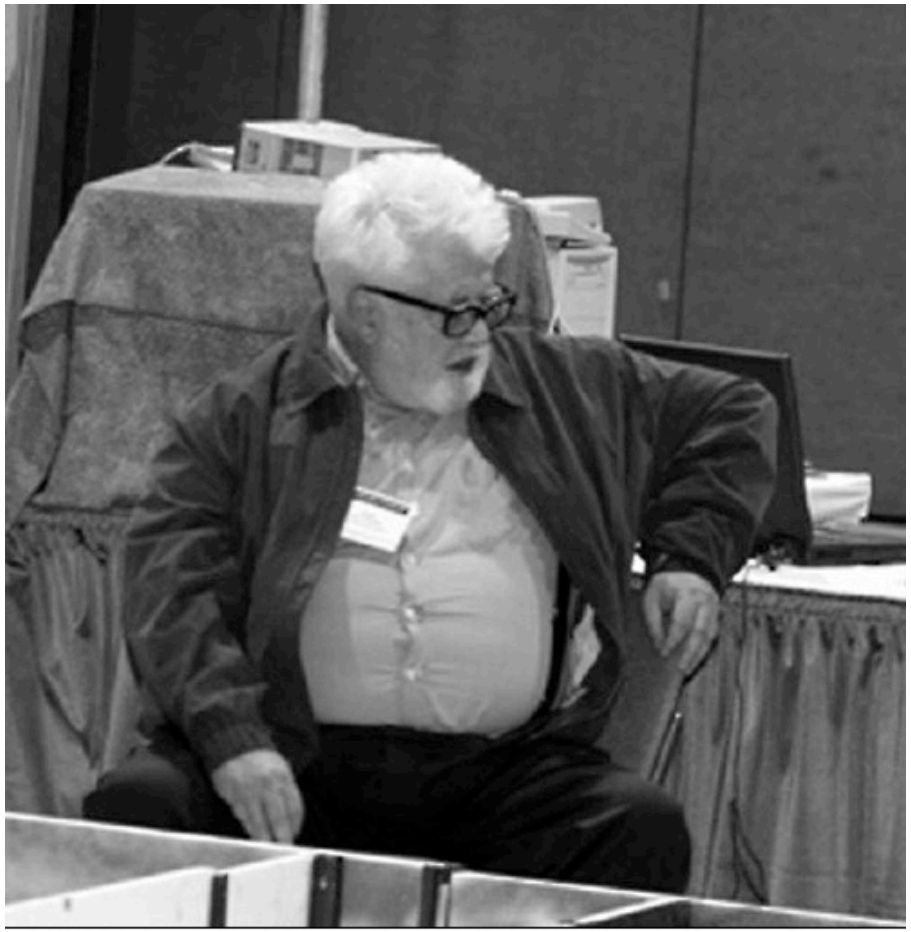
AI Pioneers – Alan Turing



Bombe machine used to crack German WWII Enigma

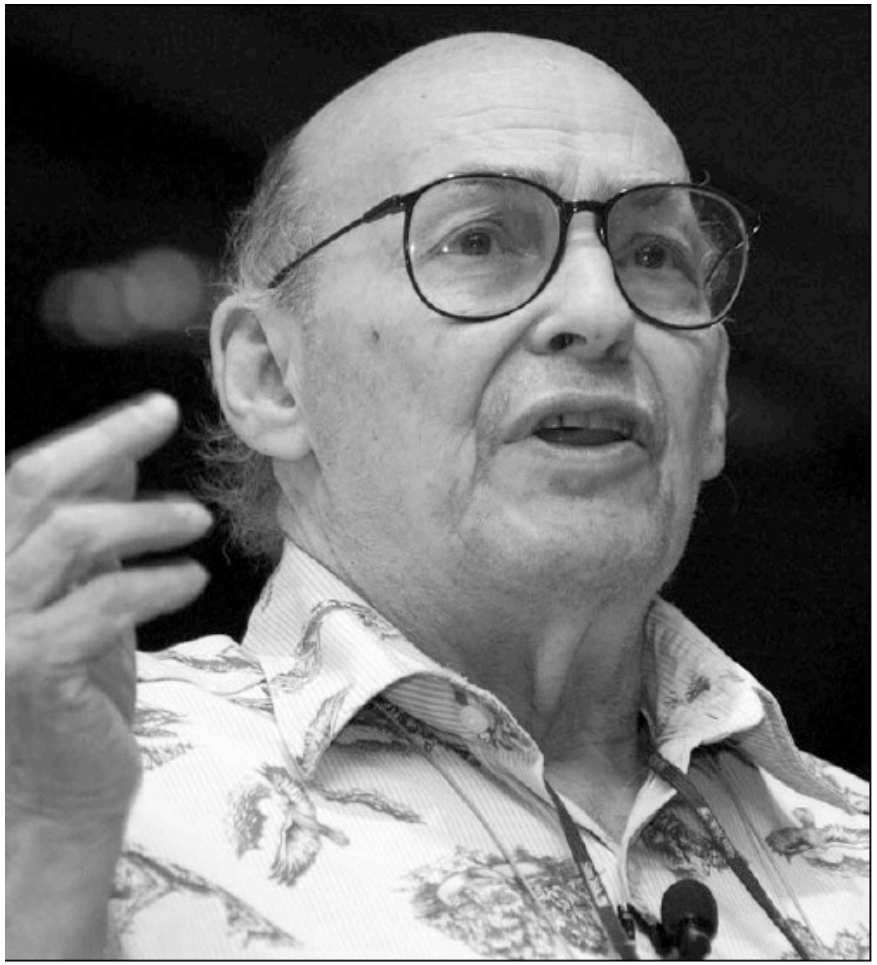
AI Pioneers

Herb Simon.

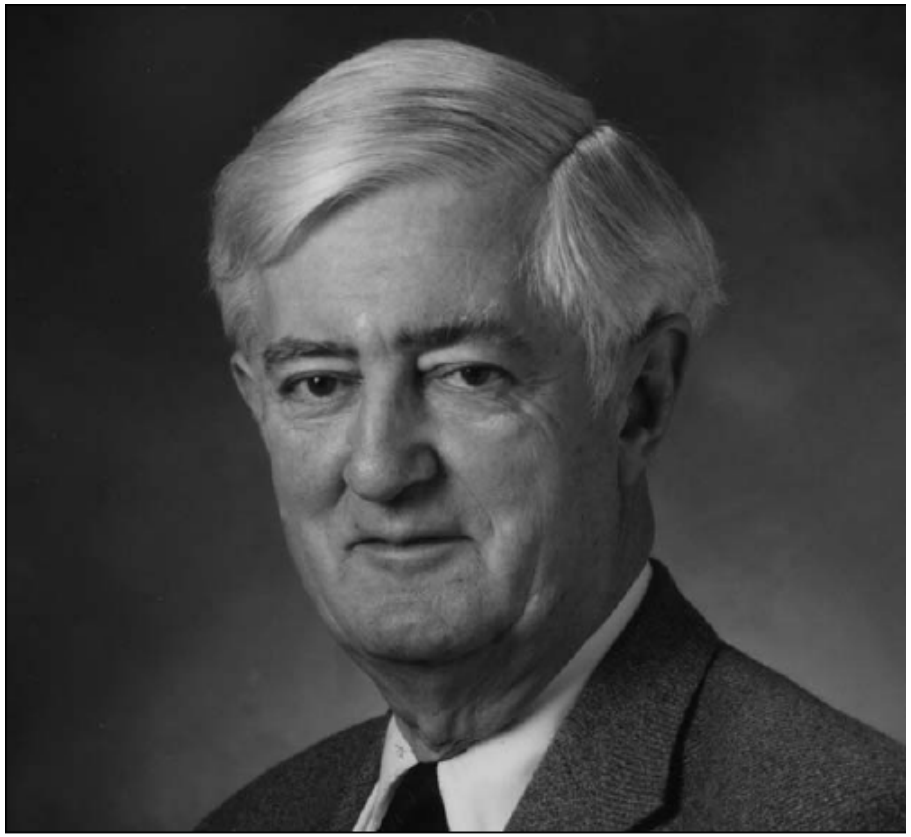


John McCarthy.

AI Pioneers

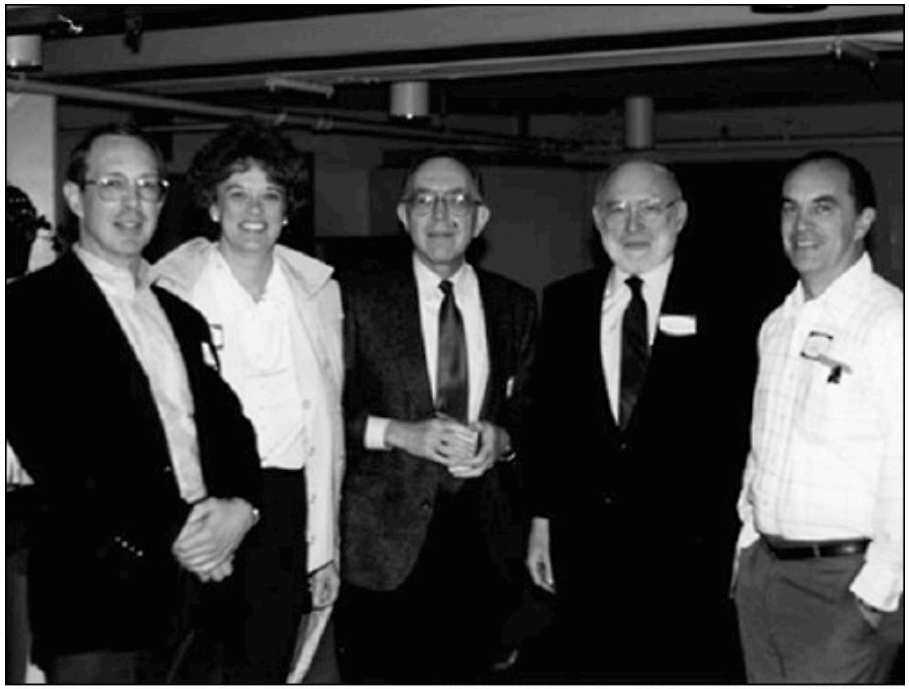


Marvin Minsky.



Oliver Selfridge.

AI Pioneers



Photograph Courtesy, National Library of Medicine

The Original Dendral Team, Twenty-Five Years Later.

Donald Michie.