

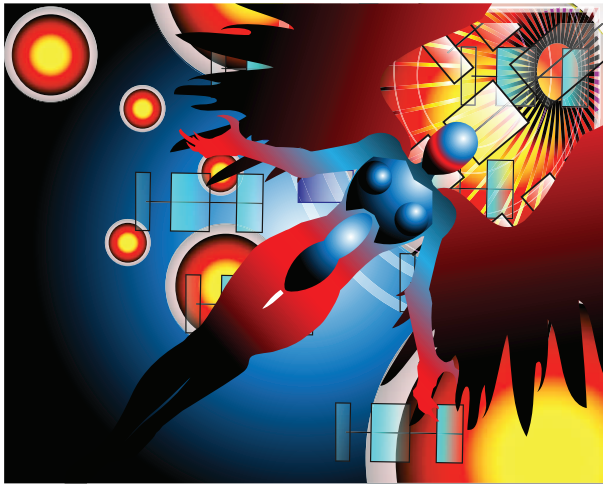
# Artificial Intelligence

## Introduction



# AI in the movies

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# Definition of AI

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“Intelligence: The ability to learn and solve problems”

Webster's Dictionary.

“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?

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**“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.

# What is AI?

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## Four schools of thoughts (Russel & Norvig)

Thinking humanly	Thinking rationally
“The exciting new effort to make computers think... <i>machines with minds</i> , 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 computers do things which, at the moment, 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?

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## 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?

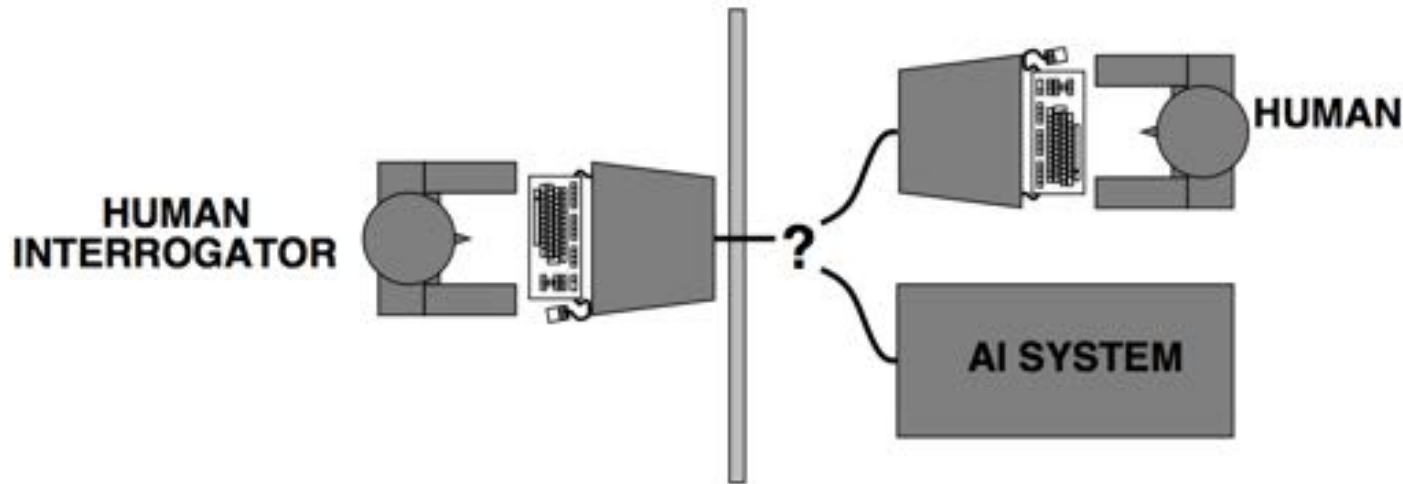
**Today, Cognitive Science and Artificial Intelligence are distinct disciplines.**

# What is AI?

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## 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.



# What is AI?

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Acting humanly:





# What is AI?

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## Thinking rationally: Laws of thoughts.

- 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?

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

# What is AI?

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## Four schools of thoughts (Russel & Norvig)

Thinking humanly	Thinking rationally
“The exciting new effort to make computers think... <i>machines with minds</i> , 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: Our approach
“The study of how to make computers do things which, at the moment, people are better.” (Rich and Knight, 1991)	“Computational Intelligence is the study of the design of intelligent agents.” (Poole et al., 1998)

# Applications of AI

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# Applications of AI

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## Speech recognition

- Virtual assistants: Siri (Apple), Echo (Amazon), Google Now, Cortana (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

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Handwriting recognition (check, zipcode)



# Applications of AI

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## Machine translation

- Historical motivation: translate Russian to English.
- First systems using **mechanical translation** (one-to-one correspondence) failed!
- “Out of sight, out of mind”  $\Rightarrow$  “Invisible, imbecile”.



# Applications of AI

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## Machine translation

- Historical motivation: translate Russian to English.
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**Oops!**

# Applications of AI

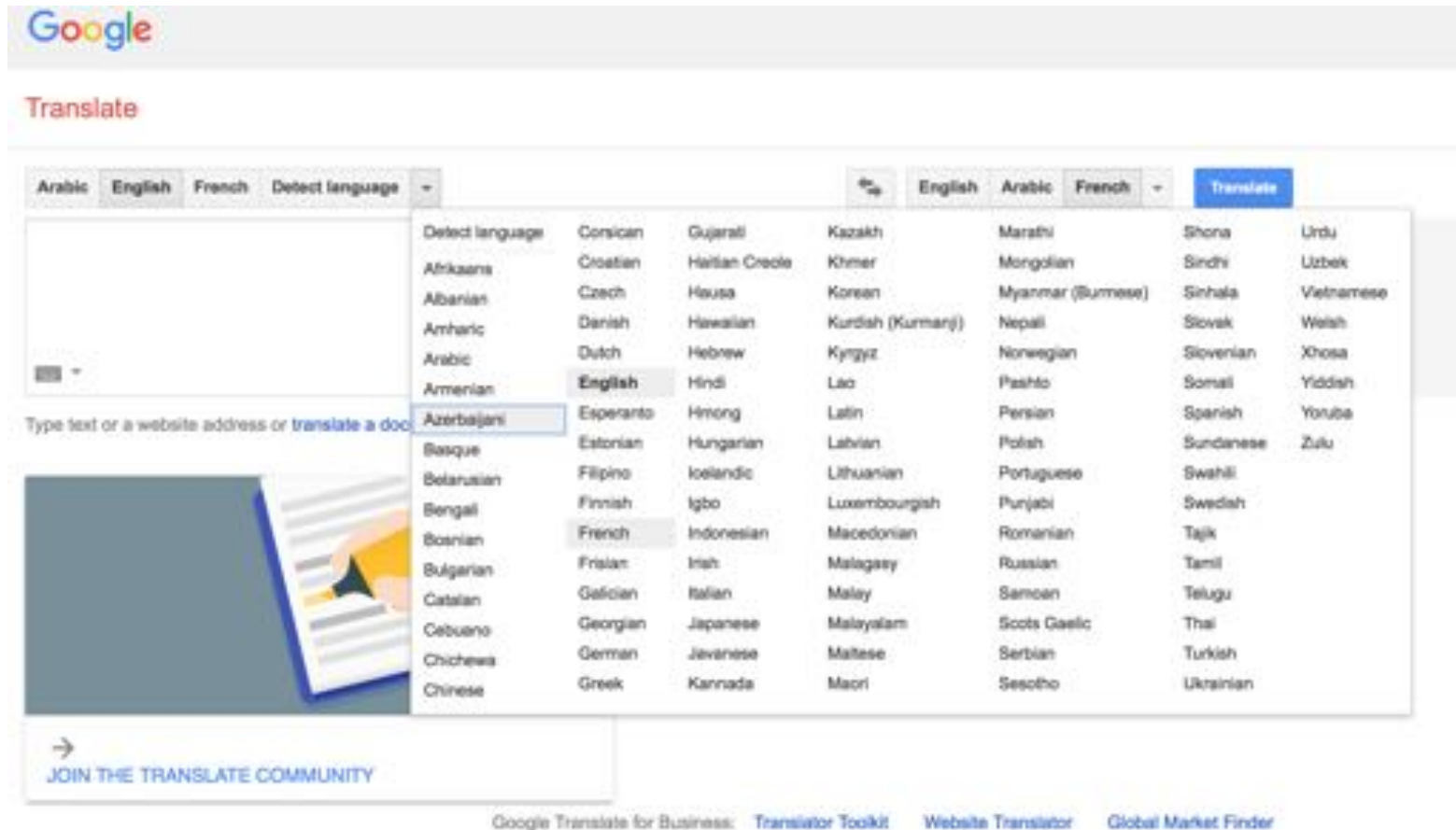
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## Machine translation

- MT has gone through ups and 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

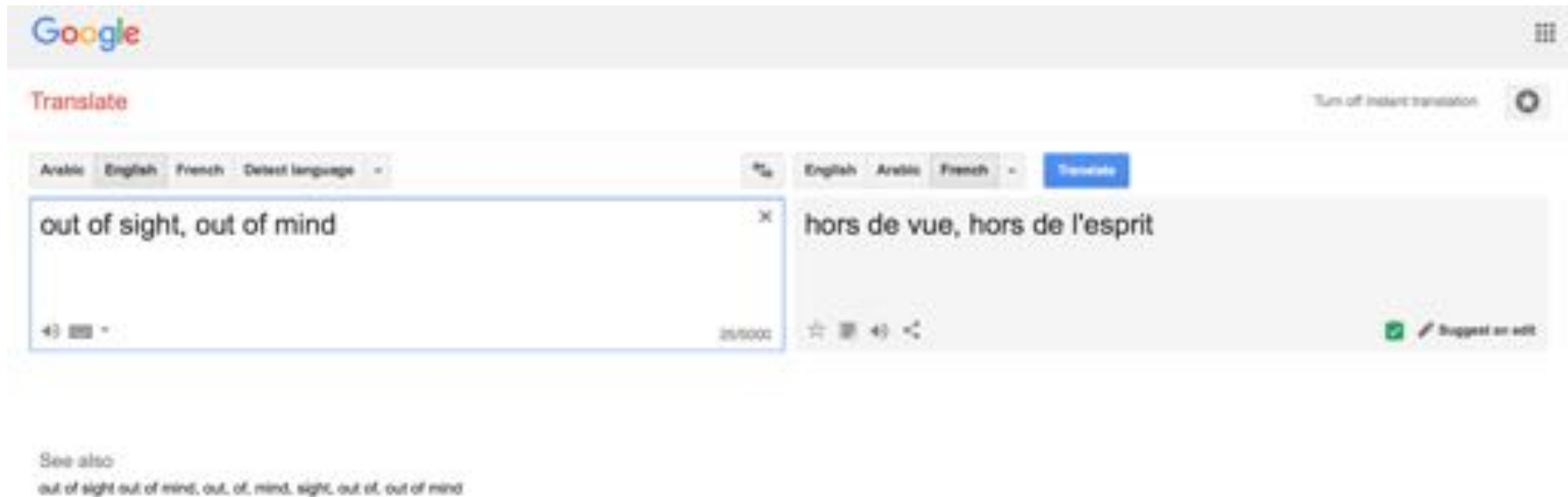


100+ languages

# Applications of AI

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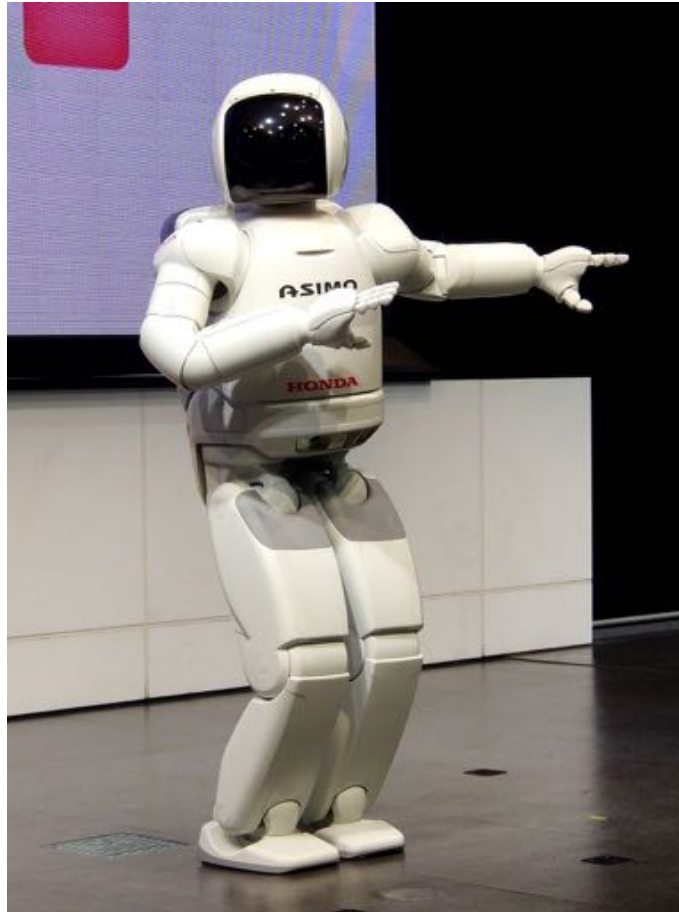
## Machine translation



# Applications of AI

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



Credit: By Momotarou2012, via Wikimedia Commons.

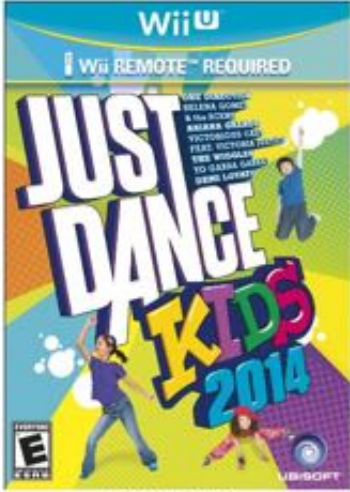
# Applications of AI

## Recommendation systems (collaborative filtering)

amazon

Shop by Department - Search kids dance wi u Go

Video Games Xbox One Xbox 360 PS4 PS3 Wii U Wii 3DS PS Vita Digital Games Kindle Fire Games Deals Best Sellers Pre-orders Trade-in



**Just Dance Kids 2014 - Nintendo Wii U**  
by Ubisoft  
Rated: Everyone (E)  
★ ★ ★ ★ ☆ (35 customer reviews)  
List Price: ~~\$20.00~~  
Price: **\$19.99** & **FREE Shipping** on orders over \$35. [Details](#)  
You Save: \$10.00 (33%)  
**In Stock.**  
Ships from and sold by Amazon.com. Gift-wrap available.  
Want it Thursday, Jan. 23? Order within 23 hrs 38 mins and choose One-Day Shipping at checkout. [Details](#)  
Platform: Nintendo Wii U  
☐ Nintendo Wii ☐ Xbox 360 ☒ Nintendo Wii U  
• 30 Brand-New Dances led by real kids  
• Dance Director Mode: Use the Wii U gamepad to make your entire family dance to silly dance moves during any  
• Kids can create custom playlists for endless fun  
• Play with up to 5 Players  
**\$7.00** new from \$15.99 **Used** from \$11.75

Customers Who Bought This Item Also Bought

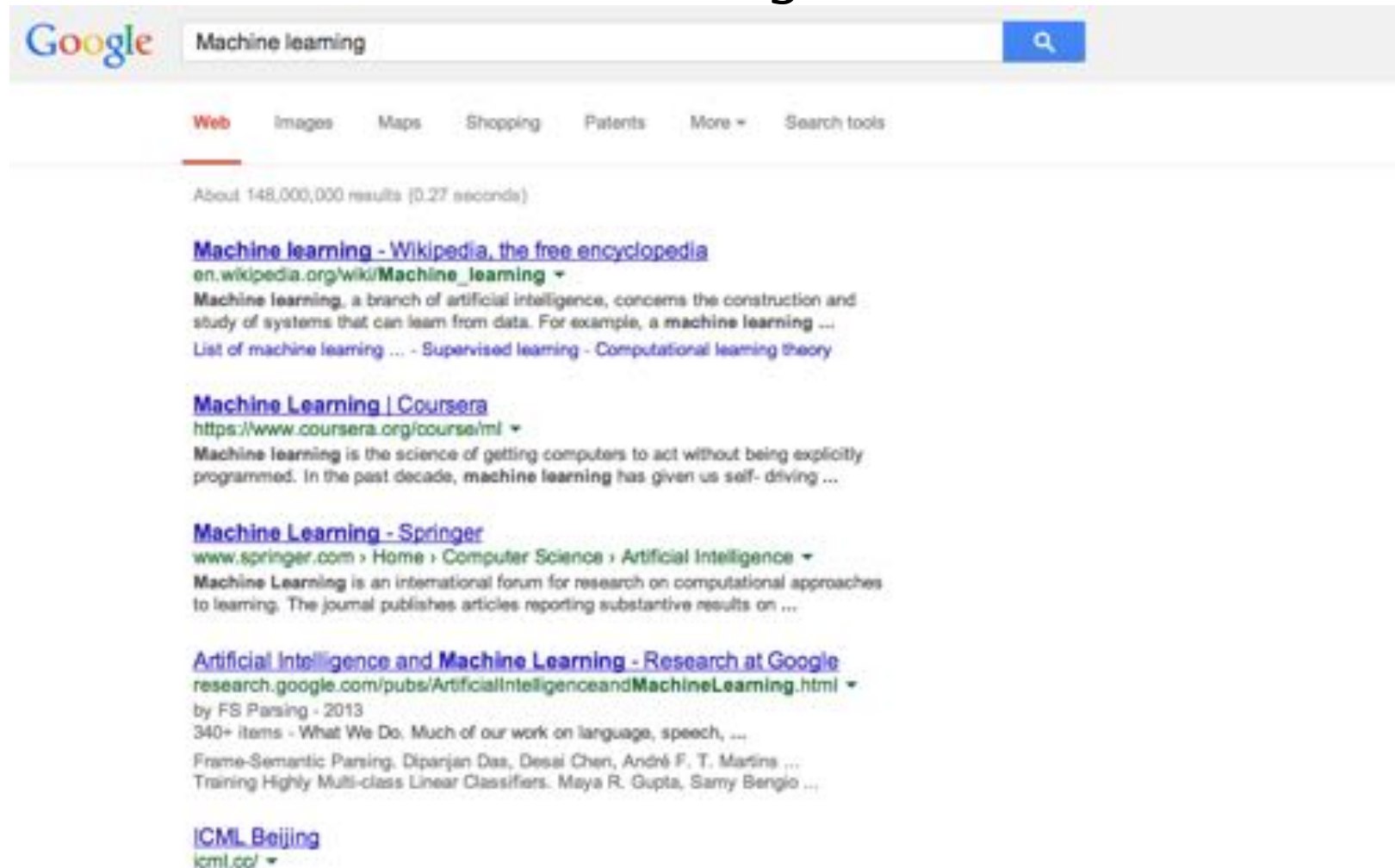
Product	Price	Rating
SNG Party with Wii U Microphone Nintendo ★★★★★ (25) Nintendo Wii U \$15.99 Prime	\$15.99	★★★★★ (25)
Wii U Microphone Nintendo ★★★★★ (6) Nintendo Wii U \$8.99 Prime	\$8.99	★★★★★ (6)
Barbie Dreamhouse Party - Nintendo Wii U Majesco Sales Inc. ★★★★★ (5) Nintendo Wii U \$39.95 Prime	\$39.95	★★★★★ (5)
Wii Party U Nintendo ★★★★★ (40) Nintendo Wii U \$39.99 Prime	\$39.99	★★★★★ (40)
Just Dance 2014 - Nintendo Wii U UBI Soft ★★★★★ (50) Nintendo Wii U \$35.21 Prime	\$35.21	★★★★★ (50)
Just Dance 4 - Nintendo Wii U UBI Soft ★★★★★ (70) Nintendo Wii U \$17.89 Prime	\$17.89	★★★★★ (70)
ESPN Sports Connection - Nintendo Wii U UBI Soft ★★★★★ (24) Nintendo Wii U \$19.23 Prime	\$19.23	★★★★★ (24)

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# Applications of AI

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## Search engines



The image shows a screenshot of a Google search results page for the query "Machine learning". The search bar at the top contains the text "Machine learning" and a blue search button with a magnifying glass icon. Below the search bar, there are tabs for "Web", "Images", "Maps", "Shopping", "Patents", "More", and "Search tools". The "Web" tab is selected. The search results are displayed below the tabs, showing "About 148,000,000 results (0.27 seconds)". The first result is "Machine learning - Wikipedia, the free encyclopedia" with a link to "en.wikipedia.org/wiki/Machine\_learning". The second result is "Machine Learning | Coursera" with a link to "https://www.coursera.org/course/ml". The third result is "Machine Learning - Springer" with a link to "www.springer.com". The fourth result is "Artificial Intelligence and Machine Learning - Research at Google" with a link to "research.google.com/pubs/ArtificialIntelligenceandMachineLearning.html". The fifth result is "ICML Beijing" with a link to "icml.cc/".

Google Machine learning

Web Images Maps Shopping Patents More Search tools

About 148,000,000 results (0.27 seconds)

[Machine learning - Wikipedia, the free encyclopedia](#)  
en.wikipedia.org/wiki/Machine\_learning  
Machine learning, a branch of artificial intelligence, concerns the construction and study of systems that can learn from data. For example, a machine learning ...  
List of machine learning ... - Supervised learning - Computational learning theory

[Machine Learning | Coursera](#)  
https://www.coursera.org/course/ml  
Machine learning is the science of getting computers to act without being explicitly programmed. In the past decade, machine learning has given us self-driving ...

[Machine Learning - Springer](#)  
www.springer.com > Home > Computer Science > Artificial Intelligence  
Machine Learning is an international forum for research on computational approaches to learning. The journal publishes articles reporting substantive results on ...

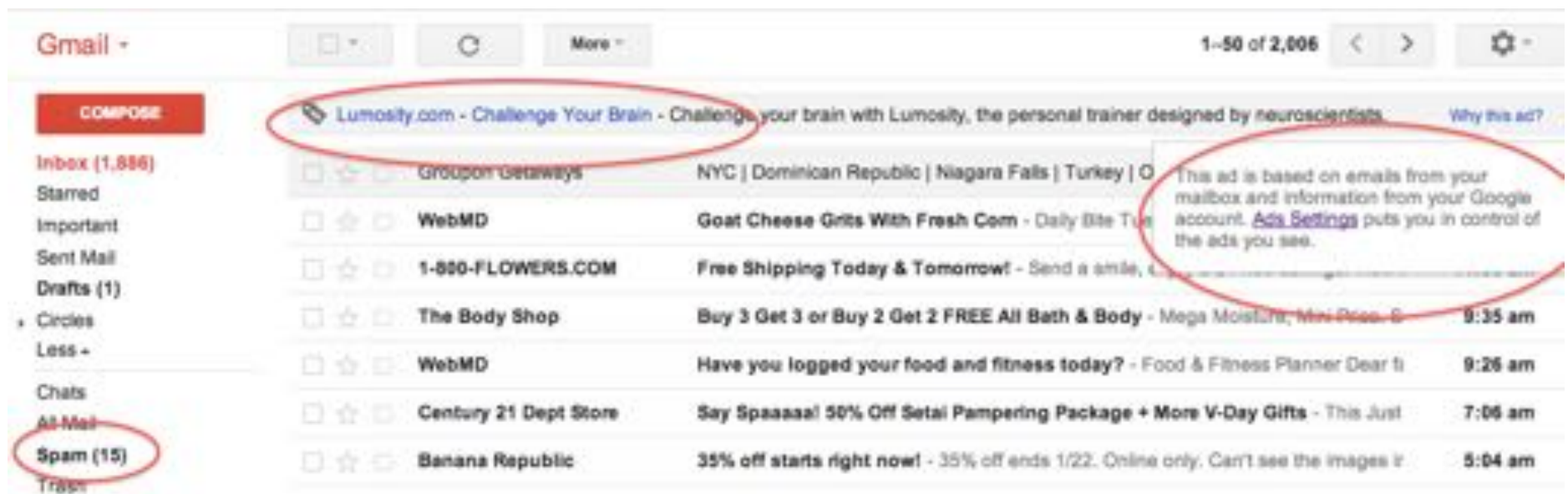
[Artificial Intelligence and Machine Learning - Research at Google](#)  
research.google.com/pubs/ArtificialIntelligenceandMachineLearning.html  
by FS Posing - 2013  
340+ items - What We Do. Much of our work on language, speech, ...  
Frame-Semantic Parsing. Dipanjan Das, Desai Chen, André F. T. Martins ...  
Training Highly Multi-class Linear Classifiers. Maya R. Gupta, Samy Bengio ...

[ICML Beijing](#)  
icml.cc/



# Applications of AI

## Email



# Applications of AI

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## Face detection



Viola-Jones method.

# Applications of AI

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## Face detection

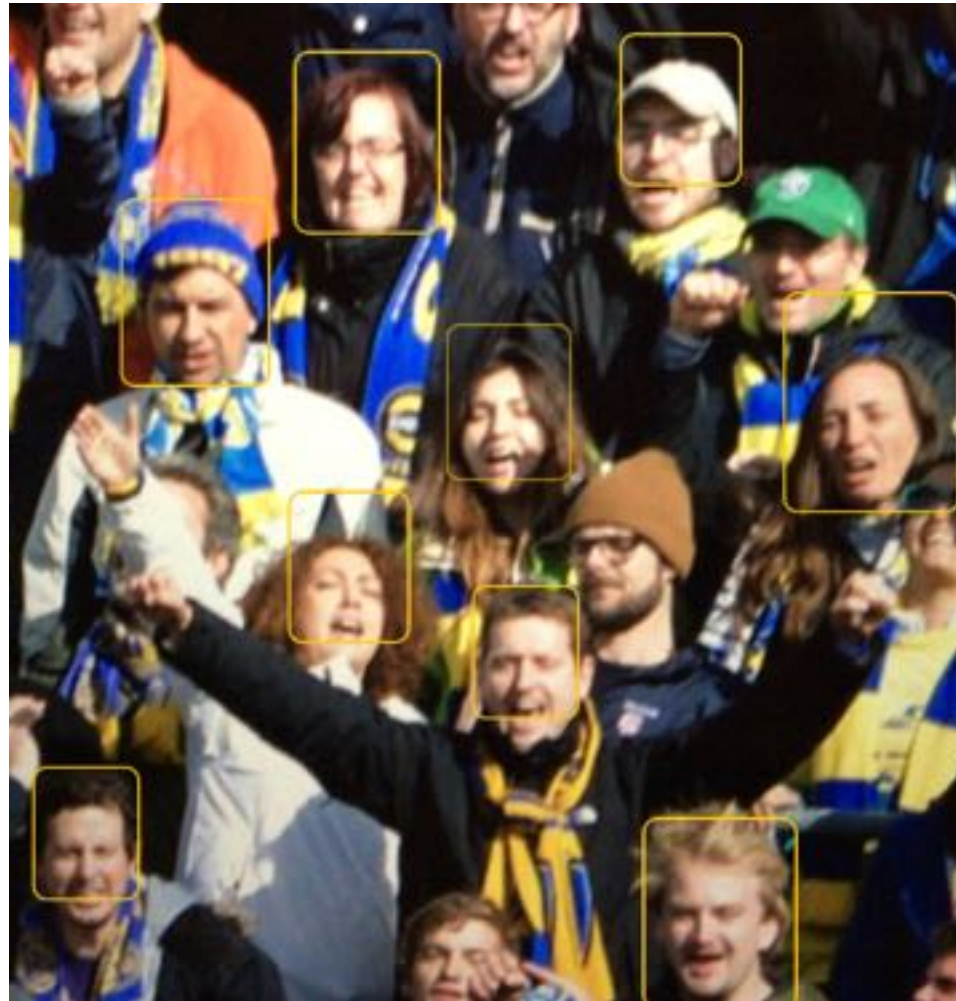


Viola-Jones method.

# Applications of AI

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## Face detection

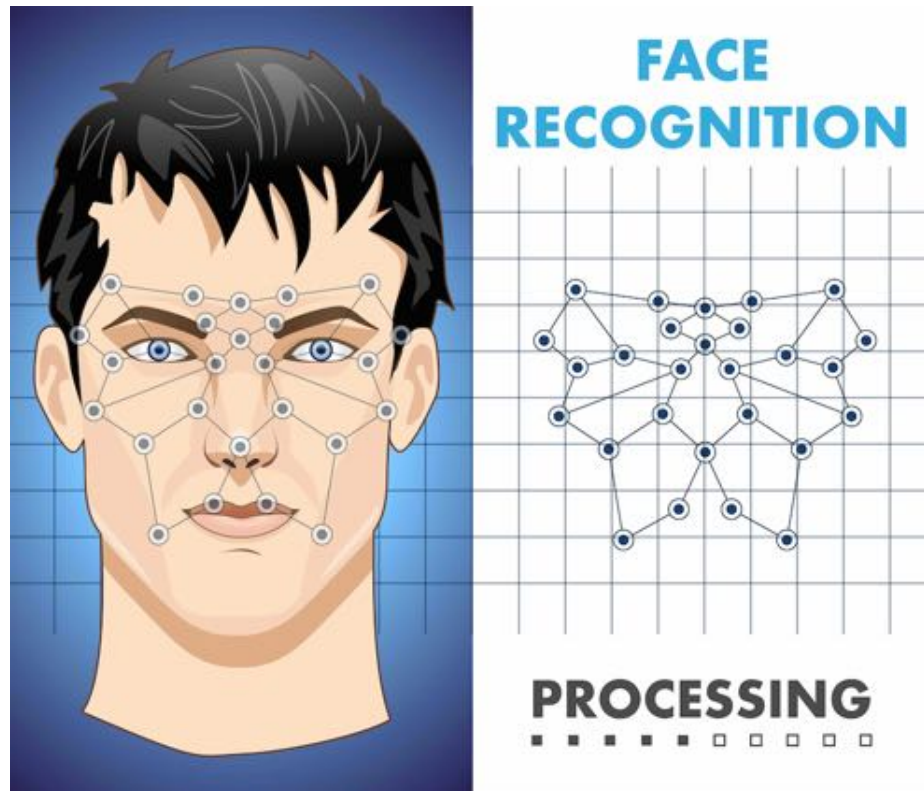


Viola-Jones method.

# Applications of AI

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## Face recognition

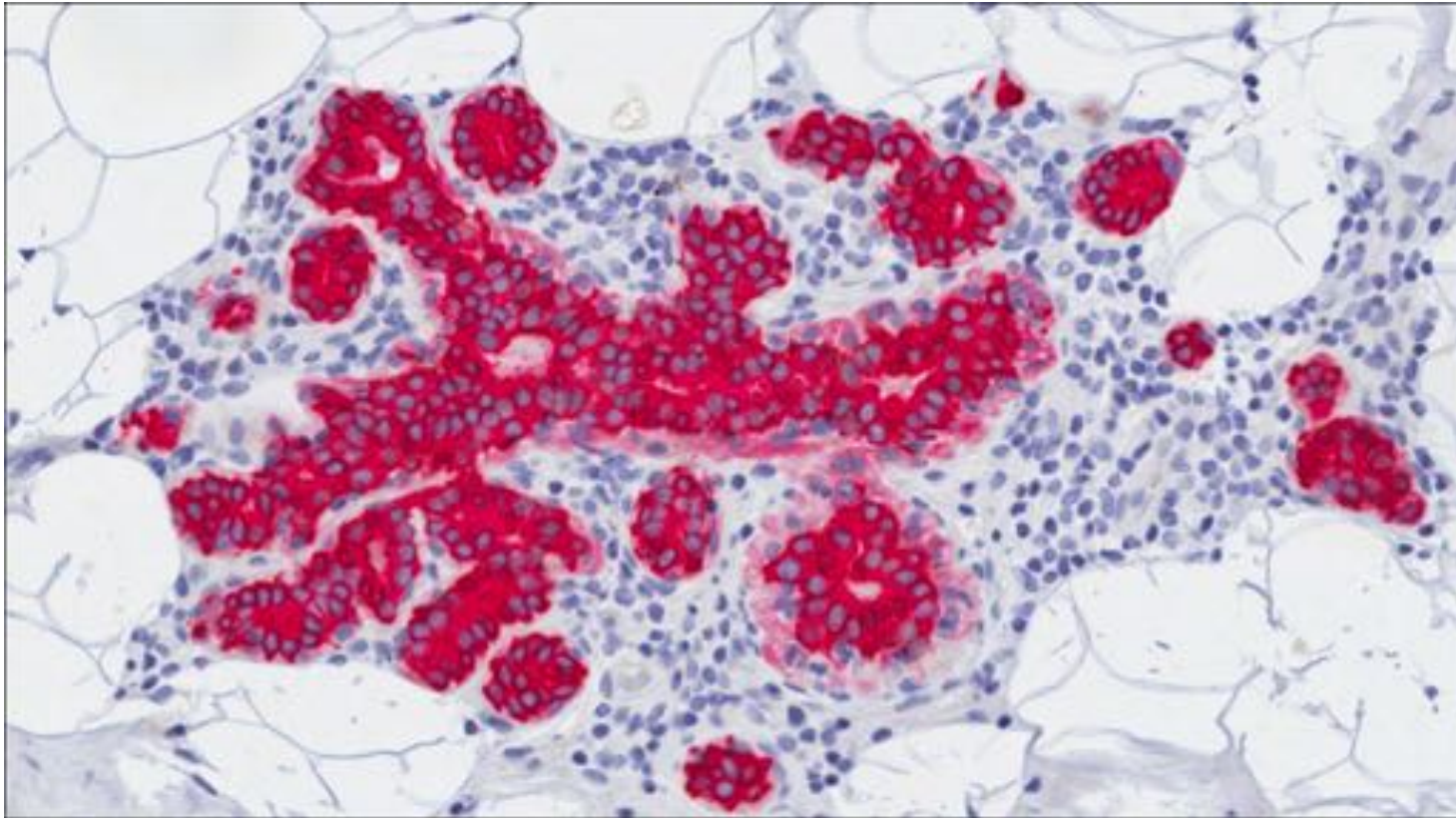




# Applications of AI

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Detection of breast cancer in mammography images



# Applications of AI

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## 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

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## Jeopardy! (2011): Humans vs. IBM Watson



By Rosemaryetoufee (Own work), via Wikimedia Commons

Natural Language Understanding and information extraction!

# Applications of AI

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**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

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## Autonomous driving



By User Spaceape on en.wikipedia, via Wikimedia Commons

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

# State-of-the-art applications

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- Speech recognition
- Autonomous planning and 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
- 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

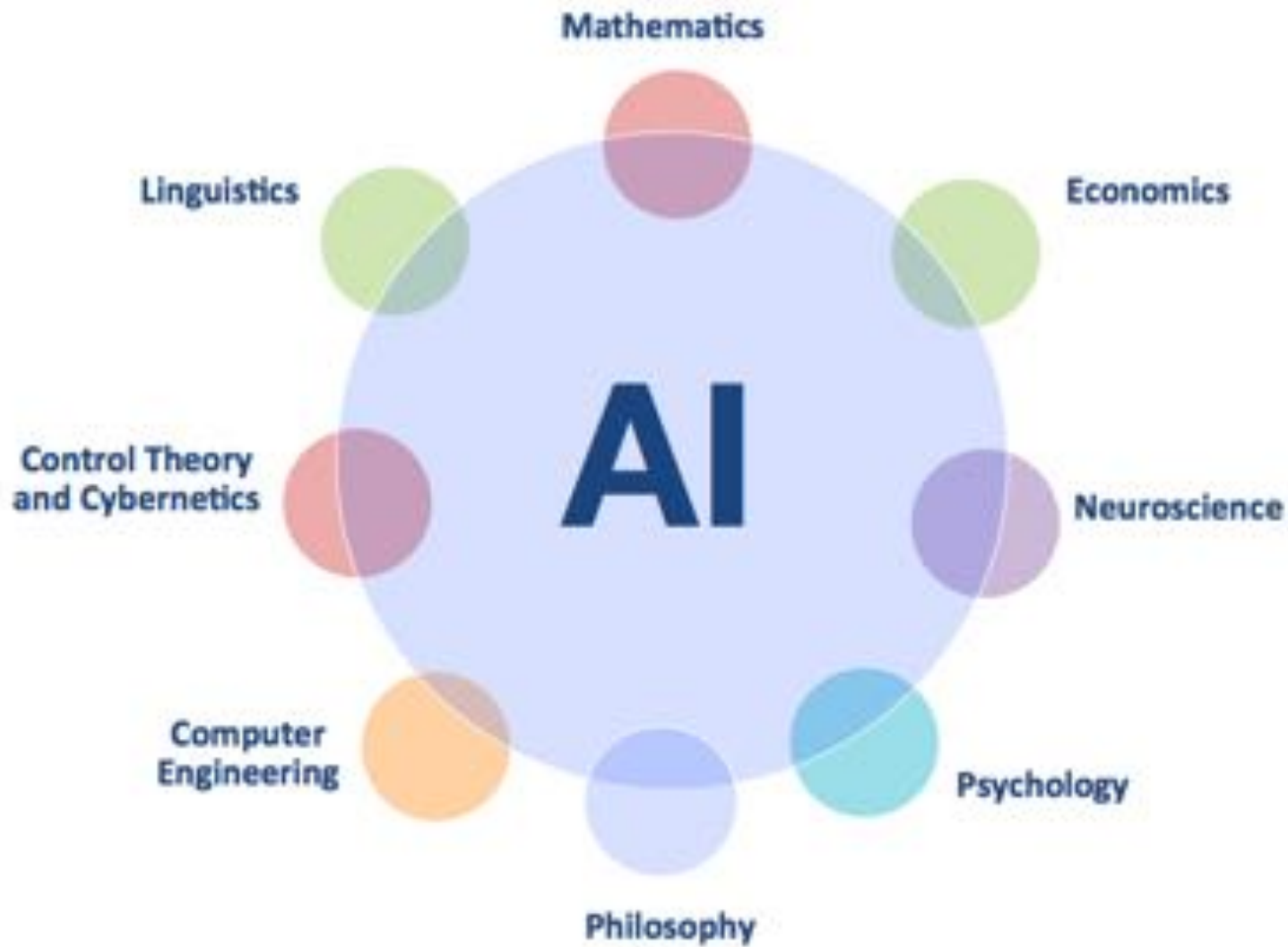
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- Protein design
- Document summarization
- Transportation/scheduling
- Computer animation

**Many more!**

# Foundation of AI

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# Foundation of AI

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- **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

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- **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

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- **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).

# AI founders

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

# AI Resources

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- Major journals/conferences: JAIR, TPAMI, JMLR, IJCAI, AAAI, IAAI, CVPR, ECAI, ICML, NIPS, etc.
- Video lectures:

[http://videlectures.net/Top/Computer\\_Science/Artificial\\_Intelligence/](http://videlectures.net/Top/Computer_Science/Artificial_Intelligence/)

# History of AI

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- **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>
- **1970-1990:** Knowledge-based AI
  - Expert systems, AI becomes an industry
  - AI winter

# History of AI

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- **1990-present**: Scientific approaches
  - Neural Networks: le retour
  - The emergence of intelligent agents
  - AI becomes “scientific”, use of probability to model uncertainty
  - AI Spring!
  - The availability of very large datasets.
    - \* Data will drive future discoveries and alleviate the complexity in AI.