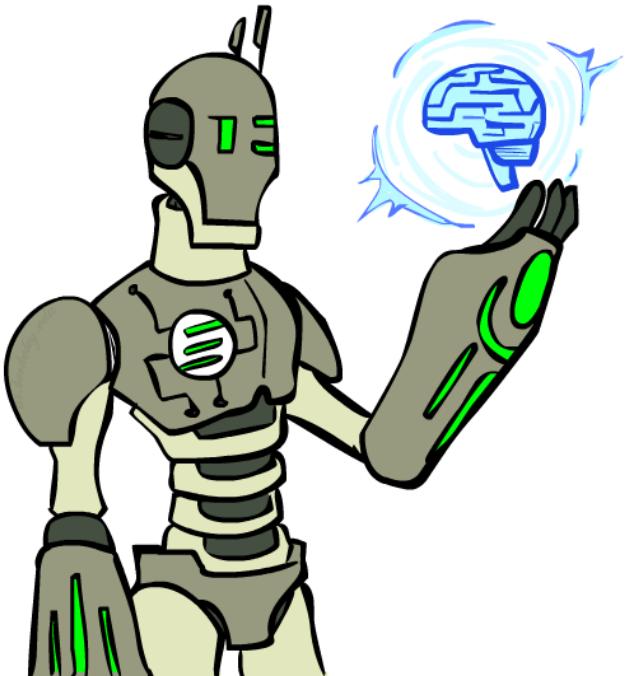


Chapter 1

Introduction to AI

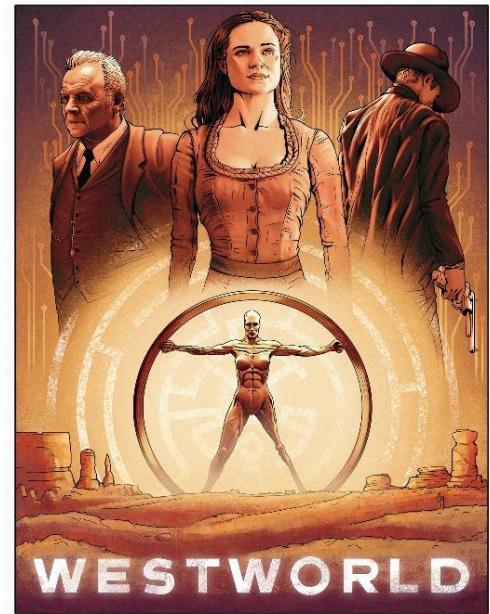
Chapter Outline

- What is AI?
- AI History
- AI Big Shots
- AI Gurus
- AI Applications



What is AI?

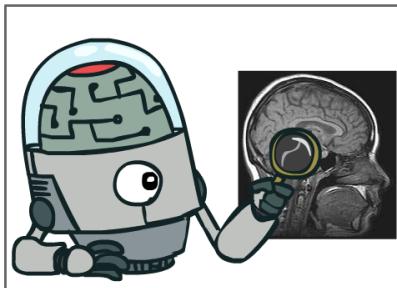
Sci-Fi AI



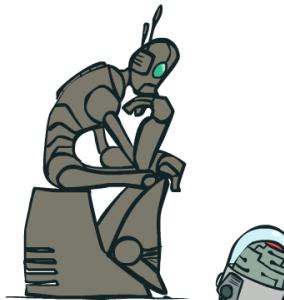
What is AI?

The science of making machines that:

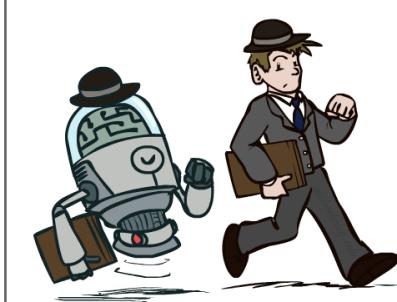
Think like people



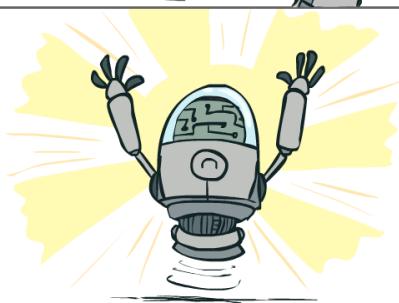
Think rationally



Act like people



Act rationally





(1/4) Acting Humanly

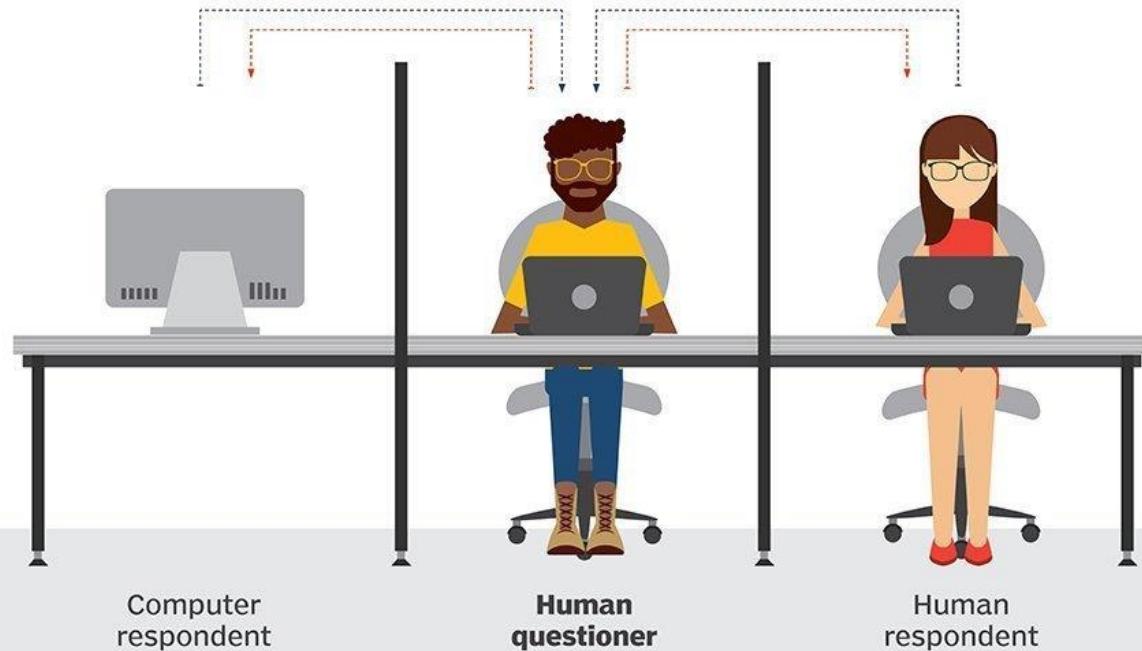
- “The art of creating machines that perform functions that require intelligence when performed by people.” (Kurzweil, 1990)
- “The study of how to make computers do things at which, at the moment, people are better.” (Rich and Knight, 1991)

Acting Humanly

Turing test

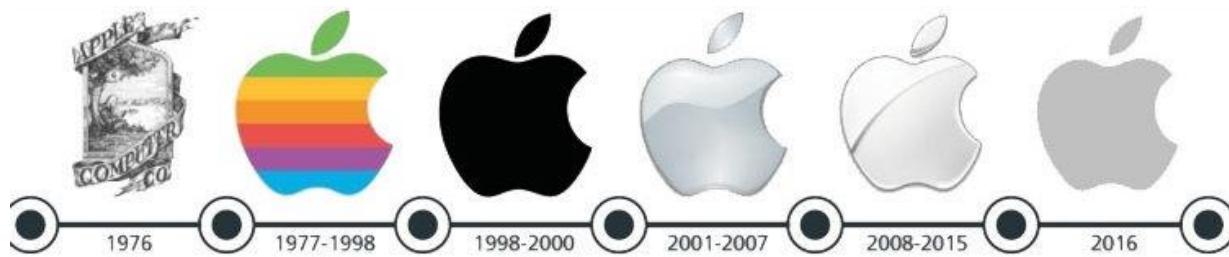
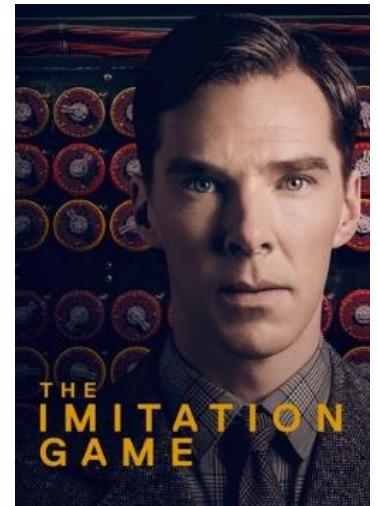
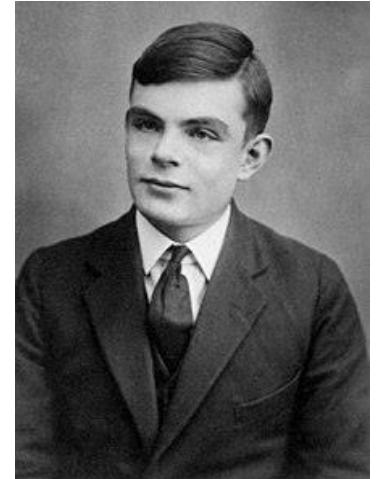
During the Turing test, the human questioner asks a series of questions to both respondents. After the specified time, the questioner tries to decide which terminal is operated by the human respondent and which terminal is operated by the computer.

■ QUESTION TO RESPONDENTS ■ ANSWERS TO QUESTIONER



Alan Turing

- In 1926, Sherborne School, formed a significant friendship with Christopher Morcom.
- From 1931 to 1934, King's College, Cambridge.
- From 1936 to 1938, postdoc at Princeton University.
- During the Second World War, worked for the Government Code and Cypher School (GC&CS) at Bletchley Park. He built the **bombe**, which is an electro-mechanical device to help decipher German **Enigma**-machine-encrypted secret messages.
- The case, Regina v. Turing and Murray, was brought to trial on 31 March 1952. Turing was convicted and given a choice between imprisonment and probation.
- On 8 June 1954, Turing's housekeeper found him dead, with an apple lay half-eaten beside his bed. The cause of death was cyanide poisoning, although the apple was not tested for cyanide.



Alan Turing

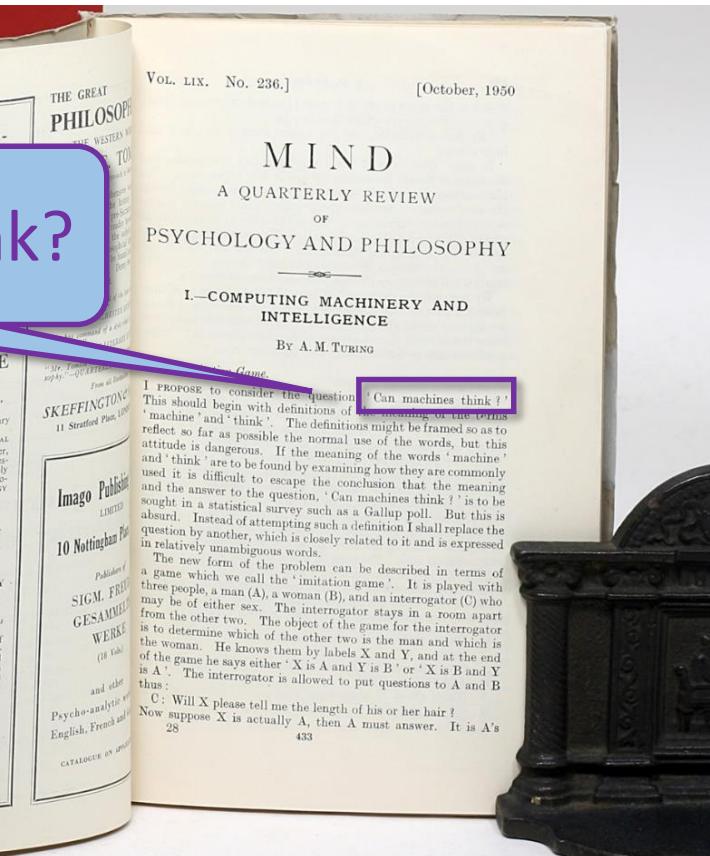
- 1936: *On Computable Numbers, with an Application to the Entscheidungsproblem*
- 1950: *Computing Machinery and Intelligence*

ON COMPUTABLE
THE

[Received]

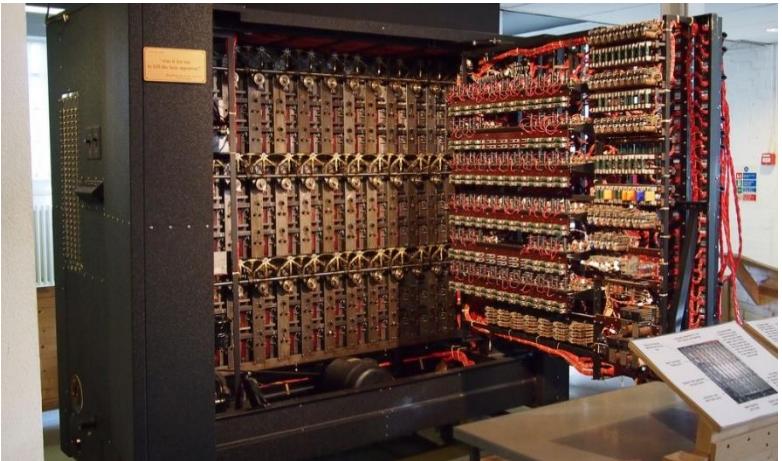
Can machines think?

The “computable” numbers may be described briefly as the real numbers whose expressions as a decimal are calculable by finite means. Although the subject of this paper is ostensibly the computable *numbers*, it is almost equally easy to define and investigate computable functions of an integral variable or a real or computable variable, computable predicates, and so forth. The fundamental problems involved are, however, the same in each case, and I have chosen the computable numbers for explicit treatment as involving the least cumbrous technique. I hope shortly to give an account of the relations of the computable numbers, functions, and so forth to one another. This will include a development of the theory of functions of a real variable expressed in terms of computable numbers. According to my definition, a number is computable if its decimal can be written down by a machine.



(1/4) Acting Humanly

- Enigma vs Bombe



(1/4) Acting Humanly

- Programming a computer to pass a **Turing Test** needs the following capabilities:
 - Natural language processing
 - Knowledge representation
 - Automated reasoning
 - Machine learning
- and a **Total Turing Test** with physical simulation:
 - Computer vision
 - Robotics

(2/4) Thinking Humanly

- “The exciting new effort to make computers think ... *machines with minds*, in the full and literal sense.” (Haugeland, 1985)
- “[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning ...” (Hellman, 1978)

(2/4) Thinking Humanly

- **Cognitive Science**

- Necessarily based on experimental investigation of actual humans or animals
- Get inside the actual workings of human minds
 - Through introspection (内省)
 - Through psychological experiments (心理实验)
 - Through brain imaging (脑成像)
- Modern authors separate the two kinds of claims; this distinction has allowed both **AI** and **cognitive science** to develop more rapidly

(3/4) Thinking Rationally

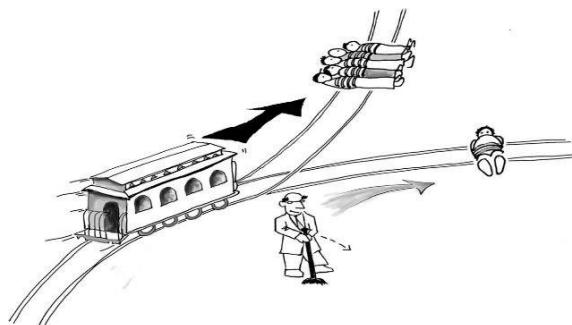
- “The study of mental faculties through the use of computational models.” (Charniak and McDermott, 1985)
- “The study of the computations that make it possible to perceive, reason, and act.” (Winston, 1992)
- Aristotle attempted to codify *right thinking*: **Syllogisms** (三段论)
 - Major premise: *All men are mortal.* (general principle)
 - Specific premise: *Socrates is a man.* (specific instance)
 - Conclusion: *Therefore, Socrates is mortal.* (Follows logically)
- **Logic**



(4/4) Acting rationally

- “Computational Intelligence is the study of the design of intelligent agents.” (Poole et al, 1998)
- “AI ... is concerned with intelligent behavior in artifacts.” (Nilsson, 1998)
- A **rational agent** acts so as to achieve the **best outcome** or, when there is uncertainty, the **best expected outcome**.
- Making **correct** inferences is sometimes part of being a **rational** agent. On the other hand, **correct** inference is not all of **rationality**; in some situations, there is no provably **correct** thing to do, but something must still be done.

- The Trolley Problem



What is Artificial Intelligence?

- **Artificial intelligence** (AI, also machine intelligence, MI) is **intelligence displayed by machines**, in contrast with the natural intelligence (NI) displayed by humans and other animals.
- In computer science AI research is defined as **the study of "intelligent agents"**: any device that perceives its environment and takes actions that **maximize its chance of success at some goal**. Colloquially, the term "artificial intelligence" is applied when a machine mimics "**cognitive**" functions that humans associate with other human minds, such as "**learning**" and "**problem solving**".

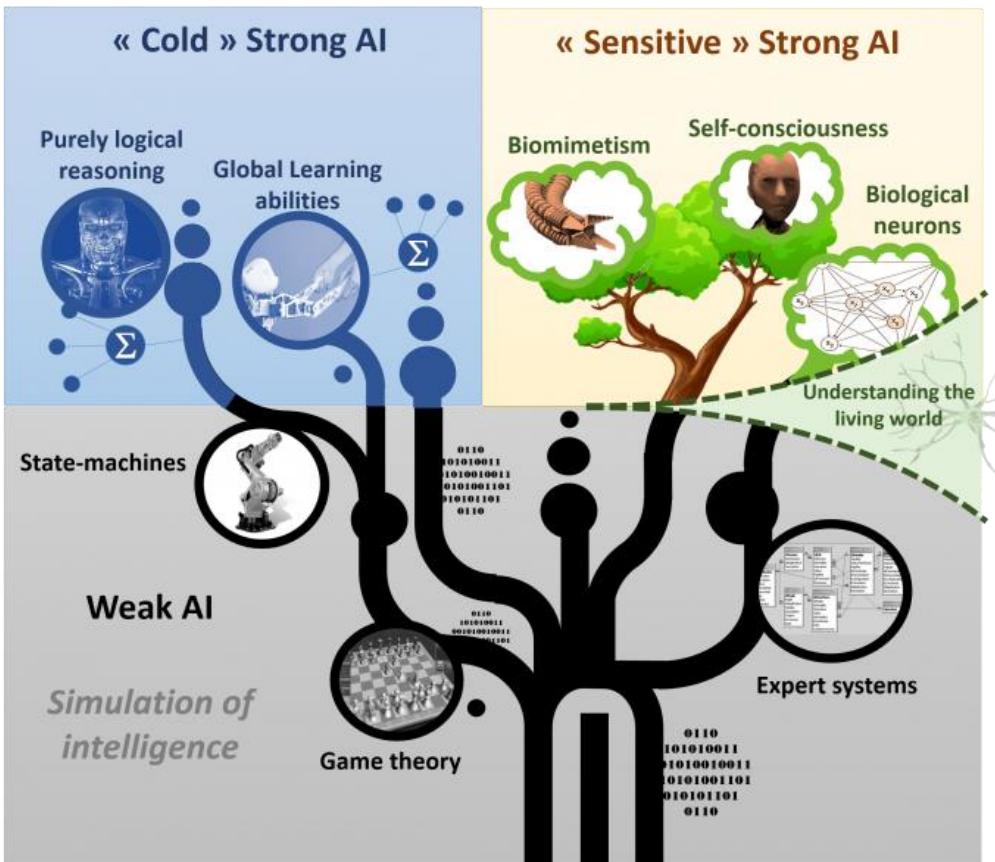
AI Stages

- **Strong AI**

- In principle able to learn and act intelligently in a broad general range, as humans can

- **Weak AI**

- Constrained in problems sets / domains
- Set of techniques for intelligent decisions and actions
- Ubiquitous across many software systems
- Does not attempt to solve the problem of general intelligence
- Most AI today is weak AI

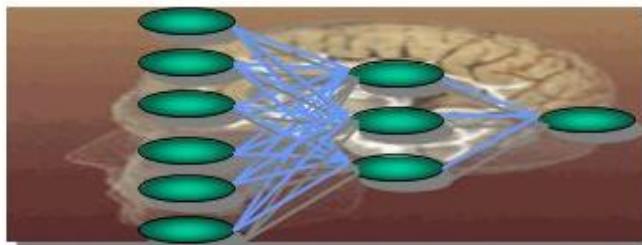


AI Paradigms

Symbolic AI
Rule-Based Systems

P	Q	R	$(P \& -Q) \vee R \Rightarrow (R \& -Q \Rightarrow -P)$
T	T	T	T F F T
T	T	F	T F F T
T	F	T	T T T F
F	T	F	T T T F
F	F	T	F F F T
F	F	F	F F T F

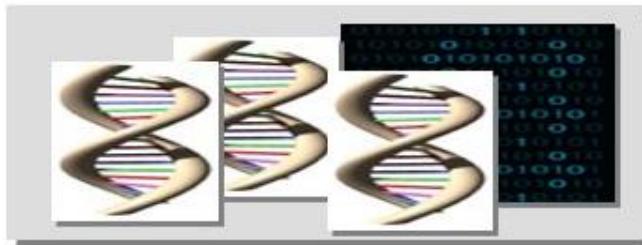
Connectionist AI
Neural Networks



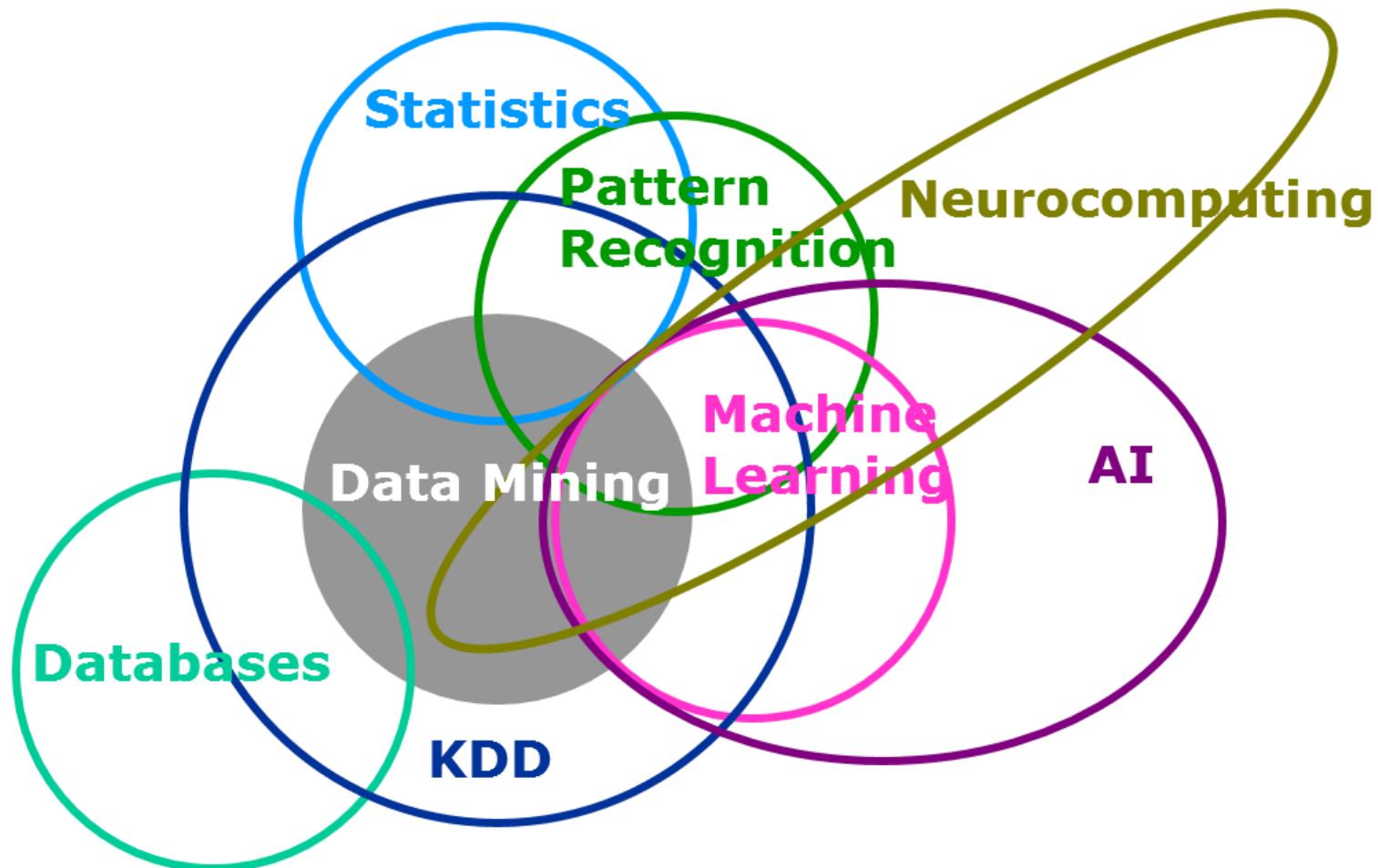
Evolutionary AI
Genetic Algorithms



Molecular AI:
DNA Computing



DM, ML & AI



AI History

1945-1955: The Gestation of AI

- Warren McCulloch & Walter Pitts
 - A model of artificial neurons in which each neuron is characterized as being "on" or "off," with a switch to "on" occurring in response to stimulation by a sufficient number of neighboring neurons.
- Donald Hebb
 - Demonstrated a simple updating rule for modifying the connection strengths between neurons, called Hebbian Learning, in 1949.
- Marvin Minsky & Dean Edmonds
 - The first neural network computer SNARC in 1950.
 - 3000 vacuum tubes and a surplus automatic pilot mechanism from a B-24 bomber to simulate a network of 40 neurons.
- Alan Turing
 - Turing Test, machine learning, genetic algorithms, and reinforcement learning.

1956: The Birth of AI

- In 1956, **John McCarthy** invited many of the leading researchers of the time in a wide range of advanced research topics such as complexity theory, language simulation, neuron nets, abstraction of content from sensory inputs, relationship of randomness to creative thinking, and learning machines to Dartmouth in New Hampshire to discuss a subject so new to the human imagination that he had to coin a new term for it: **Artificial Intelligence**.

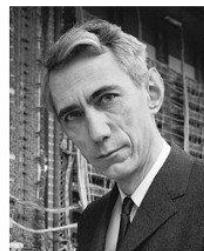
1956 Dartmouth Conference: The Founding Fathers of AI



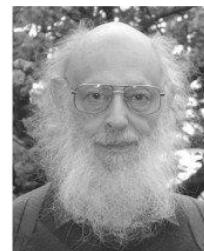
John McCarthy



Marvin Minsky



Claude Shannon



Ray Solomonoff



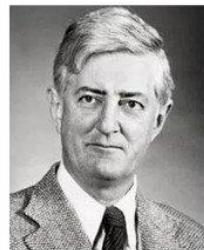
Alan Newell



Herbert Simon



Arthur Samuel



Oliver Selfridge



Nathaniel Rochester



Trenchard More



1952-1969: Early Enthusiasm, Great Expectations

- **General Problem Solver** (GPS) following Newell and Simon's Logic Theorist (LT)
- IBM (**Nathaniel Rochester**)
 - **Herbert Gelernter** constructed the **Geometry Theorem Prover** (几何定理证明器) in 1959.
 - **Arthur Samuel** wrote a series of programs for **checkers**, demonstrated on television in 1956.
- **John McCarthy** moved from Dartmouth to MIT in 1958
 - Stressed **representation and reasoning in formal logic**.
 - Defined the high-level language **Lisp**.
 - Published a paper entitled *Programs with Common Sense*, in which he described the **Advice Taker**, a hypothetical program that can be seen as the **first complete AI system**.
- **Marvin Minsky** also moved to MIT in 1958
 - Interested in getting programs to work and developed an **anti-logic outlook**.
 - Supervised a series of students who chose limited problems (**Microworlds**) that appeared to require intelligence to solve.
- Work based on the **neural networks** of McCulloch and Pitts
 - Bernie Widrow, Frank Rosenblatt (Perceptrons), etc.

1966-1973: A Dose of Reality

- **Simon** made concrete predictions:
 - Within 10 years a computer would be chess champion.
 - A significant mathematical theorem would be proved by machine.
 - (came true, or approximately true, within 40 years).
- Early systems turned out to **fail** miserably when tried out on **wider selections of problems** and on **more difficult problems**.
 - Most early programs **knew nothing** of their subject matter, they succeeded by means of simple syntactic manipulations.
 - **Intractability:** most of the early AI programs solved problems by trying out different combinations of steps until the solution was found.
 - **Fundamental limitations** on the basic structures being used to generate intelligent behavior.
 - (the new back-propagation learning algorithms for multilayer networks that were to cause an enormous resurgence in neural-net research in the late 1980s were actually discovered in 1969)

1969-1979: Knowledge-based Systems

- The first decade of AI was of a **general-purpose search mechanism** trying to string together elementary reasoning steps to find complete solutions.
- Such approaches have been called **weak methods** because, although general, they **do not scale up to large or difficult problem instances**.
- **DENDRAL** program of Stanford in 1969
 - Inferring molecular structure from the information provided by a mass spectrometer
- Heuristic Programming Project (**HPP**) of Standford
 - **MYCIN** for medical diagnoses, with about 450 rules for blood infections diagnose.

1980-present: AI Becomes An Industry

- RI (first successful commercial expert system) of **Digital Equipment Corporation** (McDermott, 1982).
 - The program helped configure orders for new computer systems; by 1986, it was saving the company an estimated **\$40 million a year**.
- By 1988, **DEC's AI group** had **40 expert systems** deployed.
- **DuPont** had 100 in use and 500 in development, saving an estimated **\$10 million a year**.
- In 1981, the **Japanese** announced the "**Fifth Generation**" project, a 10-year plan to build intelligent computers running Prolog
- In response, the **United States** formed the Microelec-tronics and Computer Technology Corporation (**MCC**) as a research consortium designed to assure national competitiveness.
- In **Britain**, the **Alvey** report reinstated the funding.
- Overall, the AT industry boomed from a few million dollars in 1980 to billions of dollars in 1988, including hundreds of companies building expert systems, vision systems, robots, and software and hardware. Soon after that came a period called the "**AI Winter**".



1986-present: Neural Networks Return

- In the mid-1980s at least **four different groups** reinvented the **back-propagation** learning algorithm first found in 1969 by Bryson and Ho.
- These so-called **connectionist** models of intelligent systems were seen by some as direct competitors both to the **symbolic models** promoted by Newell and Simon and to the **logicist approach** of McCarthy and others.



1987-present: Scientific Method

- There is a **recognition**:
 - machine learning should not be isolated from **information theory**;
 - uncertain reasoning should not be isolated from **stochastic modeling**;
 - search should not be isolated from **classical optimization** and **control**;
 - automated reasoning should not be isolated from **formal methods** and **static analysis**.
- **Hidden Markov Models** (HMMs)
- **Bayesian Networks**
- **Data Mining**



1995-present: The Emergence of Intelligent Agents

- The work of Allen Newell, John Laird, and Paul Rosenbloom on **SOAR** is the best-known example of a **complete agent architecture**.
- Founders of AI, including John McCarthy, Marvin Minsky, Nils Nilsson and Patrick Winston, have expressed **discontent** with the progress of AI:
 - AI should put less emphasis on creating ever-improved versions of applications that are good at a specific task, such as *driving a car*, *playing chess*, or *recognizing speech*. Instead, **AI should return to its roots of striving for**, in Simon's words, "**machines that think, that learn HUMAN-LEVEL AI and that create.**"
- **Artificial General Intelligence (AGI)**
- **Friendly AI**

AI Evolution

THE RISE OF AI

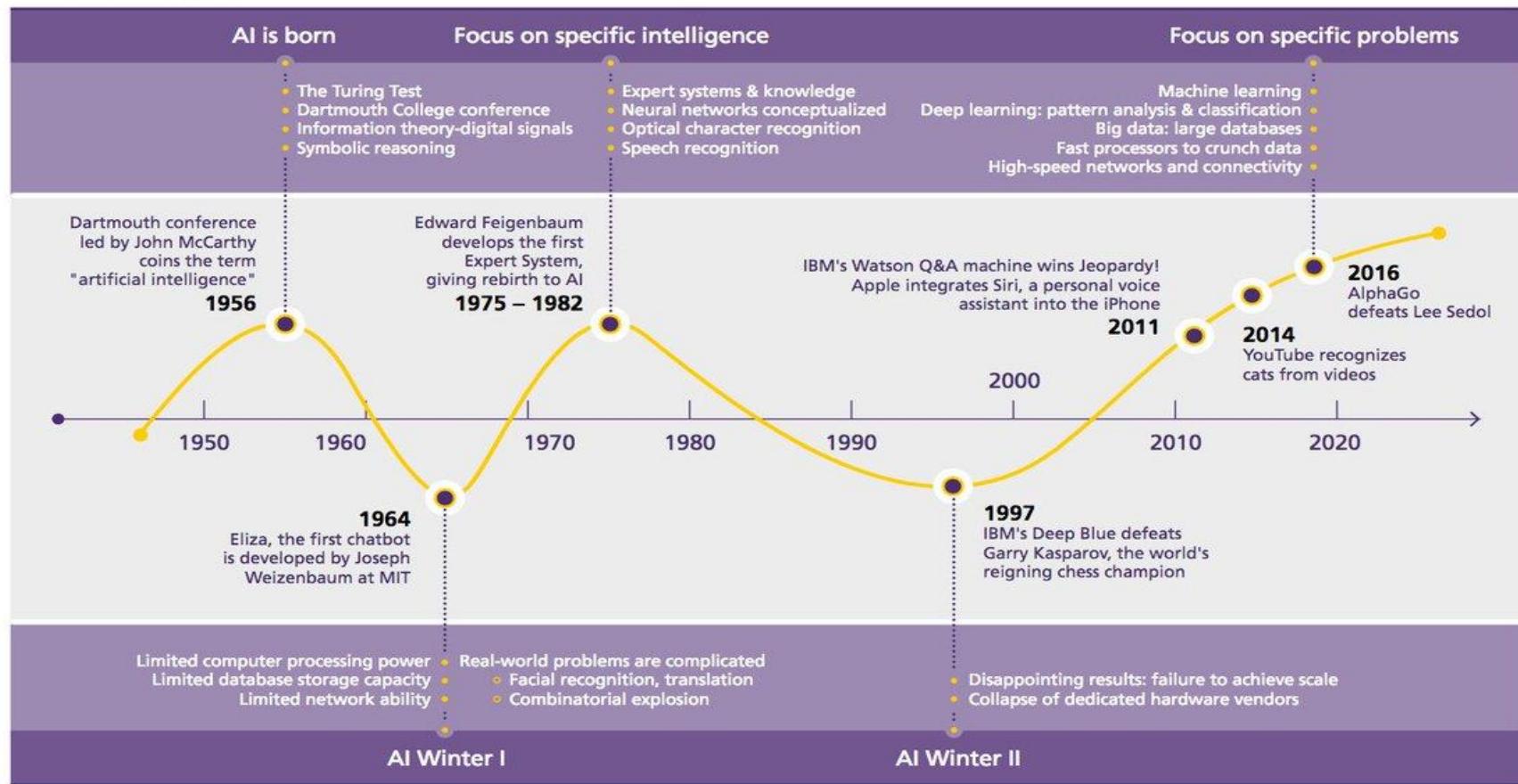


Figure 1: An AI timeline; Source: Lavenda, D./Marsden, P.

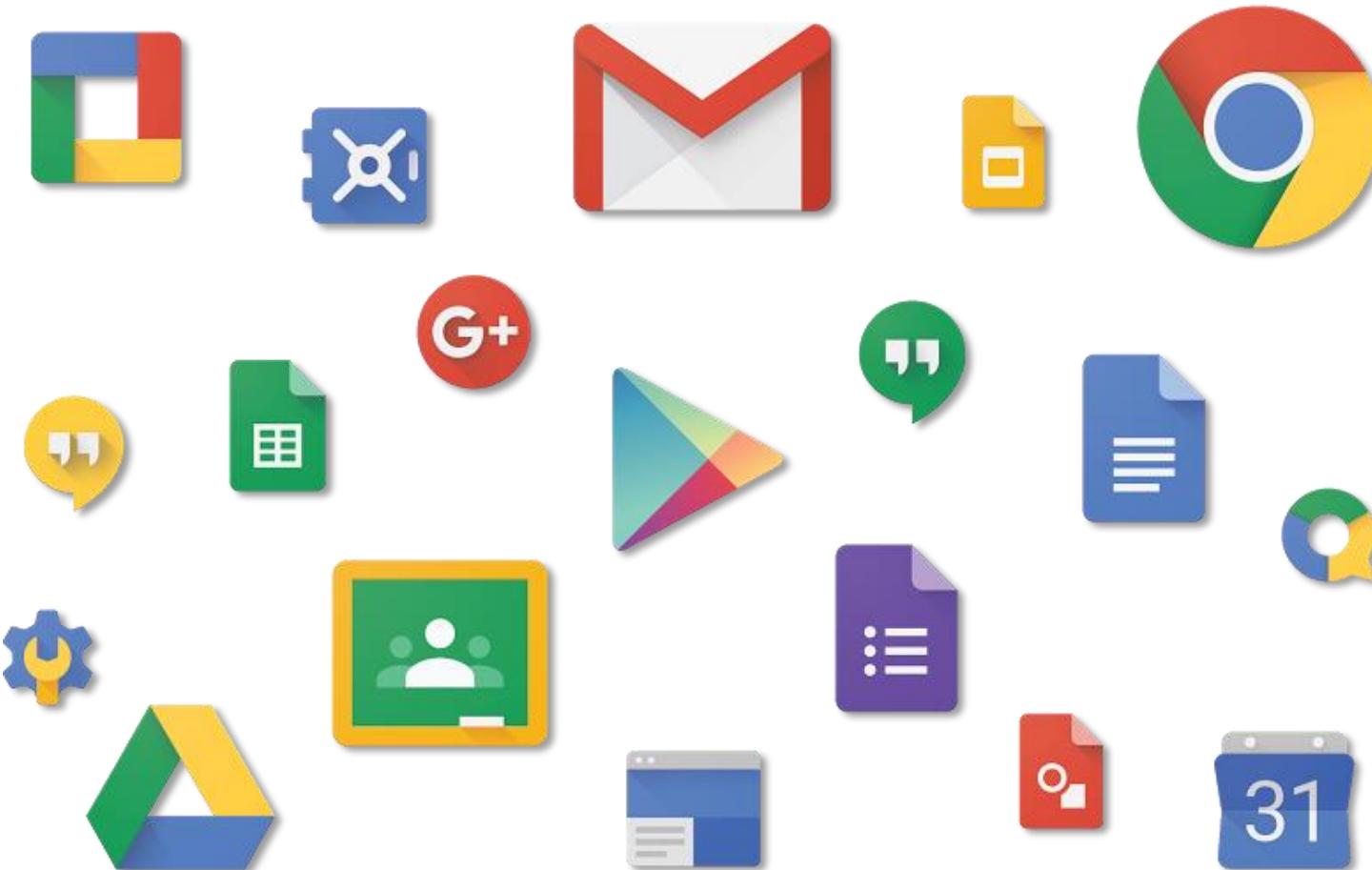
AI Big Shots

Alphabet

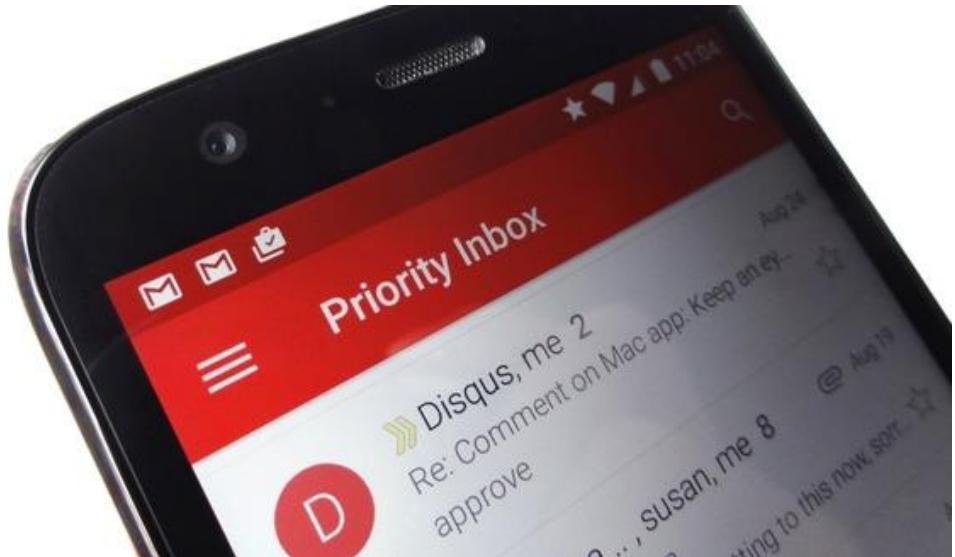
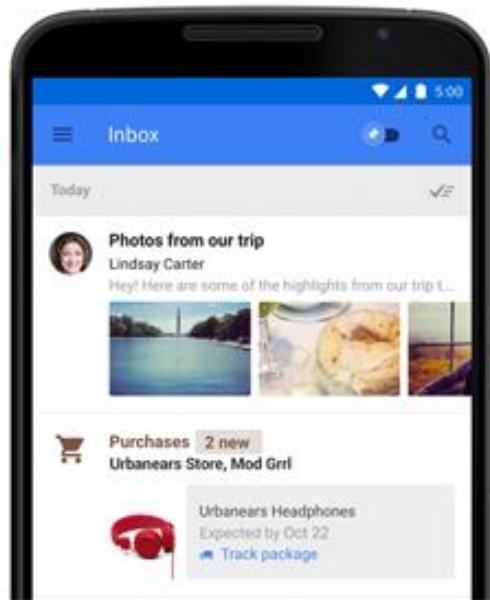
Alphabet



Alphabet: GApps



Alphabet: E-Mail



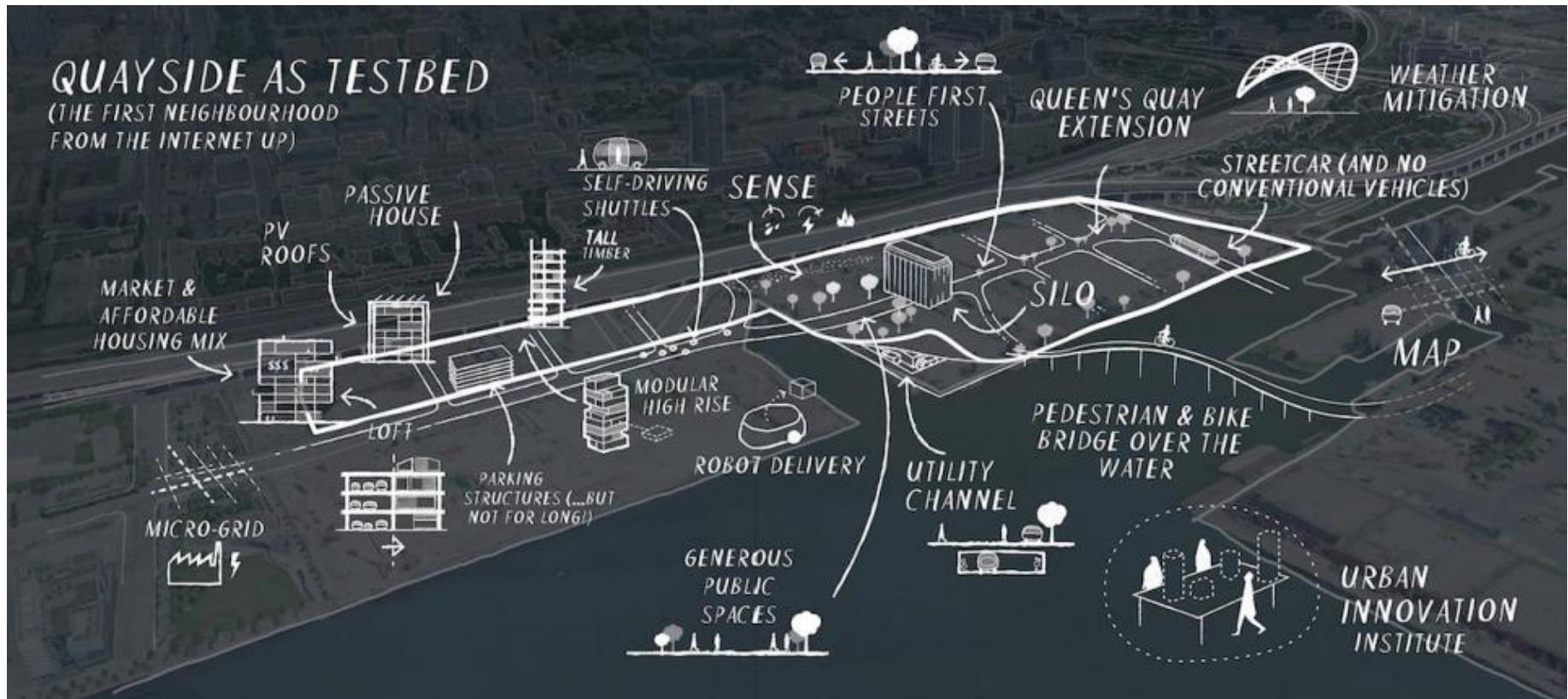
Alphabet: YouTube

- Recommendation
- Advertisement
- Censorship

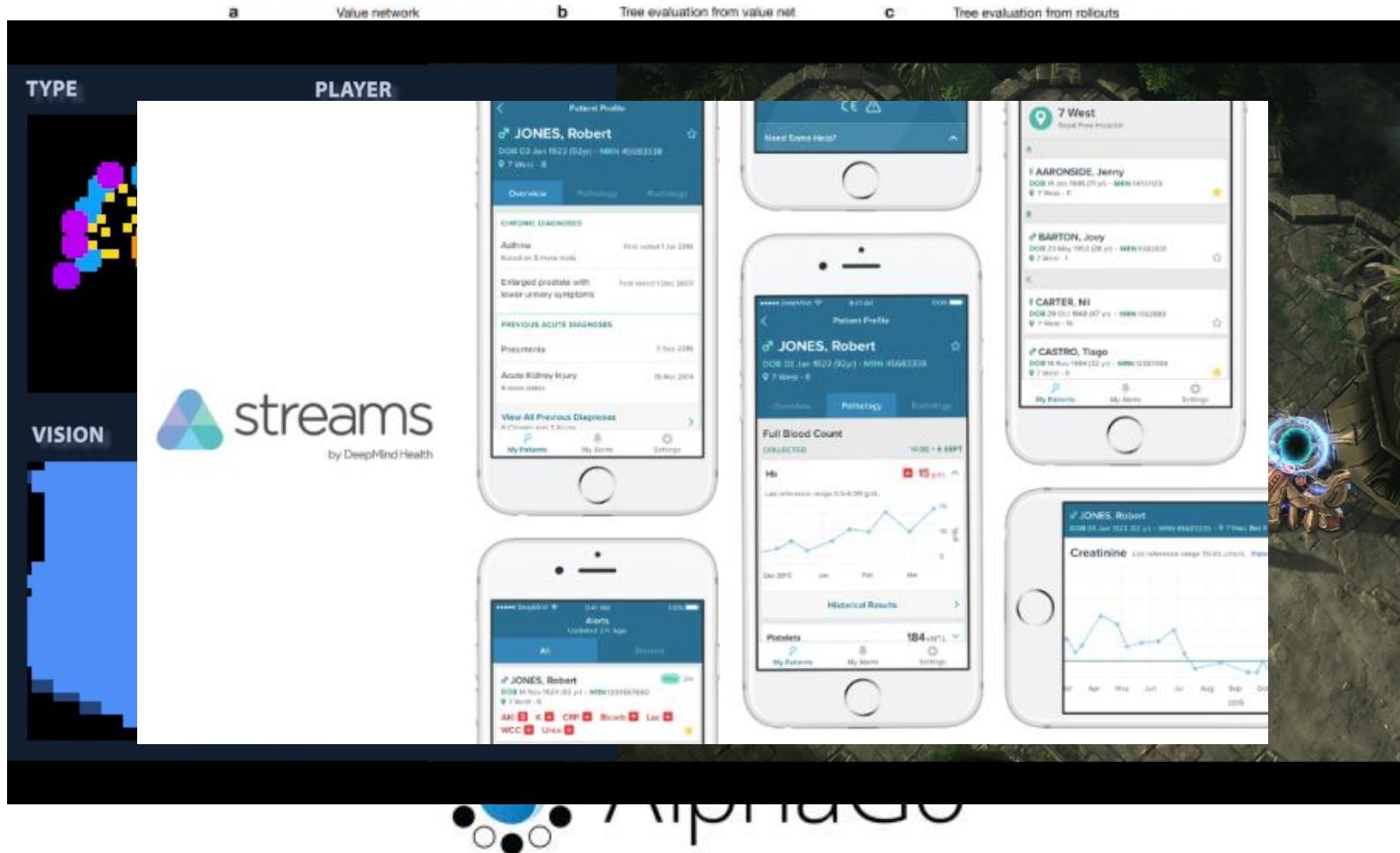


Alphabet: Sidewalk Labs

- Sidewalk Toronto



Alphabet: DeepMind



Alphabet: Google Brain



Amazon

- Recommendation system

Frequently bought together



This item: Game of Thrones: The Complete Seasons 1-6 DVD \$125.45

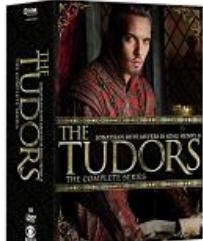
A Game of Thrones / A Clash of Kings / A Storm of Swords / A Feast of Crows / A Dance with Dragons by George R. R. Martin Mass Market Paperback \$29.64

Customers who bought this item also bought

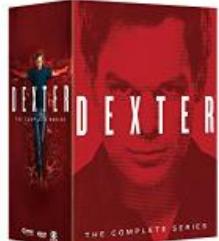
Page 1 of 5



A Game of Thrones / A Clash of Kings / A Storm of Swords / A Feast of...
› George R. R. Martin
★★★★★ 9,255
Mass Market Paperback
\$29.64 ✓prime



Tudors: The Complete Series
James Frain
★★★★★ 234
DVD
\$31.49 ✓prime



Dexter: The Complete Series
James Remar
★★★★★ 154
DVD
\$52.27 ✓prime



Breaking Bad: The Complete Series
Bryan Cranston
★★★★★ 2,031
DVD
\$76.52 ✓prime



Better Call Saul: Season 2
Bob Odenkirk
★★★★★ 97
DVD
\$16.69 ✓prime



Amazon

- Echo



Always ready, connected, and fast. **Just ask.**



Apple



Facebook



Facebook

- Chat robot

Divide these items between you and your partner.

Your partner sees the same items but with different values

You get some items, and your partner will get the rest

If you get a great deal for you then we will pay a bonus!

If you offer get low scores then your work may be rejected

Items to Split between You and Partner	Value Each to You	Number You Get
	0	0.0
	7	0.0
	1	0.0

Fellow Turkster connected! Please send a message!

Type Message Here:

Send

```

Alice : book=(count:3 value:1) hat=(count:2 value:1) ball=(count:1 value:5)
Bob   : book=(count:3 value:0) hat=(count:2 value:0) ball=(count:1 value:10)

-----
Bob   : i can i i everything else . . . . . .
Alice : balls have zero to me to
Bob   : you i everything else . . . . . .
Alice : balls have a ball to me to
Bob   : i i can i i i everything else . . . . . .
Alice : balls have a ball to me to me
Bob   : i . . . . . .
Alice : balls have zero to me to
Bob   : you i i i i everything else . . . . . .
Alice : balls have 0 to me to
Bob   : you i i i everything else . . . . . .
Alice : balls have zero to me to

```

Facebook

- DeepFace

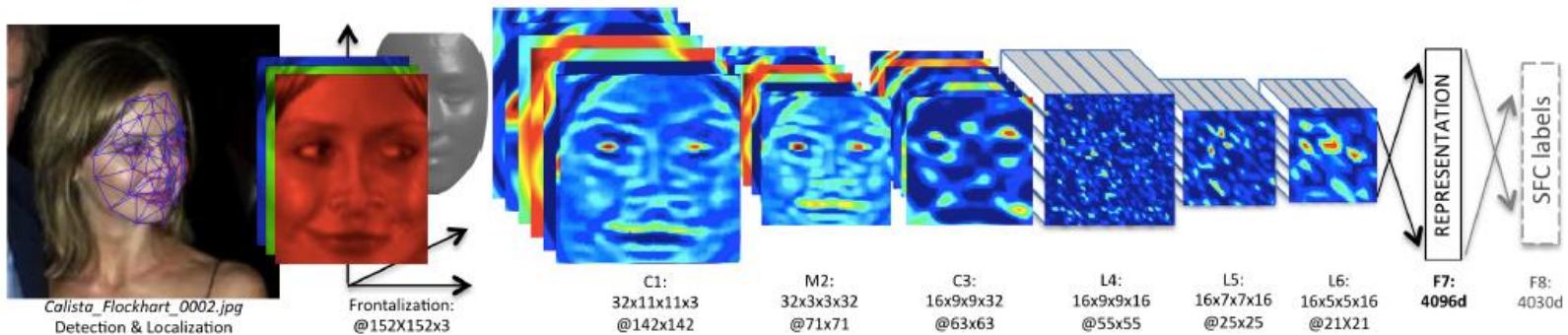


Figure 2. Outline of the *DeepFace* architecture. A front-end of a single convolution-pooling-convolution filtering on the rectified input, followed by three locally-connected layers and two fully-connected layers. Colors illustrate outputs for each layer. The net includes more than 120 million parameters, where more than 95% come from the local and fully connected layers.

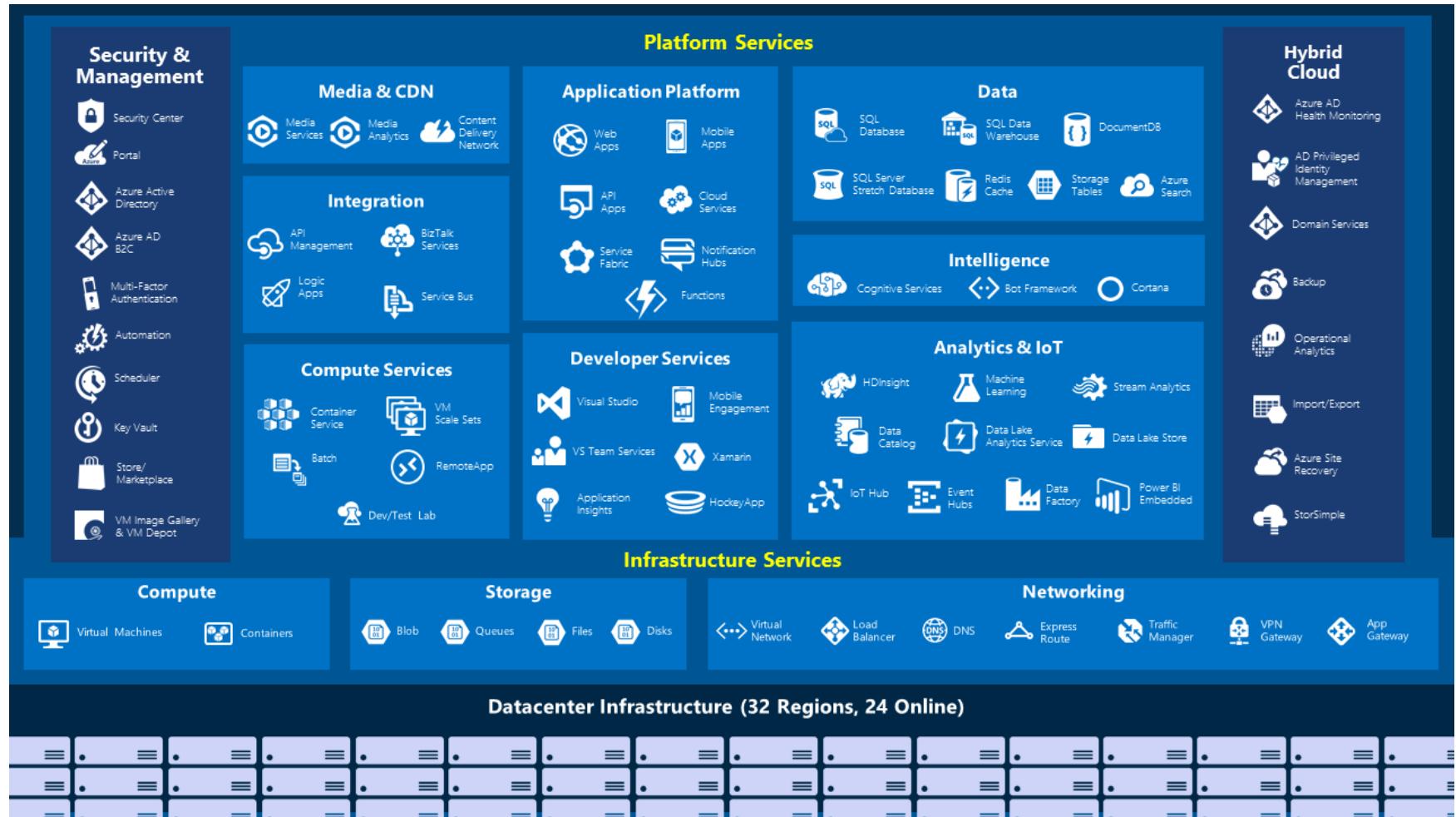
Facebook

- CherryPi
 - Go: 1×10^{170} vs StarCraft: 1×10^{270}



Microsoft

- Azure + ML



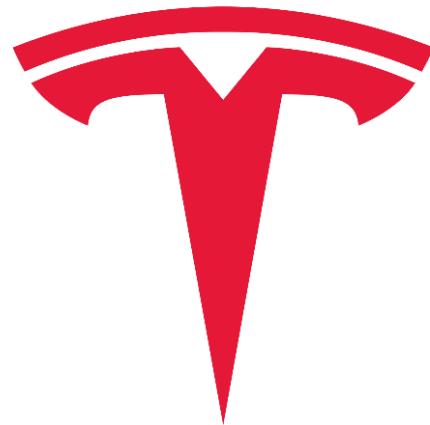
Microsoft

- Cortana/Xiaoice





Elon Musk



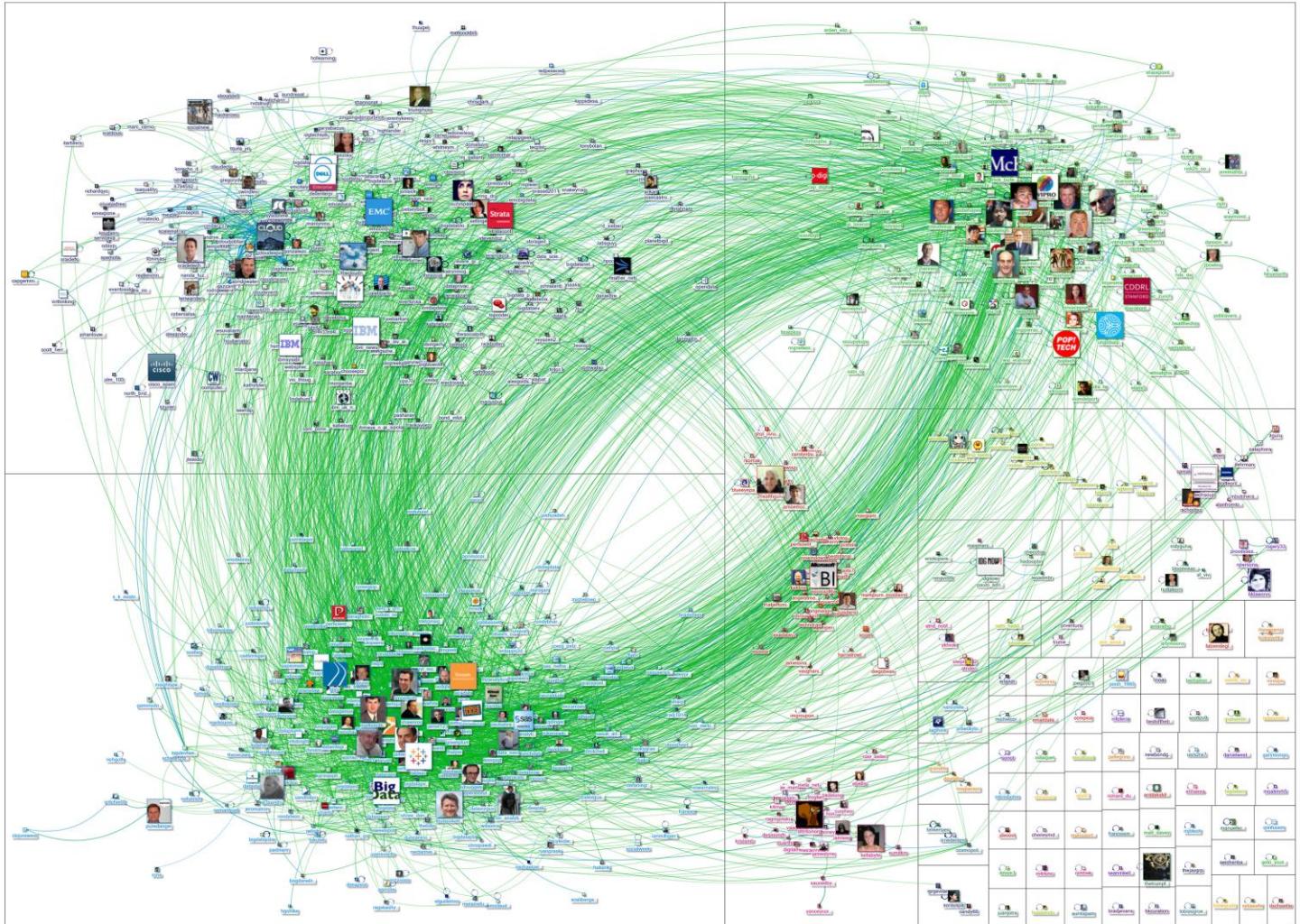
TESLA

OpenAI



Twitter

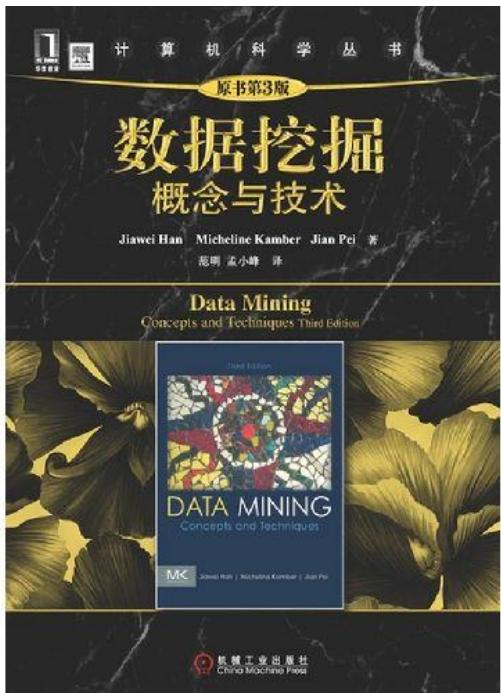
Social media network connections among Twitter users



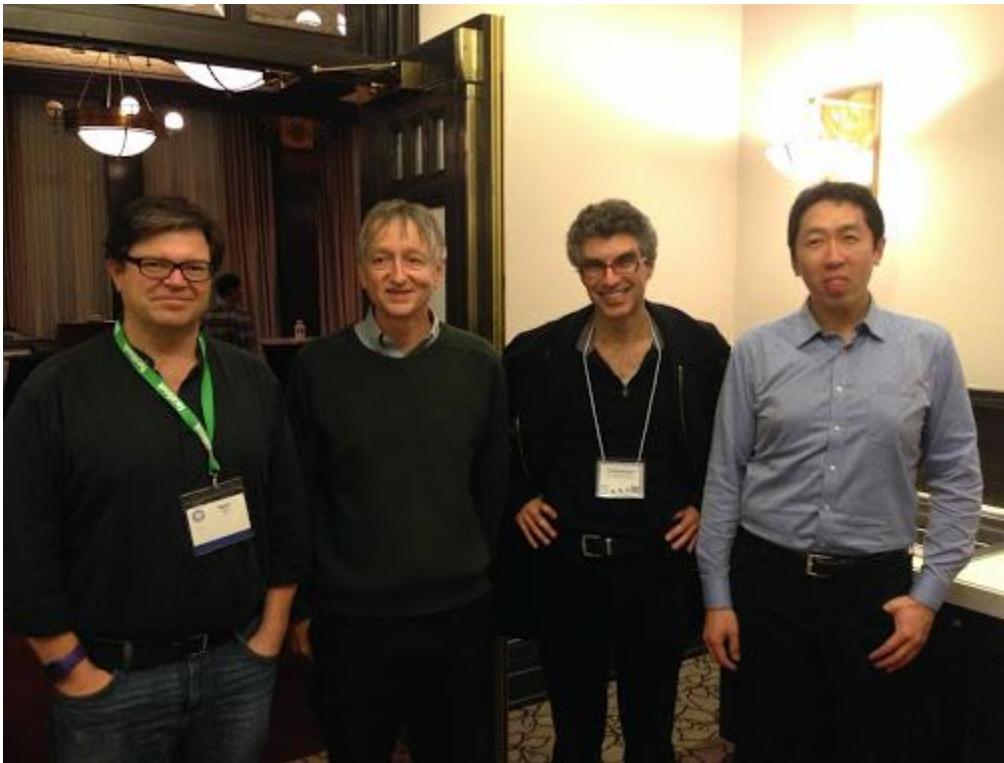
Gurus

Jiawei Han (韩家炜)

- University of Illinois at Urbana-Champaign
- ACM Fellow, IEEE Fellow
- ICDM, VLDB, KDD



Deep Learning



Geoffrey Hinton

- Bachelor of Arts in experimental psychology in King's College, Cambridge
- PhD in artificial intelligence in University of Edinburgh
- Prof in University of Toronto
- Backpropagation (BP)
- Father of neural networks
- Father of deep learning
- Google (DNNResearch)
 - 2 stuff: Alex Krizhevsky, Ilya Sutskever
 - 1 toolkit: cat face recognition
- Neural Networks Renaissance
- His aunt Joan Hinton



Yann LeCun

- 杨乐康？闫乐村？
- New York University
- Postdoctoral in Hinton's lab
- First director of Facebook AI Research
- Convolutional Neural Network (CNN)
- Generative Adversarial Network (GAN)
- Neural Networks Renaissance



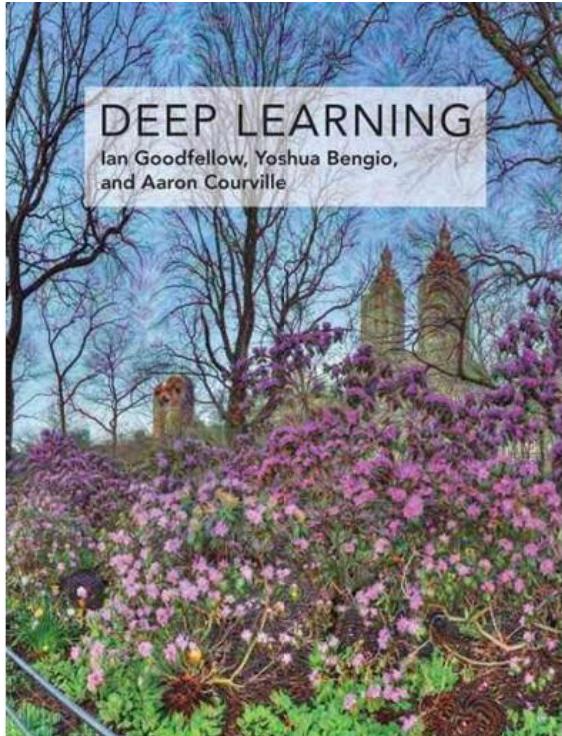
Yoshua Bengio

- Université de Montréal
- Postdoctoral in Michael Jordan's lab
- Colleague of Yann LeCun in AT&T Bell Labs
- Neural Networks Renaissance
- Focus on academia
- Advisor of Microsoft (After Maluuba acquired by Microsoft)



Ian Goodfellow

- Ph.D. from Université de Montréal
- Under the supervision of Yoshua Bengio
- Google Brain
- Generative Adversarial Network (GAN)
- OpenAI



Andrew Ng (吴恩达)

- Born in London, UK
- Parents were Hong Kongers
- Stanford University
 - Carnegie Mellon University (CMU)
 - Massachusetts Institute of Technology (MIT)
 - University of California, Berkeley (UC Berkeley)
- Co-founder of Google Brain (Deep Learning Project)
- Co-founder and chairman of Coursera
- (Former) Chief Scientist of Baidu
- Wife: Carol Reiley
 - cofounder and President of drive.ai



The image shows the header of the IEEE Spectrum website. It features the IEEE SPECTRUM logo at the top right, followed by social media links for Facebook, Twitter, LinkedIn, and Google+. Below that are links for "Engineering Topics" and "Special Reports". At the bottom, there are links for "Automaton | Robotics | Humanoid Robots".

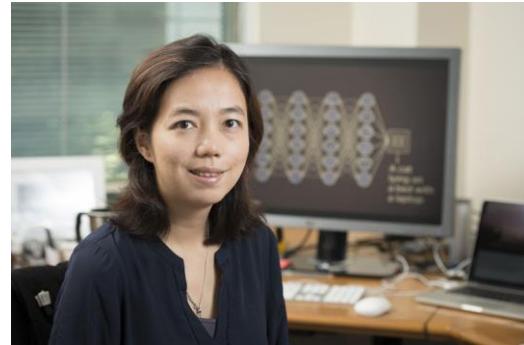
Robots Bring Couple Together,
Engagement Ensues

By Evan Ackerman and Erico Guizzo
Posted 31 Mar 2014 | 19:03 GMT



Feifei Li (李飞飞)

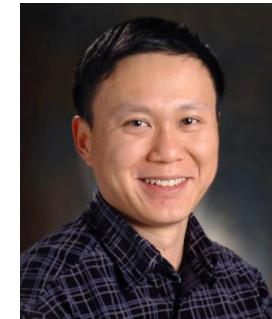
- Went to US when she was 16
- Wash dishes before college
- Dry cleaning business at Princeton
- Director of Stanford Artificial Intelligence Lab (SAIL) and Stanford Vision Lab
- (Former) Chief Scientist of AI/ML, Google Cloud
 - Andrew Moore (CMU Dean) to take over Feifei Li at the end of 2018
- **ImageNet**
 - Jia Deng, Wei Dong, Richard Socher, Li-Jia Li, Kai Li, Fei-Fei Li.
ImageNet: A Large-Scale Hierarchical Image Database. CVPR, 2009.
(cited by 5196)
 - Over 14 million URLs of images and 20 thousand categories (~1TB)
 - Challenge started in 2000, ended in 2017



Some more...

- **Jian Pei (裴建)**

- Simon Fraser University
- Data Mining: Concepts and Techniques
- SIGKDD Chair
- Former chief AI scientist of Huawei
- Vice president of JD since 2018



- **Zhihua Zhou (周志华)**

- Nanjing University
- Chang Jiang Scholars Program
- National Science Fund for Distinguished Young Scholars
- Fellow of the ACM, AAAI, AAAS, IEEE, IAPR, IET/IEE, CCF
 - 1st AAAI Fellow from mainland China
 - 1st ACM Fellow with Ph.D. of mainland Chinese university



AI Applications



Chess & Go

- **1997.5, Deep Blue 3.5:2.5 Garry Kasparov (2 wins, 1 defeat, 3 draws)**
 - Defeated by GK on 1996.2 with 2-4
- **2015.10, AlphaGo 5-0 European Go champion Fan Hui (樊麾) (2-dan)**
 - This was the first time a computer Go program had beaten a professional human player on a full-sized board without handicap
- **2016.3, AlphaGo 4-1 Lee Sedol (李世石) (9-dan)**
 - Used 1,920 CPUs and 280 GPUs
- **2016.12-2017.1 AlphaGo using account “Magister/Master” achieves 60 wins and 0 losses on Tygem server**
 - Its adversaries included many world champions
- **2017.5, AlphaGo 3-0 Ke Jie (柯洁) (9-dan)**
 - AlphaGo was awarded professional 9-dan by Chinese Weiqi Association
 - AlphaGo retired after the game
- **2017.10, AlphaGo Zero was published in *Nature***
 - By playing games against itself, it surpassed the strength of AlphaGo Lee in three days by winning 100 games to 0, reached the level of AlphaGo Master in 21 days, and exceeded all the old versions in 40 days

PC Games: RTS/MOBA

- **DOTA2**

- 2017.8, OpenAI defeated Dendi on 1v1 (Ti7)
- 2017.10 Stork 4:0 AI team
 - MJ, ZZZK, TSCMOO, CherryPi
- 2018.6 OpenAI won a 5v5 game
- 2018.8 OpenAI 2:1 semi-pro gamers (6500+)
- The International DOTA2 Championships 2018 (Ti8)
 - 1st round OpenAI 2:0
 - 2nd round OpenAI 0:2

- **Starcraft II**

- DeepMind cannot defeat a simple PC
- <https://github.com/deepmind/pysc2>

- **Atari**

- 7 games (B.Rider, Pong, Breakout, Enduro) by DeepMind on NIPS 2013
- Montezuma's Revenge
- DeepMind vs OpenAI

- **Quake**

- DeepMind

Natural Language

- Speech technologies (e.g. Siri)
 - Automatic speech recognition (ASR)
 - Text-to-speech synthesis (TTS)
 - Dialog systems
- Language processing technologies
 - Question answering
 - Machine translation
 - Web search
 - Text classification, spam filtering, etc...



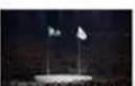
全部

奥运会乒乓女团第一轮 日本队(石川佳纯/福原爱/伊藤美诚)3:0获胜 轻松晋级

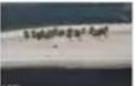
简讯：李茜/樊兰克/帕洁卡的波兰队输了。比赛持续3场大战，由李茜/樊兰克/帕洁卡组成的波兰队迎战由石川佳纯/福原爱/伊藤美诚组成的日本队，终以0:3落败，波兰止步奥运会乒乓球女子团体赛一轮。该比赛于北京时间8...
782阅读 · 0评论 · 2016-08-13 14:10

 **奥运会乒乓球女团第一轮 新加坡队(冯天薇/于梦雨/周...**

简讯：北京时间8月12日21:00时，由马天薇/于梦雨/周逸盈组成的新加坡队在奥运会乒乓球女子团体赛第一轮中对阵由迈库雷特/埃尔温拉特利/埃尔米组成埃及队。经过3场...
138阅读 · 0评论 · 2016-08-13 14:10

 **奥运乒乓女团第一轮 朝鲜队(李明顺/李美光/金宋伊)力...**

简讯：奥运会乒乓球女子团体赛第一轮于北京时间8月12日21:00时在里约会议中心-3号馆展开。比赛共持续3场大战，高潮迭起，3:0，3:0，3:1.....李明顺/李美光/金宋伊的朝...
107阅读 · 1评论 · 2016-08-13 14:10

 **奥运会乒乓球男团第一轮 瑞典队(帕尔/卡尔森/卡尔森)...**

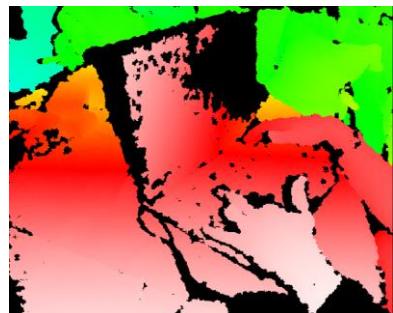
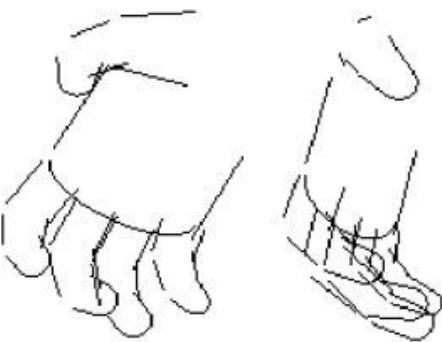
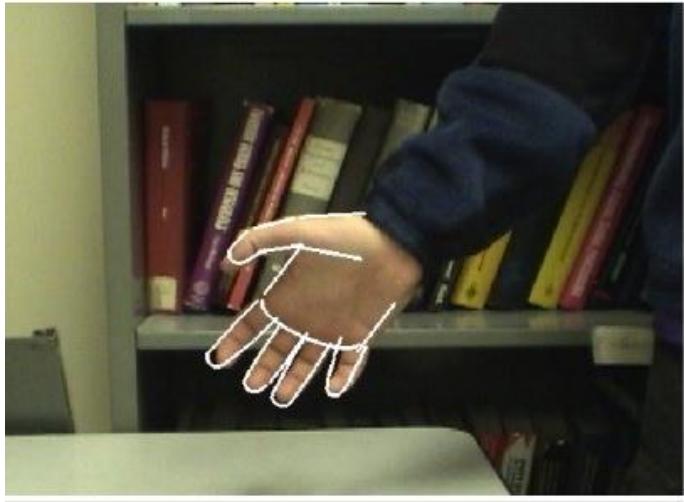
简讯：北京时间8月13日06:30时，奥运会乒乓球男子团体赛第一轮在里约会议中心-3号馆如期举行。耗时3场大战，帕尔/卡尔森/卡尔森选手瑞典队发挥出色，以3:0的比分力...
45阅读 · 1评论 · 2016-08-13 14:10

| 历史最佳文章

- 1 奥运会羽毛球混双小组赛 知名球员徐晨/马晋组合(中国)1:2负于波兰组合 遗憾失利
65035阅读 · 2016/08/12 20:52
- 2 奥运会羽毛球女双小组赛 韩国组合2:0力克中国组合 收获胜利
59442阅读 · 2016/08/13 07:28
- 3 奥运羽球男子双打小组赛 柴飚/洪炜组合(中国)负于日本组合 遗憾失利
13904阅读 · 2016/08/12 00:40
- 4 奥运会羽毛球混双小组赛 顶尖选手张楠/赵芸蕾组合(中国)大胜李晋熙/周凯华组合(中国香港) 轻松全取3分
7459阅读 · 2016/08/12 20:11
- 5 奥运会羽毛球混合双打小组赛 著名球员数野健太/栗原文音组合(日本)力克周菲利/苏班迪组合(美国) 轻...

Vision (Perception)

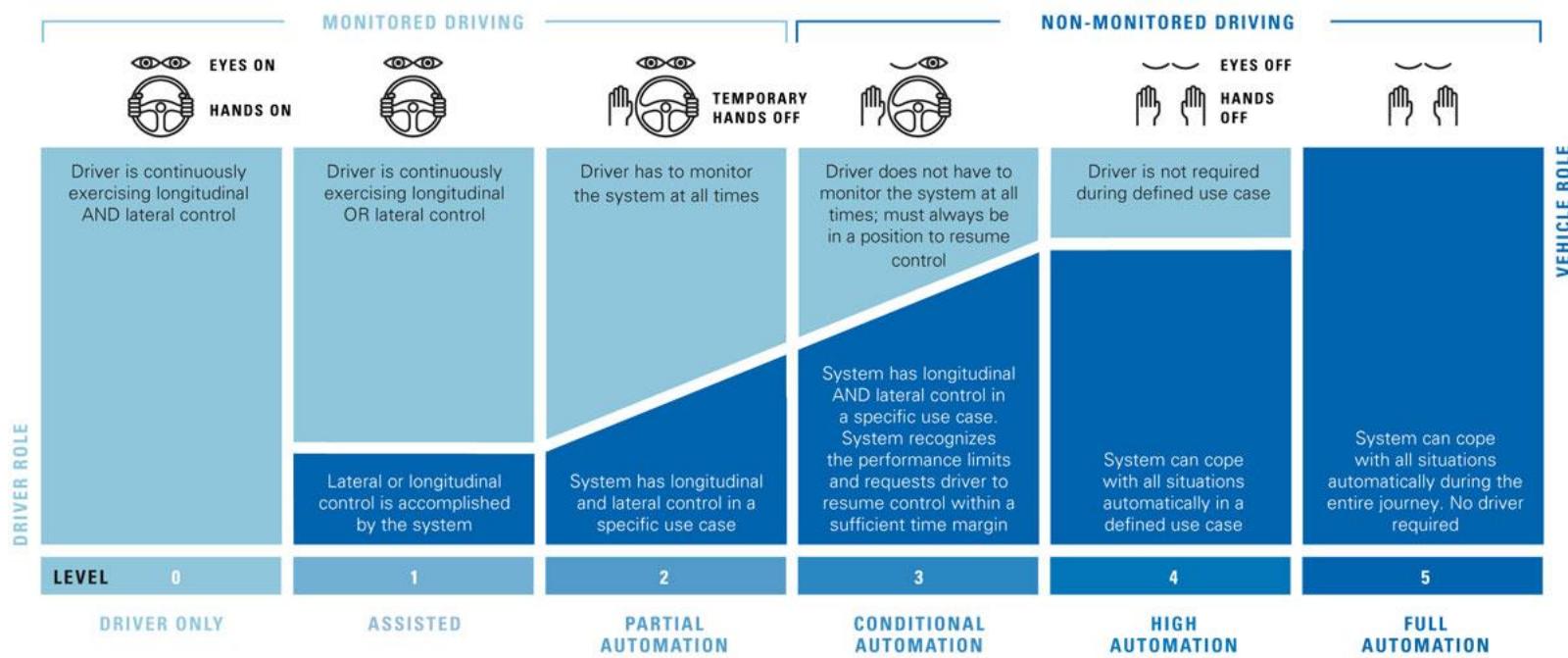
- Object and face recognition
- Scene segmentation
- Image classification



Images from Erik Sudderth (left), wikipedia (right)

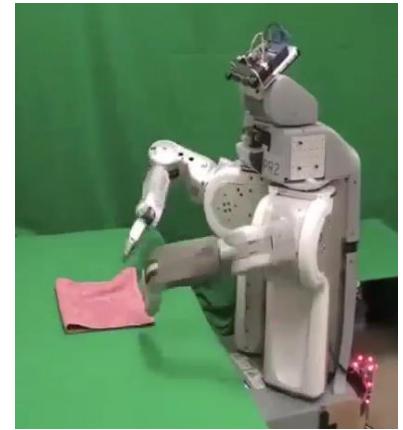
Autopilot

- DARPA
 - Shakey in 1960s
 - ALV in 2000s
- Google
 - 10100 in 2012
 - Waymo in 2016
- Tesla



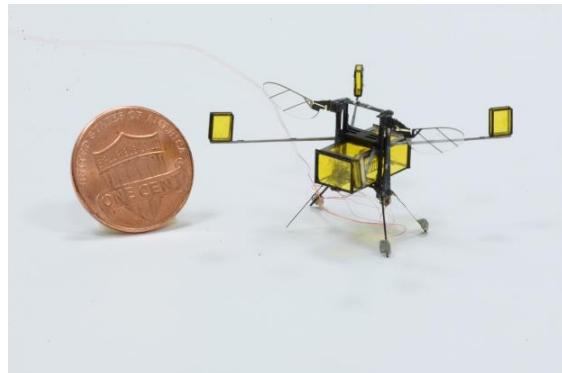
Robotics

- Karel Capek
 - Robota in *Rossum's Universal Robots* (《罗莎姆万能机器人》 1920)
- KUKA
 - Media (94.55% in 2016)
 - Timo Boll
 - Foxconn, Siasun
- Boston Dynamics
 - MIT, Google X
 - BigDog
- Service Robots



Drones

- 1917 Peter Cooper, Elmer Sperry
- 2010 AR Drones by Parrot
- 2006 DJI 2012 Phantom
- 2009 3D Robotics
- Services:
 - DJI algoriculture MG-1
 - Amazon 2013
 - Google X Wing
 - JD 185 drone ports in Sichuan
 - SF drone base in Chengdu Shuangliu
- Micro:
 - RoboBee by Harvard and DARPA
 - 103 3D-printed Perdix drones from F/A-18
 - CETC (中国电子科技集团) 67 drones in 2016.11, 119 in 2017.6.



End of Chapter 1