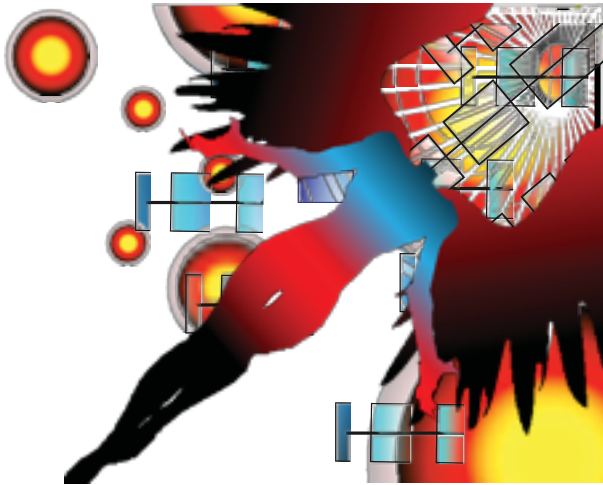# Artificial Intelligence

Introduction

AI in the movies

Definition of AI

"Intelligence: The ability to learn and solve problems"

Webster's Dictionary.

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"Artificial intelligence (AI) is the intelligence exhibited by machines or software'

Wikipedia.

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"The science and engineering of making intelligent machines"

McCarthy.

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"Artificial intelligence (AI) is the intelligence exhibited by machines or software'

Wikipedia.

"The science and engineering of making intelligent machines"

McCarthy.

"The study and design of intelligent agents, where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success."

Russel and Norvig AI book.

Why AI?

"Just as the Industrial Revolution freed up a lot of humanity from physical drudgery, I think AI has the potential to free up humanity from a lot of the mental drudgery."

Andrew Ng.

Applications of AI

Applications of AI

Speech recognition

- Virtual assistants: Siri (Apple), Echo (Amazon), Google Now, Cor- tana (Microsoft).

- "They" helps get things done: send an email, make an appointment, find a restaurant, tell you the weather and more.

- Leverage deep neural networks to handle **speech recognition** and **natural language understanding**.

Applications of AI

Handwriting recognition (check, zipcode)

Applications of AI

Machine translation

- Historical motivation: translate Russian to English.

- First systems using **mechanical translation** (one-to-one cor-
  respondence) failed!

- "Out of sight, out of mind")   "Invisible, imbecile".

Applications   of AI

Machine translation

- Historical motivation: translate Russian to English.

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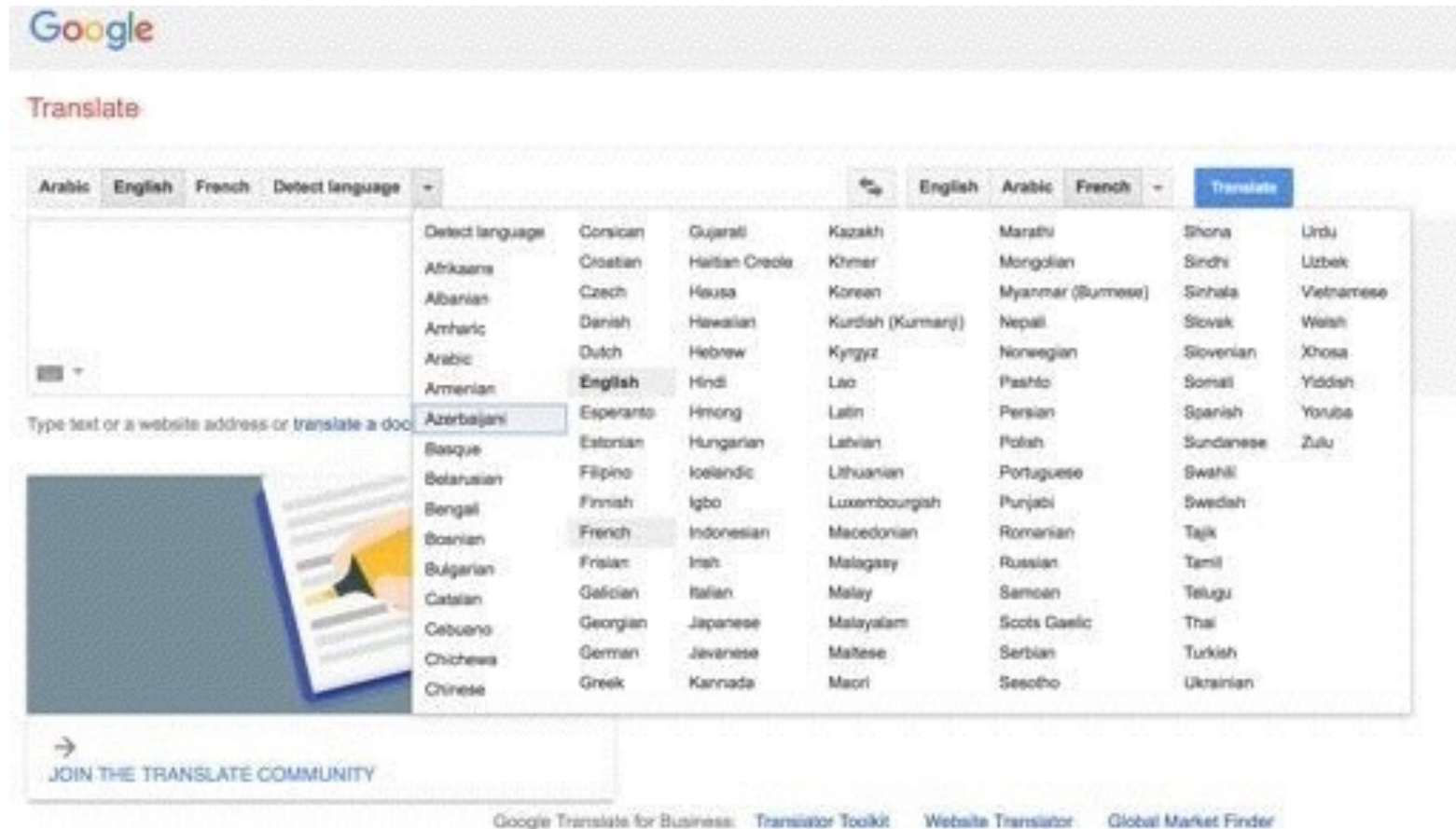## Oops!

Applications   of AI

Machine translation

- MT   has gone through upsand downs.

- Today,   **Statistical   Machine   Translation**   leverages   the   vast amounts of **available translated corpuses**.

- While there is room for improvement, machine translation has made significant progress.

Applications of AI

Machine translation

1 0 0+ languages

Applications of AI

Machine translation

Applications of AI

Robotics: Awesome robots today!   NAO, ASIMO, and more!

Credit: By Momotarou2012, via Wikimedia Commons.

Applications of AI

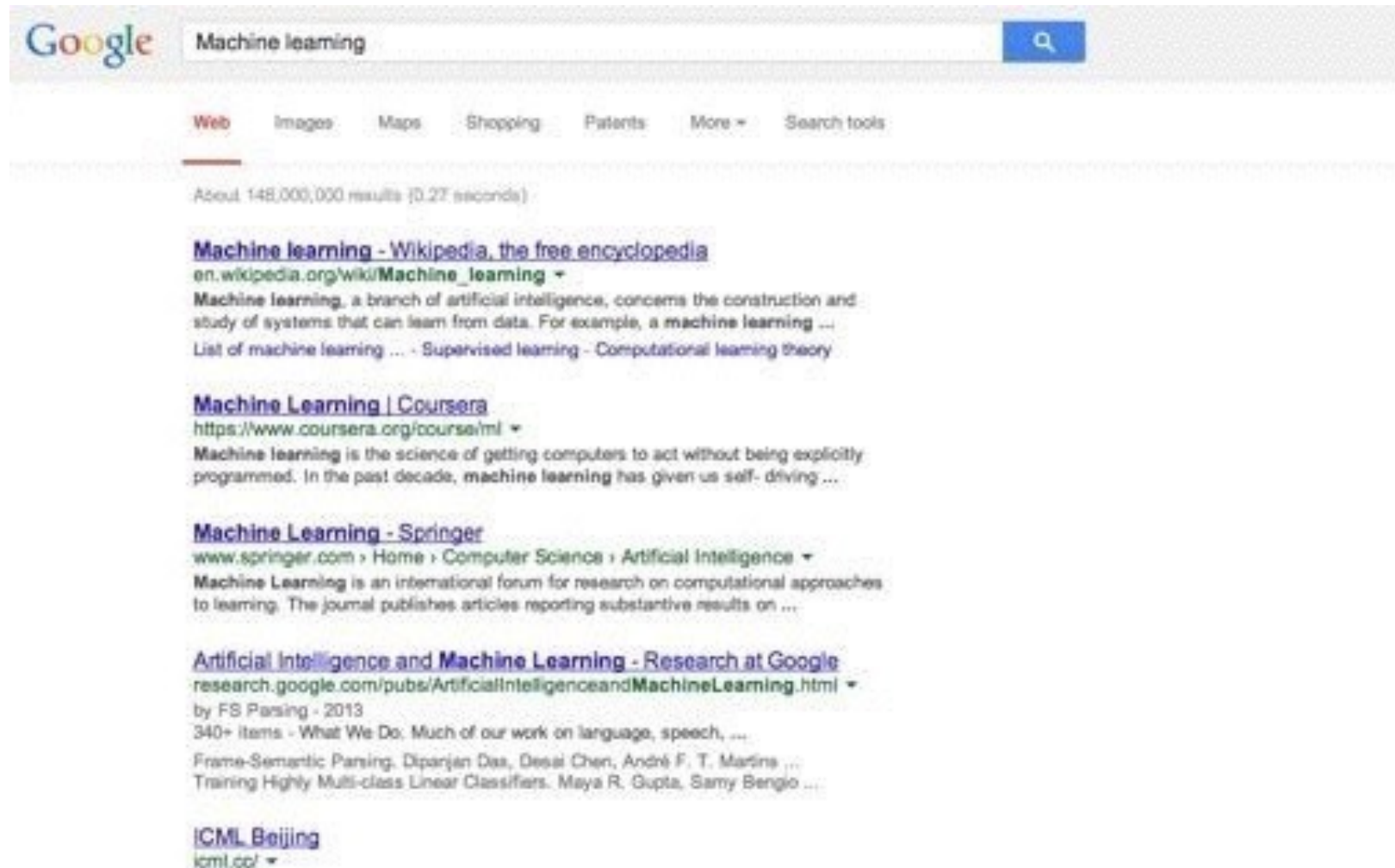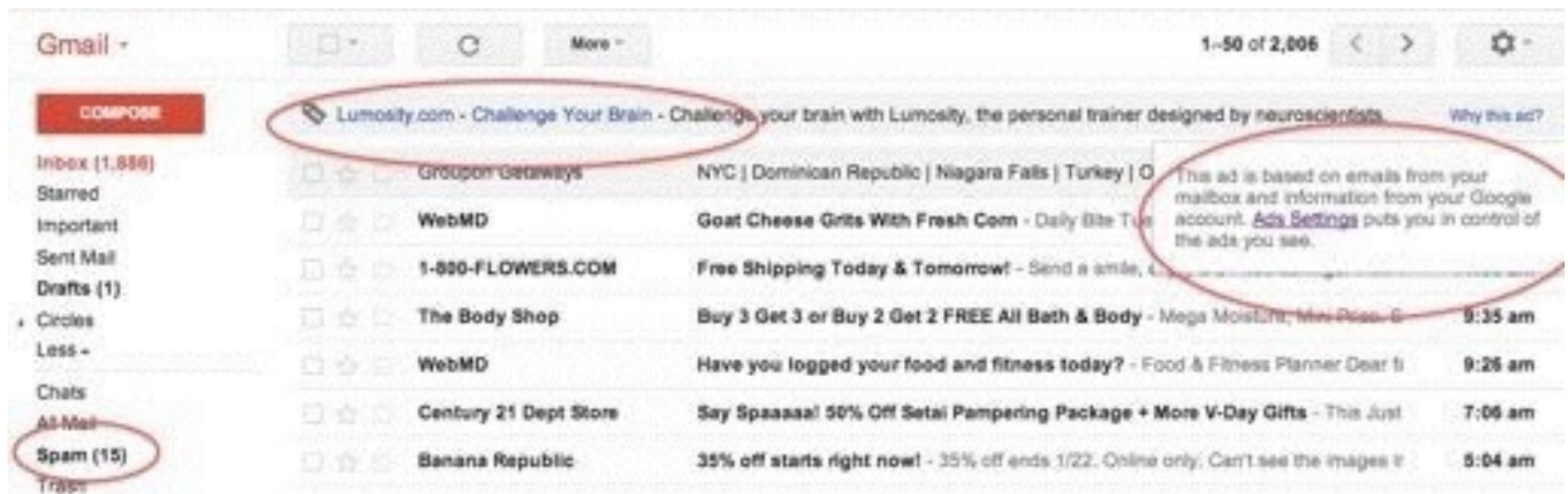**Recommendation systems (collaborative filtering)**

Applications of AI

Search engines

Applications of AI

Email

Applications of AI
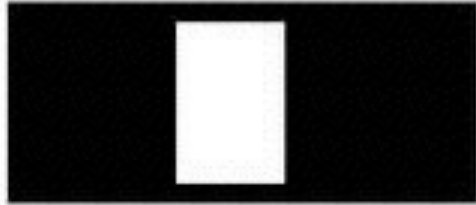
Face detection

Viola-Jones method.

Applications of AI

Face detection

Viola-Jones method.

Face detection

Viola-Jones method.

Applications of AI

Face recognition
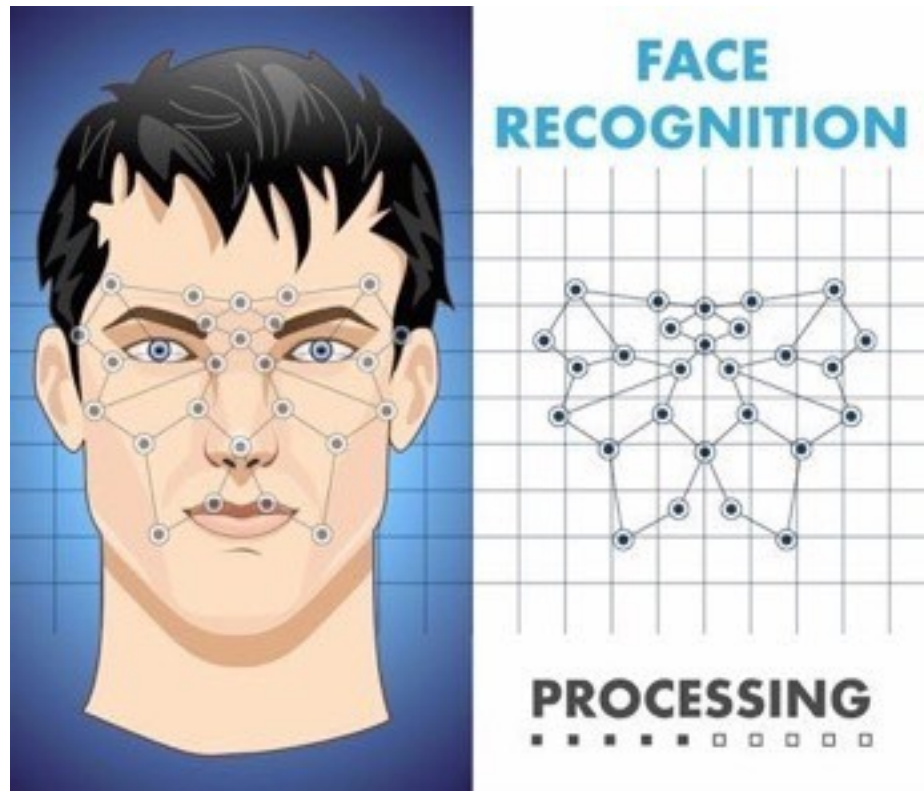
Applications of AI

Detection of breast cancer in mammography images
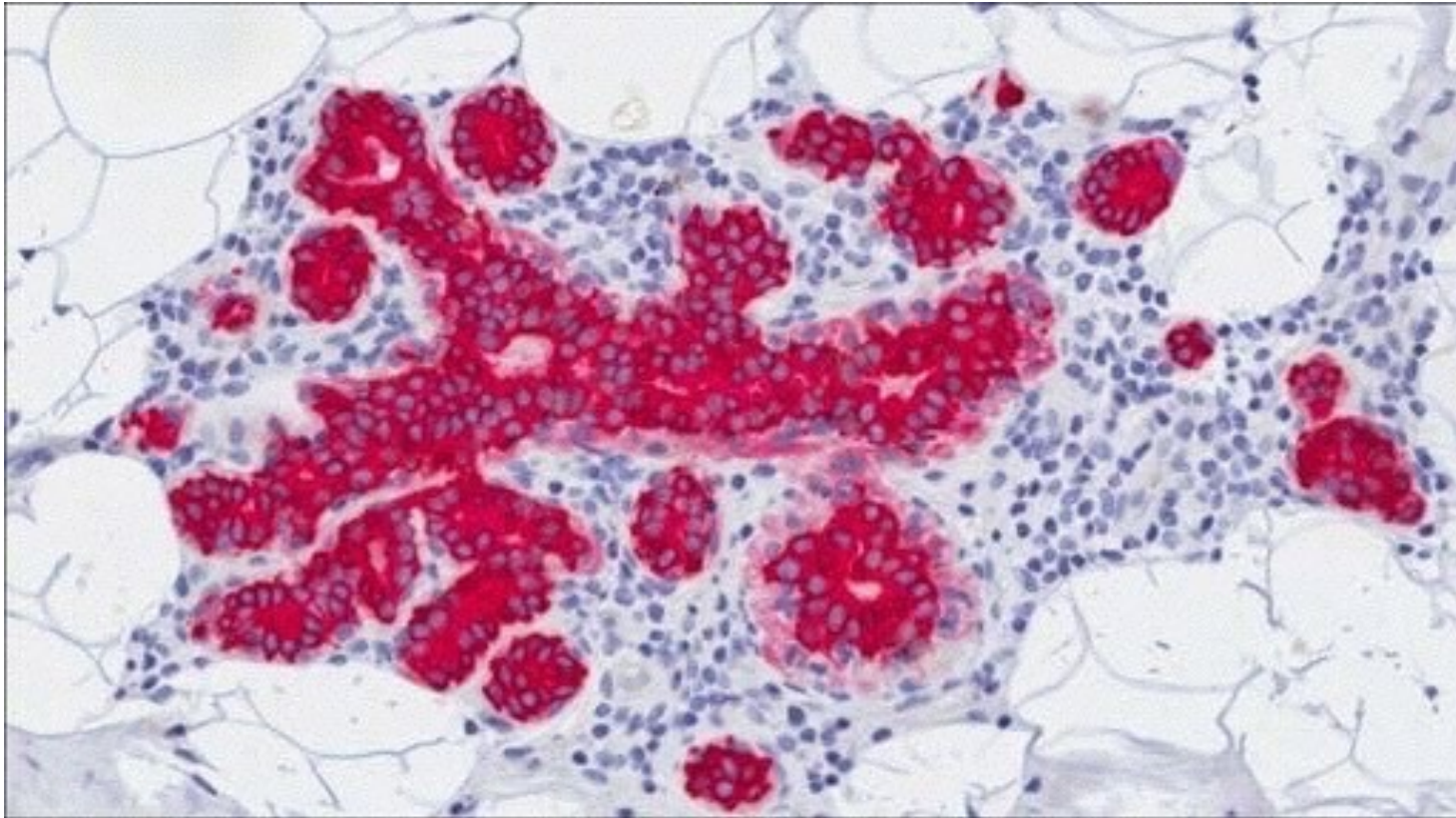
Applications   of AI

Chess (1997):   Kasparov vs. IBM Deep Blue

(Left) Copyright 2007, S.M.S.I., Inc. - Owen Williams, The Kasparov Agency, via Wikimedia

Commons (Right) By James the photographer, via Wikimedia Commons

Powerful search algorithms!

Applications of AI

Jeopardy! (2011): Humans vs. IBM Watson

By Rosemaryetoufee (Own work), via Wikimedia Commons

Natural Language Understanding and information extraction!

Applications of AI

Go (2016): Lee Sedol versus Google AlphaGo

(Left) By LG Electronics, via Wikimedia Commons (Right) By Google DeepMind, via

Wikimedia Commons

Deep Learning, reinforcement learning, and search algorithms!

Applications of AI

Autonomous driving

By User Spaceape on en.wikipedia, via Wikimedia Commons

- DARPA Grand Challenge
  - 2005: 132 miles
  - 2007: Urban challenge
          Google self-driving car
  - 2009:

State-of-the-art applications

- Speech recognition
- Autonomous planning scheduling
- Financial forecasting
- Game playing, video games
- Spam fighting
- Logistics planning
- Robotics (household, surgery, navigation)
- Machine translation
- Information extraction
- VLSI layout
- Automatic assembly
- Sentiment analysis

and

- Fraud detection
- Recommendation systems
- Web search engines
- Autonomous cars
- Energy optimization
- Question answering systems
- Social network analysis
- Medical diagnosis, imaging
- Route finding
- Traveling salesperson
- Protein design
- Document summarization
- Transportation/scheduling
- Computer animation

State-of-the-art applications

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- Computer animation

Many more!

Foundation of AI
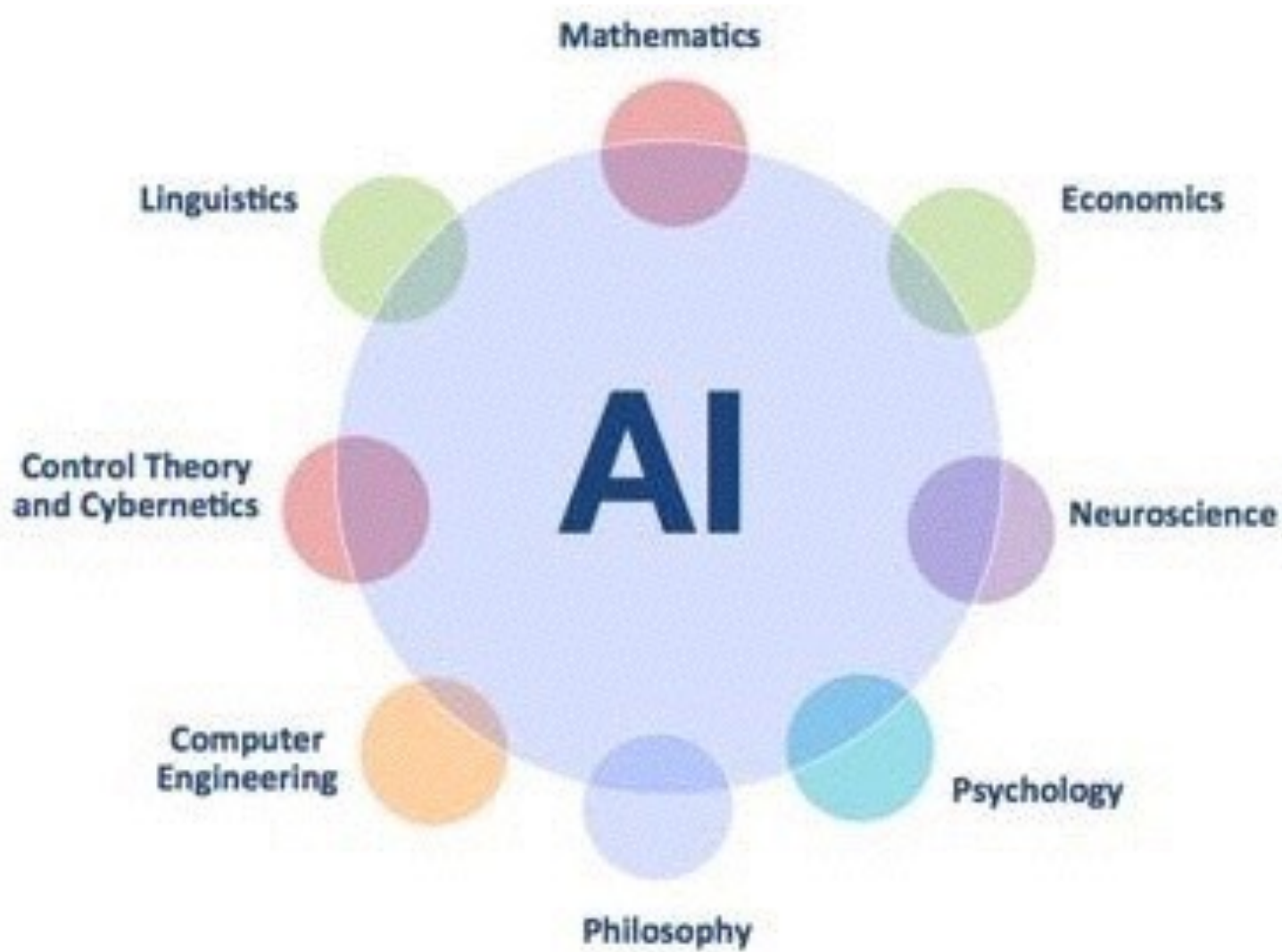
Foundation of AI

- **Philosophy**
  - Logic, methods of reasoning.
  - Mind as physical system that operates as a set of rules.
  - Foundations of learning, language, rationality.

- **Mathematics**
  - Logic: Formal representation and proof.
  - Computation, algorithms.
  - Probability.

- **Economics**
  - Formal theory of rational decisions.
  - Combined decision theory and probability theory for decision making under uncertainty.
  - Game theory.
  - Markov decision processes.

Foundation of AI

- **Neuroscience**
  - Study of brain functioning.
  - How brains and computers are (dis)similar.

- **Psychology**
  - How do we think and act?
  - Cognitive psychology perceives the brain as an information processing machine.
  - Led to the development of the field *cognitive science*: how could computer models be used to study *language, memory, and thinking* from a psychological perspective.

- **Computer engineering**
  - Cares about how to build powerful machines to make AI possible.
  - E.g., Self-driving cars are possible today thanks to advances in computer engineering.

Foundation of AI

- **Control theory and cybernetics**
  - Design simple optimal agents receiving feedback from the environment.
  - Modern control theory design systems that maximize an objective function over time.

- **Linguistics**
  - How are language and thinking related.
  - Modern linguistics + AI = Computational linguistics (Natural language processing).

History of AI and CS

- Edsac - the Electronic Delay Storage Automatic Calculator - that ran for the first time in 1949 and was built to serve scientists at the University of Cambridge.
- Edsac - a machine created by Prof Maurice Wilkes
- 1948 the Manchester Small Scale Experimental Machine, or Manchester "Baby" prototype computer (Manchester Baby), ran its first program, written by Tom Kilburn. https://youtu.be/cozcXiSSkwE

"I got some estimates of a star's age, how long it was going to last," she said. "One of the nice things was that with programming you could repeat it. Iterate. You could not do that with a hand calculation.
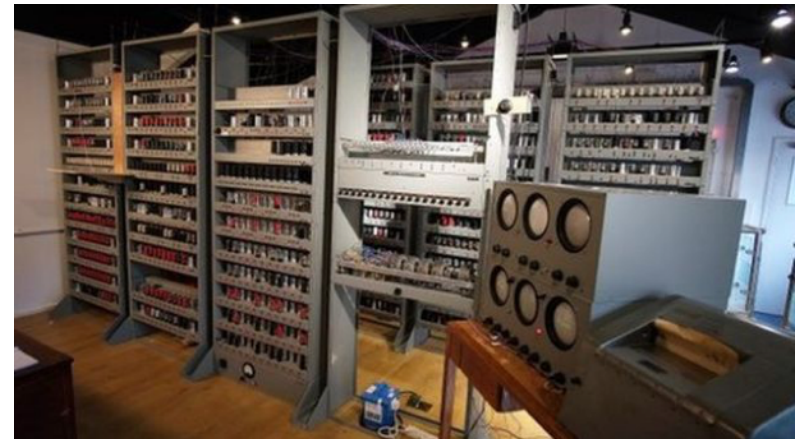
Joyce Wheeler was one of a select group of scientists who used Edsac in their research

MIND

A QUARTERLY REVIEW

OF

PSYCHOLOGY AND PHILOSOPHY

I.—COMPUTING MACHINERY AND INTELLIGENCE

By A. M. Turing

1. *The Imitation Game.*

I PROPOSE to consider the question, 'Can machines think?' This should begin with definitions of the meaning of the terms 'machine' and 'think'. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words 'machine' and 'think' are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, 'Can machines think?' is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.

The new form of the problem can be described in terms of a game which we call the 'imitation game'. It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either 'X is A and Y is B' or 'X is B and Y is A'. The interrogator is allowed to put questions to A and B thus:

C: Will X please tell me the length of his or her hair?

Now suppose X is actually A, then A must answer. It is A's

Computing machinery and intelligence

- In 1936, he invented the idea of a 'Universal Machine' that could decode and perform any set of instructions and laid foundations for computing
- He played a major role in WW2, devising techniques to decode german enigma cipher
- In 1950 Alan Turing published Computing Machinery and Intelligence, in which he asked: "Can machines think?"
- first attempts to describe how 'artificial' intelligence could be developed.
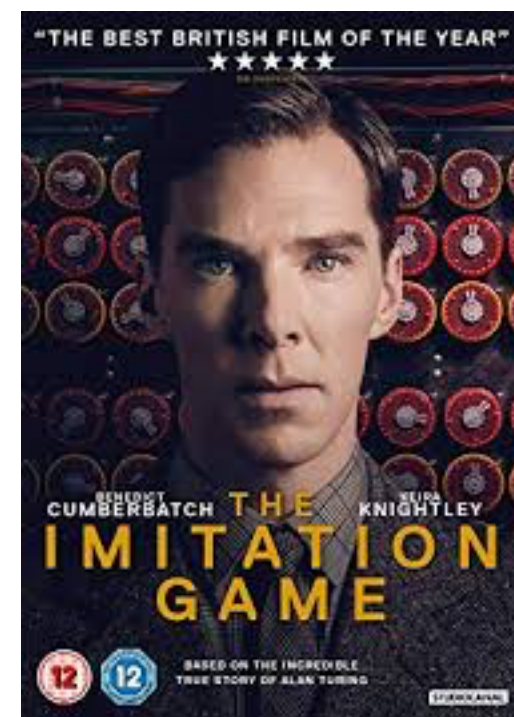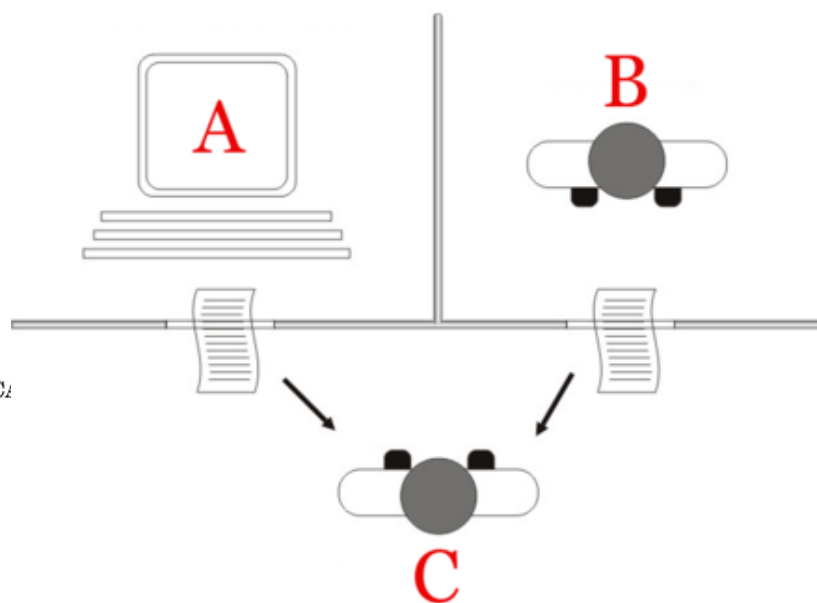- It famously proposed the 'imitation game',

230   A. M. TURING

ON COMPUTABLE NUMBERS, WITH AN APPLICA
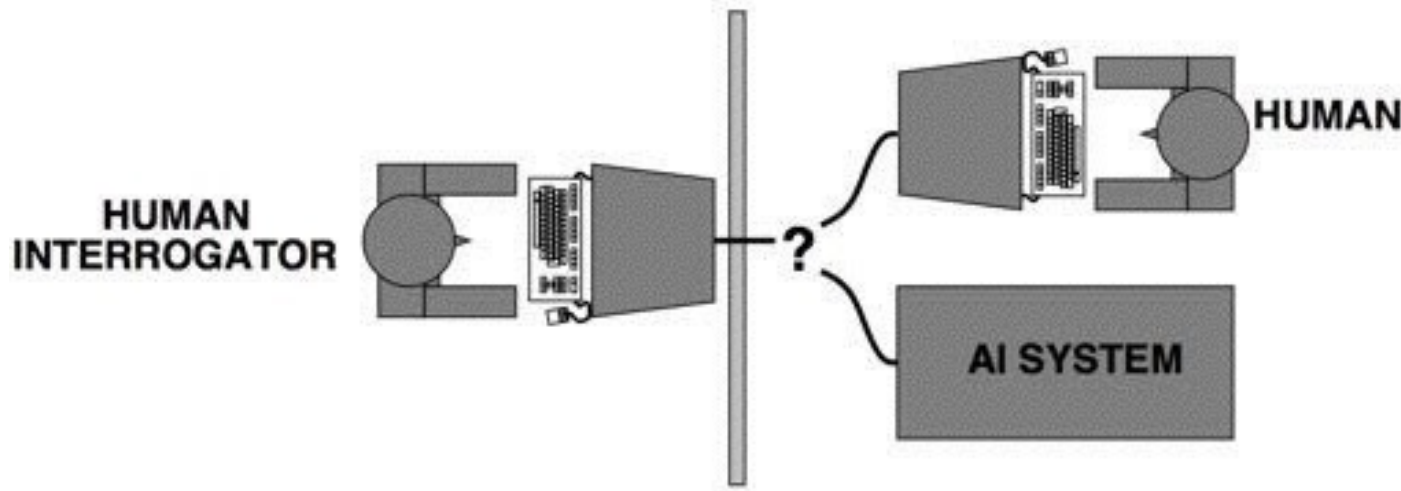THE ENTSCHEIDUNGSPROBLEM

By A. M. TURING.

[Received 28 May, 1936.—Read 12 November, 1936.]

"THE BEST BRITISH FILM OF THE YEAR"
★★★★★

BENEDICT CUMBERBATCH THE KEIRA KNIGHTLEY
IMITATION GAME

BASED ON THE INCREDIBLE TRUE STORY OF ALAN TURING

What is AI?

Acting humanly:

- **Turing test (Alan Turing 1950)**: A computer passes the test of intelligence, if it can fool a human interrogator.

Credit: From Russel and Norvig slides.

- **Major components of AI:** knowledge, reasoning, language, understanding, learning.

Natural language Processing, computer vision, robotics

MCCULLOCH PITTS NEURONS(1943)

A LOGICAL CALCULUS OF THE IDEAS IMMANENT IN NERVOUS ACTIVITY*

■ WARREN S. MCCULLOCH AND WALTER PITTS
University of Illinois, College of Medicine,
Department of Psychiatry at the Illinois Neuropsychiatric Institute,
University of Chicago, Chicago, U.S.A.

Because of the "all-or-none" character of nervous activity, neural events and the relations among them can be treated by means of propositional logic. It is found that the behavior of every net can be described in these terms, with the addition of more complicated logical means for nets containing circles; and that for any logical expression satisfying certain conditions, one can find a net behaving in the fashion it describes. It is shown that many particular choices among possible neurophysiological assumptions are equivalent, in the sense that for every net behaving under one assumption, there exists another net which behaves under the other and gives the same results, although perhaps not in the same time. Various applications of the calculus are discussed.
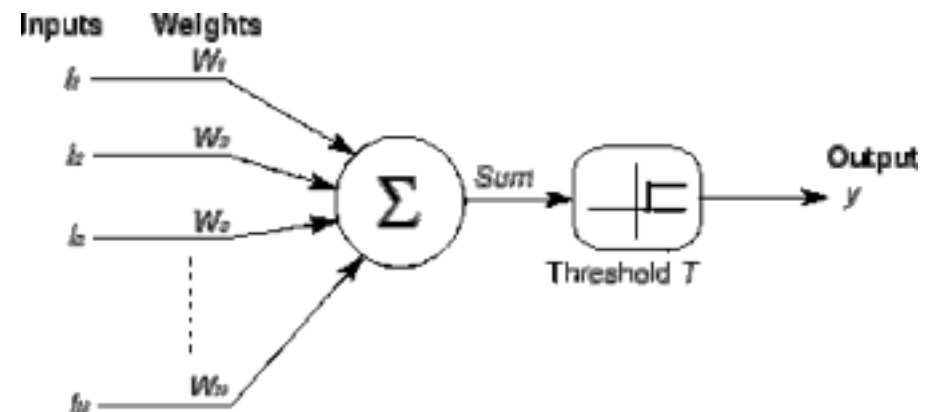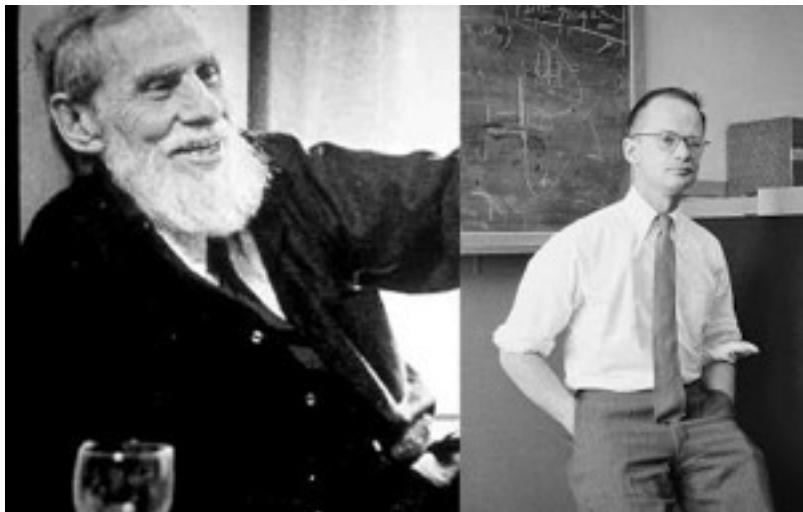
Marvin Minsky and Dean Edmonds (1951)

Two undergraduate students at Harvard, Marvin Minsky and Dean Edmonds, built the first neural network computer in 1950.
SNARC - used 3000 vacuum tubes and a surplus automatic pilot mechanism from a B-24 bomber to simulate a network of 40 neurons.
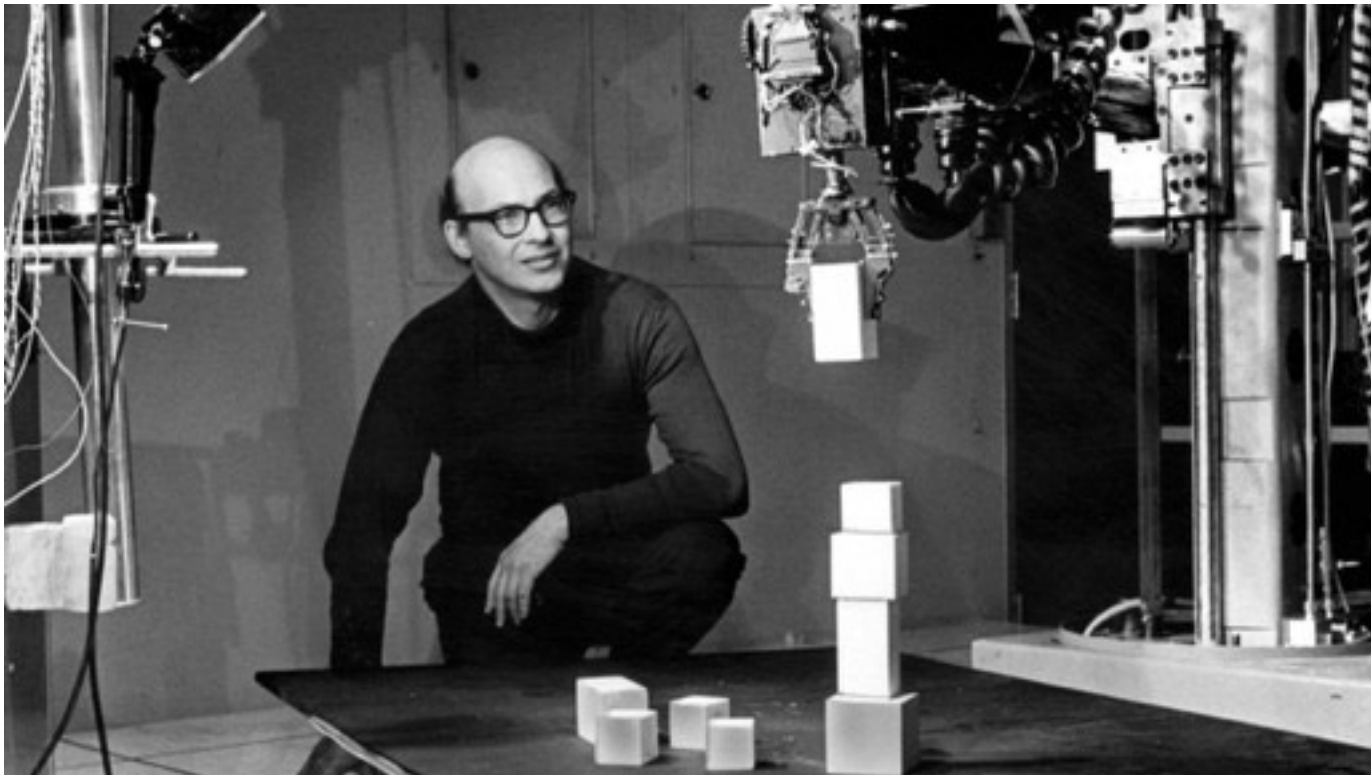
Dartmouth Conference 1956

- John Mccarthy coined the term artificial intelligence in 1955
- Newell and Simon introduced Logic theorist - computer program capable of thinking non-numerically
- This was followed up with General Problem Solver.

Dartmouth Conference: The Founding Fathers of AI

John McCarthy   Marvin Minsky   Claude Shannon   Ray Solomonoff
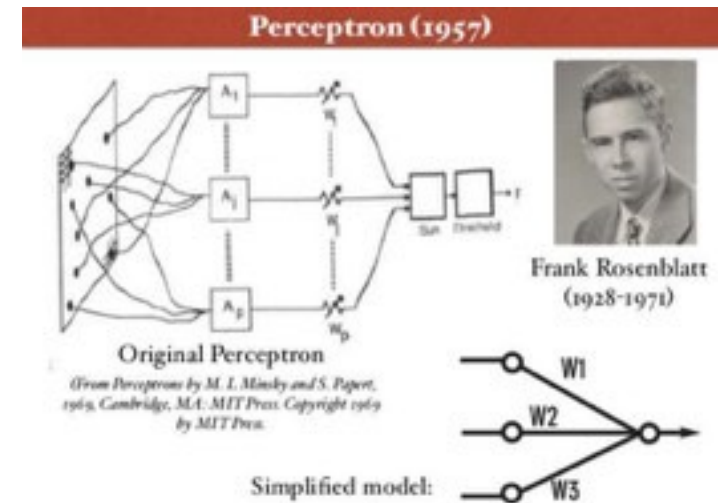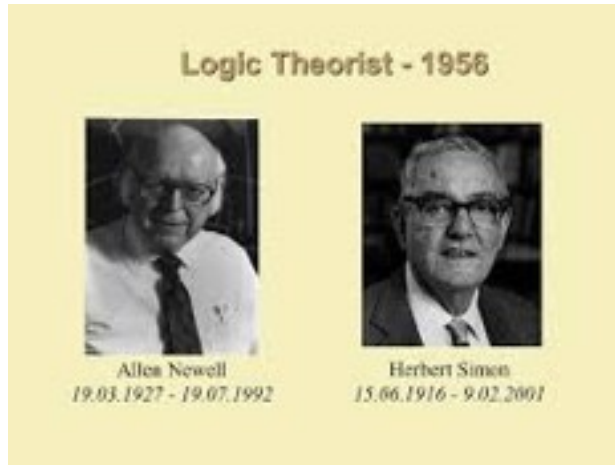
Alan Newell   Herbert Simon   Arthur Samuel

And three others...
Oliver Selfridge (Pandemonium theory)
Nathaniel Rochester (IBM, designed 701)
Trenchard More (Natural Deduction)

History of AI

- **1940-1950** : Gestation of AI
  - McCulloch & Pitts: Boolean circuit to model of brain
  - Turing's Computing Machinery and Intelligence
    http://www.turingarchive.org/browse.php/B/9

- **1950-1970** : Early enthusiasm, great expectations
  - Early AI programs, Samuel's checkers program
  - Birth of AI @Dartmouth meeting 1956.
  - Check out the MIT video "The thinking Machine" on youtube
    https://www.youtube.com/watch?v=aygSMgK3BEM

Early age (1952-1969)

Logic Theorist - 1956

Allen Newell
19.03.1927 - 19.07.1992

Herbert Simon
15.06.1916 - 9.02.2001

Arthur Samuel's checkers program on the IBM 701, 1956

Perceptron (1957)

Original Perceptron
(from Perceptron by M. L. Minsky and S. Papert, 1969, Cambridge, MA: MIT Press. Copyright 1969 by MIT Press.)

Simplified model:

Frank Rosenblatt
(1928-1971)

W1
W2
W3

Machine translation research
- required general knowledge of the subject to resolve ambiguity

Early AI programs solved by trying various combinations
- works only for very few objects, actions and states.

History of AI

- **1958. InMIT AI LabMemo No. 1,McCarthy defined the high-level language Lisp, which was to become LISP the dominant AI programming language for the next 30 years.**

- **a paper entitled Programs with Common Sense : principles of knowledge representation and reasoning**

- **McCarthy stressed representation and reasoning in formal logic, whereas Minsky was more interested in getting programs to work and eventually developed an anti-logic outlook.**

- **Frank Rosenblatt (1962) with his perceptrons. The perceptron convergence theorem (Block et al., 1962) says that the learning algorithm can adjust the connection strengths of a perceptron to match any input data,**

History of AI

- **1970-1990:**

  - Knowledge-based AI Expert systems, AI becomes an industry
  - AI winter

  - **1990-present**:   Scientific approaches

    - Machine learning becoming dominant method to tackle AI problems

      - return of neural networks (back propagation algorithm), support vector machines, DEEPLEARNING

    - AI becomes "scientific", use of probability to model uncertainty

    - The availability of very large datasets.
      Availability of computation power in the form of GPUs

What is AI?

Four schools of thoughts (Russel & Norvig)

Thinking humanly	Thinking rationally
"The exciting new e↵ort to make computers think... *machines with minds*, in the full and literal sense." (Haugeland, 1985)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985
Acting humanly	**Acting rationally**
"The study of how to make com- puters do things which, at the mo- ment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole et al., 1998)

What is AI?

Thinking humanly: cognitive approach

Requires to determine how humans think! 1960's "cognitive revolution".

Requires scientific theories of internal activities of the brain
- What level of abstraction?   "Knowledge" or "circuits"?
- How to validate?

Today, Cognitive Science and Artificial Intelligence are distinct disciplines.

What is AI?

Thinking rationally: Laws of thoughts.

Socrates is a man
All mean are mortal
Socrates is mortal

- Codify "right thinking" with **logic**.

- Several Greek schools developed various forms of logic: *notation* and *rules of derivation* for thoughts.

- Problems:

  1. Not all knowledge can be expressed with logical notations.
  2. Computational blow up.

What is AI?

Acting rationally:

- The right thing: that which is expected to maximize goal achievement, given the available information.

- A **rational agent** is one that acts so as to achieve the best outcome, or when there is uncertainty, the best expected out-come.

- Aristotle (Nicomachean Ethics):
"Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good."

What is AI?

Four schools of thoughts (Russel & Norvig)

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Acting humanly	**Acting rationally: Our approach**
"The study of how to make com- puters do things which, at the mo- ment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole et al., 1998)

AI founders

- Aristotle
- Alan Turing
- John Mc Carthy
- Warren McCulloh
- Walter Pitts
- Claude Shannon
- Marvin Minsky
- Dean Edmonds
- Herbert Simon
- Allen Newell
- David Waltz
- Tom Mitchell
- Stuart J. Russell
- Peter Norvig
- etc.

Course roadmap

1. Introduction to AI systems
2. Game playing
    1. Search techniques
    2. Pruning techniques
    3. Intelligent search with machine learning
    4. IBM deep blue, AlphaGo
3. Machine learning
    1. Supervised learning : classification and Regression
    2. Unsupervised learning
    3. Reinforcement learning
4. Natural language processing
    1. Text classification
    2. Sequence labeling
    3. Google translate, IBM Watson
4. Computer Vision and Speech

Course logistics

- **Suggested readings**:
  - We recommend this book, which is the main reference in the field:

    Artificial Intelligence, A Modern Approach. Stuart Russell and Peter Norvig. Third Edition. Pearson Education.

    http://aima.cs.berkeley.edu/

  - Check out the list of readings, useful links we suggest for this course.