

AI & Robotics

Introduction



Goals 1/2



The junior-colleague

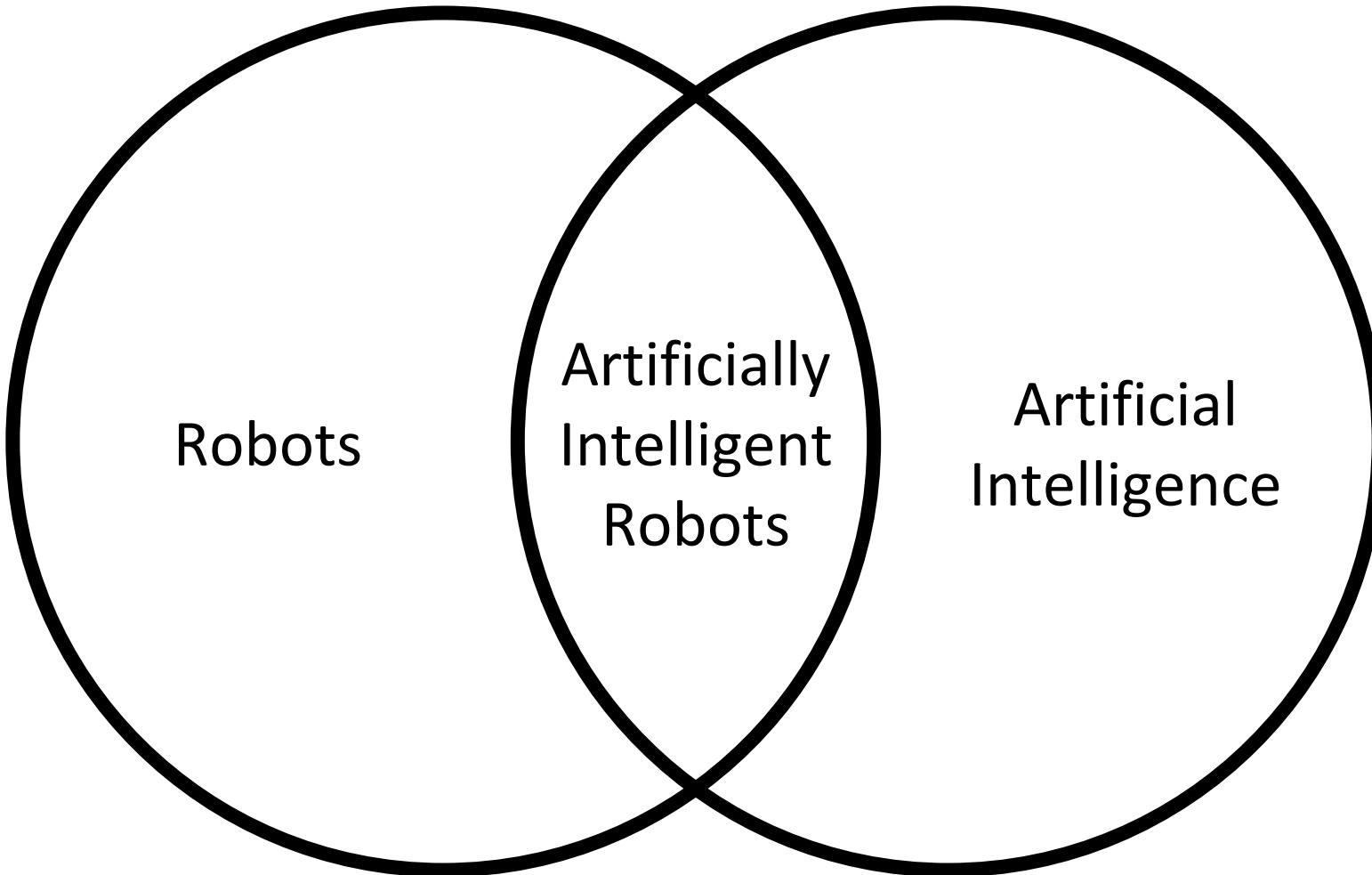
- can describe in own words the relation between robots and AI, including the intersection and draw a venn diagram depicting this relation.
- can explain the term robotics, robots and AI in own words.
- can describe the history of robots in and provide examples of historical important robots.
- knows the origin of the term “robot”.
- can categorize robots according to its type.
- can describe the difference between weak and strong AI and use examples to further clarify the difference.
- can describe the history of AI and realize the historical importance of Turing, Zuse, Ada, The Founding Fathers of AI.
- can explain the Turing test in his or her own words.

Goals 2/2



The junior-colleague

- can describe the subsets of AI: ML and DL in own words using a venn diagram and a timeline.
- can draw a timeline of the long history of AI, pointing out the numerous AI winters.
- can describe the relation between Moore's Law and AI.
- can describe the relation between the amount of available data and AI.
- can describe the limitations of the standard AI venn diagram and explain AI using a provided diagram depicting different fields.
- can explain the different learning types (supervised, unsupervised and reinforcement) using own words and examples.



Robotics

What is robotics?

The branch of technology that deals with the design, construction, operation, and application of robots.

-- Oxford Dictionary

What is robotics?

Robotics is a discipline born from Mechanics, Physics/Mathematics, Automation and Control, Electronics, Computer Science, Cybernetics and Artificial Intelligence.

This shows that Robotics is a unique combination of many scientific disciplines, whose fields of applications are broadening more and more, according to the scientific and technological achievements.

-- Gianmarco Veruggio

(source: <https://ieeexplore.ieee.org/document/4115667>)

What is a robot?



What is a robot?

A robot is a machine, especially one programmable by a computer, capable of carrying out a complex series of actions automatically.

-- Oxford Dictionary

History of robots



Concepts akin to a robot can be found as long ago as the 4th century BC.

The Greek mathematician Archytas of Tarentum postulated a mechanical bird he called "The Pigeon", propelled by steam.

History of robots



One of the **first recorded designs of a humanoid robot** was made by Leonardo da Vinci (1452–1519) in around 1495.

Drawings of a mechanical knight in armour which was able to sit up, wave its arms and move its head and jaw

History of robots



The **first humanoid robot** was a soldier with a trumpet, made in 1810 by Friedrich Kaufmann in Dresden, Germany.

History of robots



The term "robot" was first used to denote fictional automata in the 1921 play R.U.R. or Rossumovi Univerzální Roboti (Rossum's Universal Robots) by the Czech writer Karel Čapek.

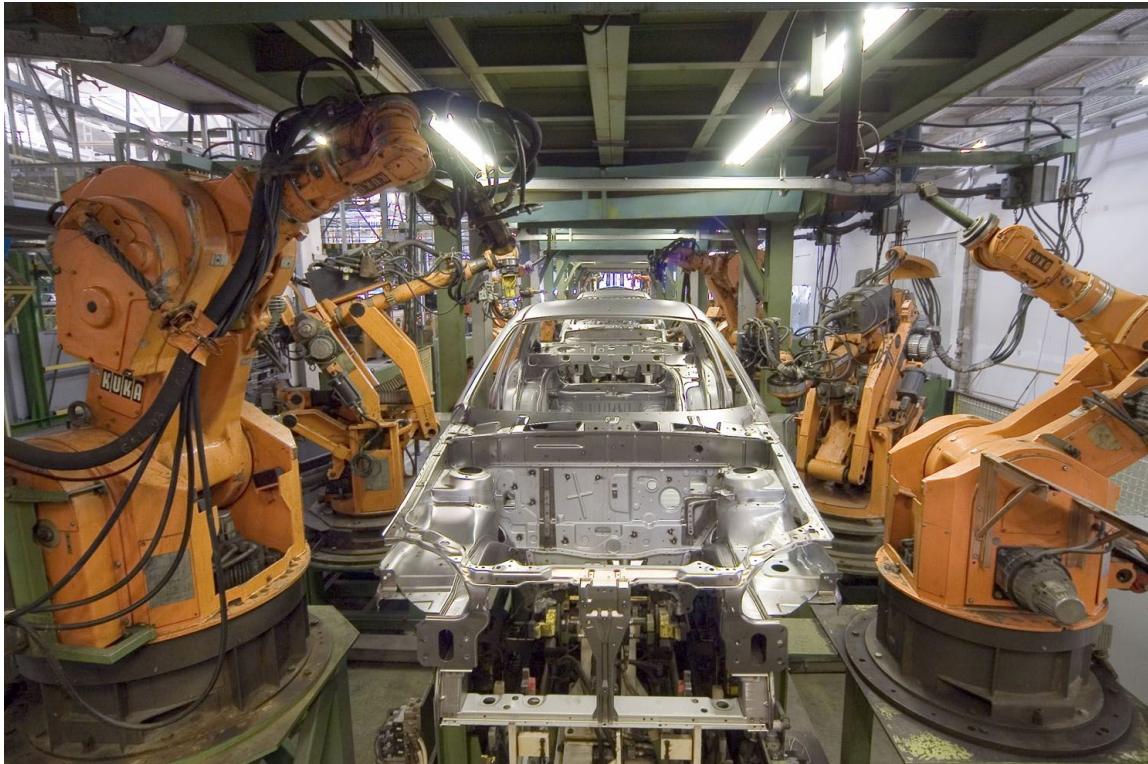
According to Čapek, the word was created by his brother Josef from the Czech *robo*ta, meaning servitude.

History of robots



Japanese robotics have led the field since the 1970s. The Waseda University initiated the WABOT project in 1967, and in 1972 completed the WABOT-1, the world's first full-scale humanoid intelligent robot. Honda revealed the most advanced result of their humanoid project in 2000, named ASIMO.

History of robots



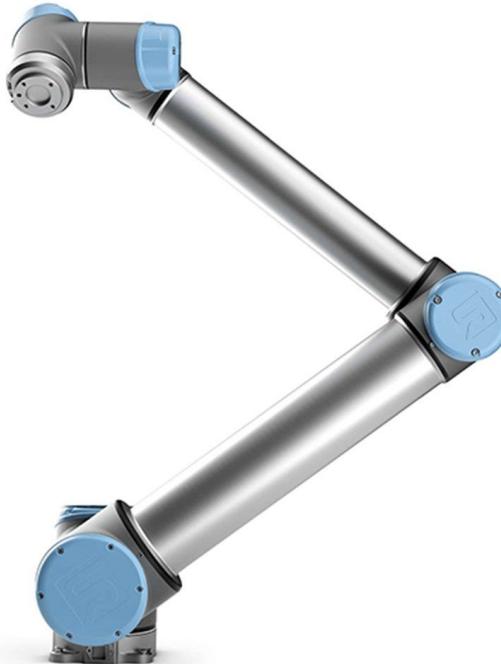
History of robots



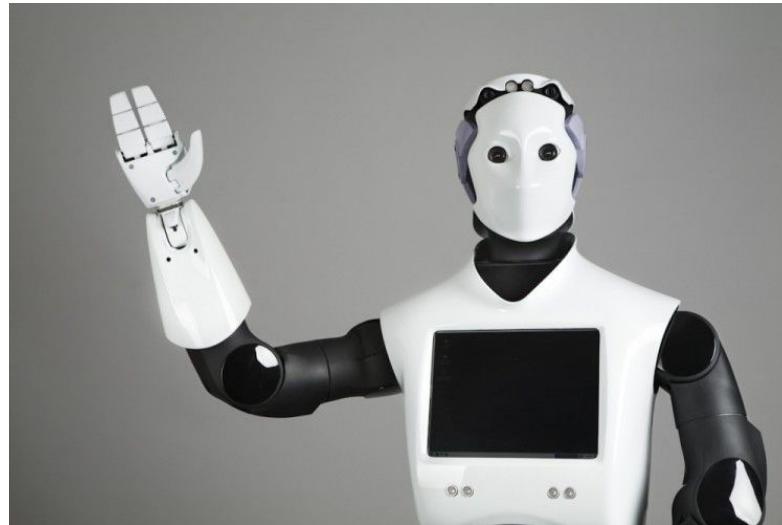
History of robots



History of robots



History of robots



State of the art...



Boston Dynamics: WildCat 2013



[Source]: <https://www.youtube.com/watch?v=wE3fmFTtP9g>

Boston Dynamics: Spot 2015



[Source]: <https://www.youtube.com/watch?v=M8YjvHYbZ9w>

Boston Dynamics: Atlas 2016



[Source]: <https://www.youtube.com/watch?v=rVlhMGQgDkY>

Boston Dynamics: Handle 2017



[Source]: <https://www.youtube.com/watch?v=-7xvqQeoA8c>

Boston Dynamics: Atlas 2017



[Source]: <https://www.youtube.com/watch?v=fRj34o4hN4I>

Boston Dynamics: Spotmini 2017



[Source]: <https://www.youtube.com/watch?v=kgaO45SyaO4>

Boston Dynamics: Spotmini 2018

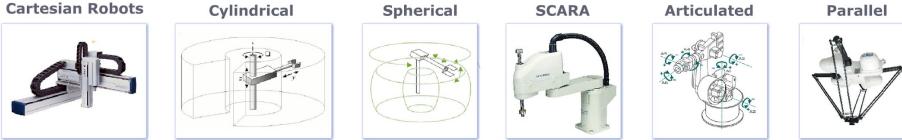


[Source]: <https://www.youtube.com/watch?v=fUyU3lKzoio>

All Types of Robots

by Locomotion

STATIONARY ROBOTS



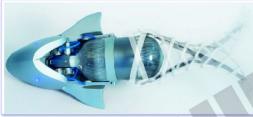
WHEELED ROBOTS



LEGGED ROBOTS



SWIMMING ROBOTS



FLYING ROBOTS



ROBOTIC BALLS



SWARM ROBOTS



MODULAR ROBOTS



MICRO Robots



NANO Robots



SOFT ROBOTS



SNAKE Robots



CRAWLER Robots



HYBRID Robots



Jimmy Meets Sophia the Human-Like Robot



[Source]: https://www.youtube.com/watch?v=Bg_tJvCA8zw Apr 25, 2017

Artificial Intelligence

What is Artificial Intelligence?



What is Artificial Intelligence?

The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

-- Oxford Dictionary

« Cold » Strong AI

Purely logical reasoning



Global Learning abilities



State-machines



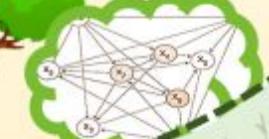
Biomimeticism



Self-consciousness



Biological neurons



Understanding the living world

Weak AI

Simulation of intelligence

Game theory

« Sensitive » Strong AI

State-machines



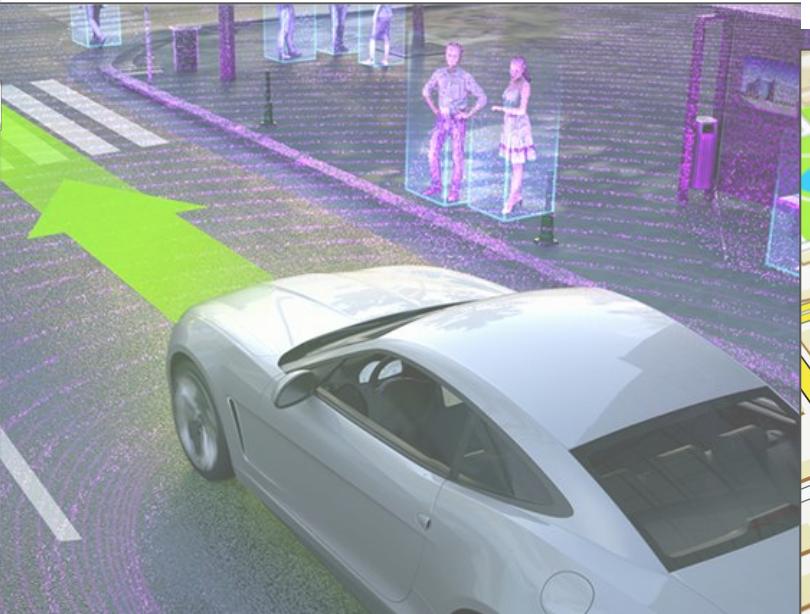
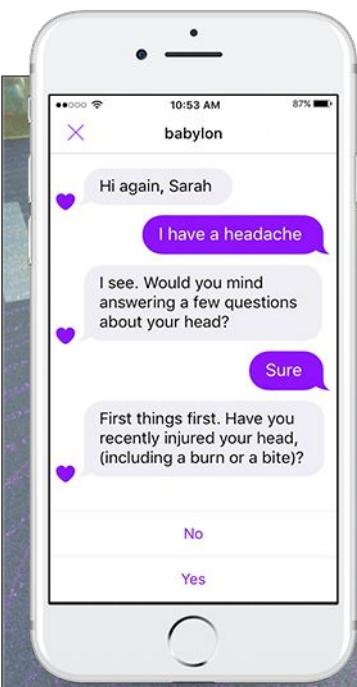
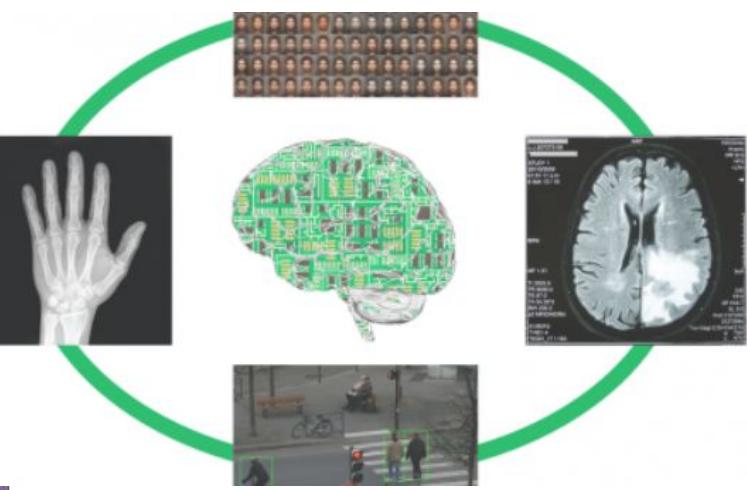
Expert systems

0110
101010011
01010010011
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010101101
0110

Weak AI

- Focused on a specific task
- No consciousness
- Automation
- Optimization
- Analysis
- Based on data and statistics

=> All “AI” systems developed so far

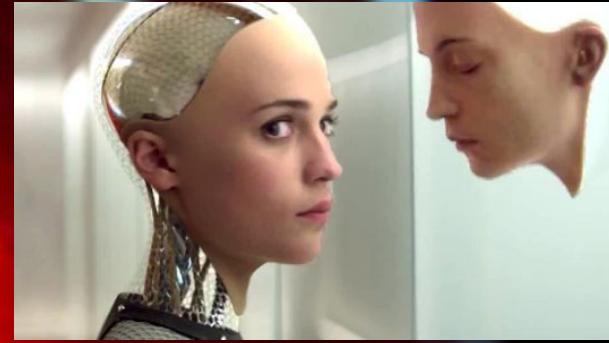


Strong AI

- All purpose: can use its intelligence for any kind of task
- General intelligence
- Matches or exceeds human intelligence
- Based on reasoning
- Consciousness?

=> Futurism and science fiction?

Strong AI



History of AI



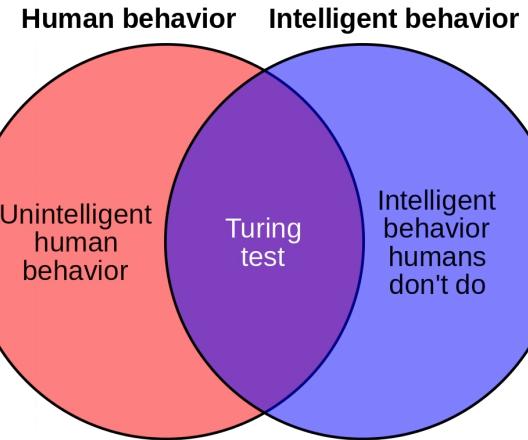
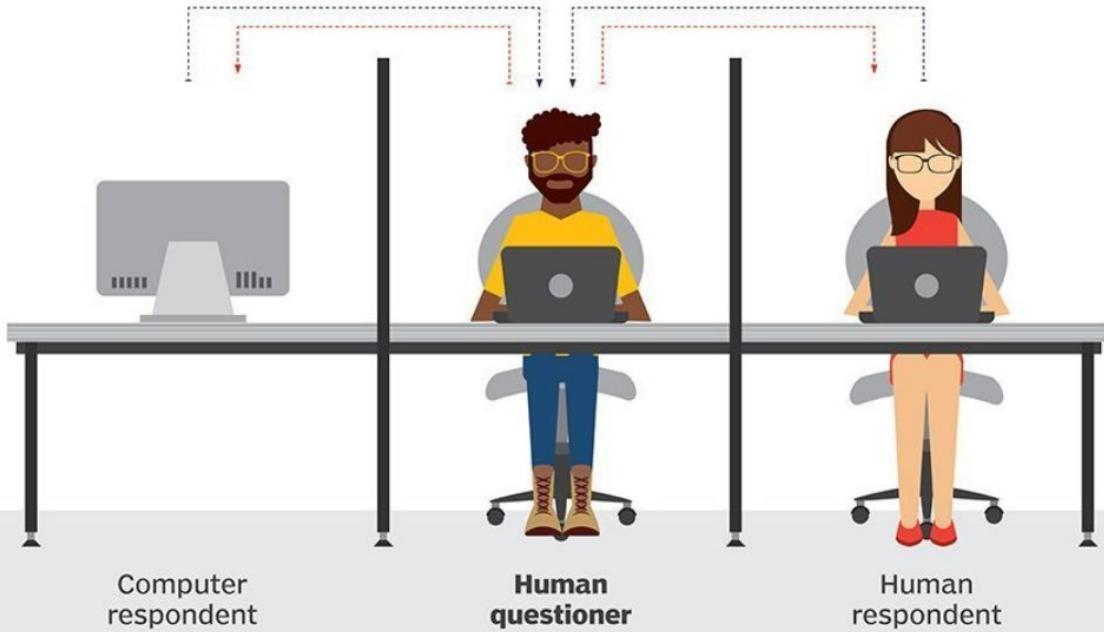
- "*I believe that at the end of the century the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted*" - Alan Turing, 1947
- "*A computer would deserve to be called intelligent if it could deceive a human into believing that it was human*" - Alan Turing, 1950

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



TURING TEST EXTRA CREDIT:
CONVINCE THE EXAMINER
THAT HE'S A COMPUTER.

YOU KNOW, YOU MAKE
SOME REALLY GOOD POINTS.
/

I'M ... NOT EVEN SURE
WHO I AM ANYMORE.



History of AI



- *"Die Gefahr, dass der Computer so wird wie der Mensch, ist nicht so groß wie die Gefahr, dass der Mensch so wird wie der Computer."* - Konrad Zuse
(The danger of computers becoming like humans is not as great as the danger of humans becoming like computers.)
- Inventor of the first Turing-complete programmable, fully automatic digital computer: the Z3

The birth of modern AI

1956 Dartmouth Conference: The Founding Fathers of AI



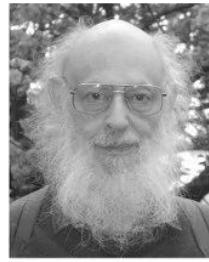
John MacCarthy



Marvin Minsky



Claude Shannon



Ray Solomonoff



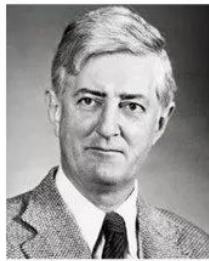
Alan Newell



Herbert Simon



Arthur Samuel



Oliver Selfridge



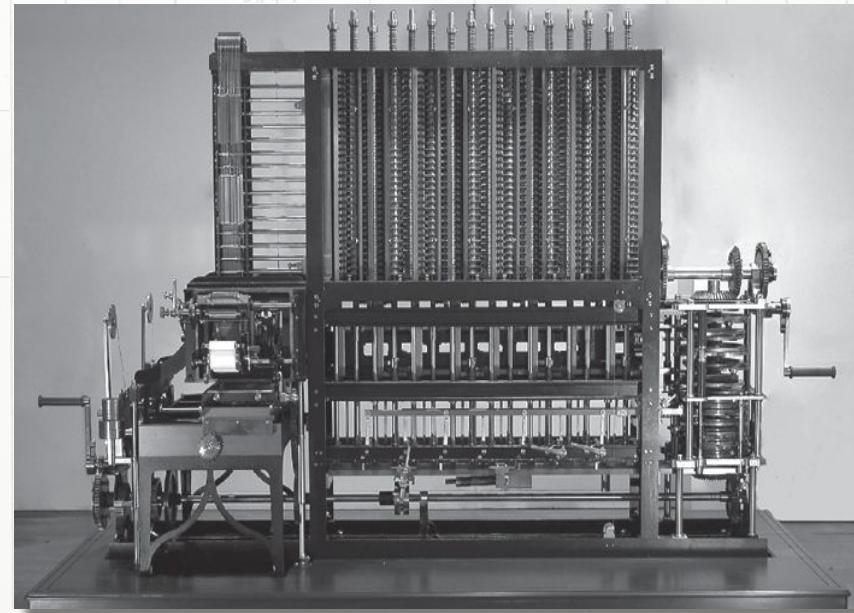
Nathaniel Rochester



Trenchard More

Diagram for the computation by the Engine of the Numbers of Bernoulli. See Note G. (page 722 et seq.)

Number of Operation.	Nature of Operation.	Variables acted upon.	Variables giving indication of change in the value of V_n .	Indication of change in the value of V_n .	Data.				Working Variables.								Result Variables.											
					IV_1	IV_2	IV_3	$0V_4$	$0V_5$	$0V_6$	$0V_7$	$0V_8$	$0V_9$	$0V_{10}$	$0V_{11}$	$0V_{12}$	$0V_{13}$	$0V_{14}$	$0V_{15}$	$0V_{16}$	IV_{21}	IV_{22}	IV_{23}	IV_{24}	$0V_{25}$	$0V_{26}$		
1	\times	$IV_2 \times IV_8$	IV_4, IV_5, IV_6	$\{IV_2 = 1V_2\}$ $\{IV_3 = 1V_3\}$ $\{IV_4 = 2V_3\}$ $\{IV_5 = 1V_5\}$ $\{IV_6 = 1V_6\}$	$= 2n$...	2	n	2n	2n	2n	B_1	B_2	B_3	B_4	B_5	B_6	B_7
2	-	$IV_4 - IV_1$	IV_4	$\{IV_4 = 2V_3\}$ $\{IV_1 = 1V_1\}$	$= 2n - 1$	1	2n - 1	
3	+	$IV_8 + IV_1$	IV_8	$\{IV_8 = 1V_8\}$ $\{IV_1 = 1V_1\}$ $\{2V_4 = 0V_5\}$ $\{2V_5 = 0V_5\}$	$= 2n + 1$	1	2n + 1		
4	+	$2V_3 - 2V_4$	IV_{11}	$\{2V_3 = 0V_5\}$ $\{2V_4 = 0V_5\}$	$= 2n - 1$	0	0		
5		
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19			
20			
21			
22			
23			
24	+	$IV_{12} + 0V_2$	IV_{24}	$\{4V_{13} = 0V_{13}\}$ $\{0V_{24} = IV_{24}\}$ $\{IV_1 = IV_1\}$	$= B_7$	1	B_7				
25	+	$IV_1 + IV_8$	IV_8	$\{IV_3 = IV_8\}$ $\{0V_6 = 0V_6\}$ $\{8V_7 = 0V_7\}$	$= n + 1 = 4 + 1 = 5$	1	...	$n + 1$	0	0	B_7				

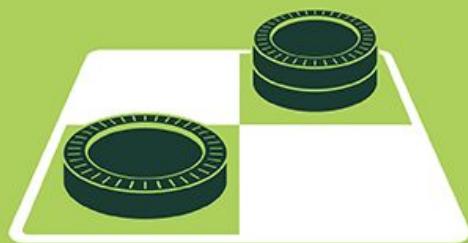


Here follows a repetition of Operations thirteen to twenty-three.

24	+	$IV_{12} + 0V_2$	IV_{24}	$\{4V_{13} = 0V_{13}\}$ $\{0V_{24} = IV_{24}\}$ $\{IV_1 = IV_1\}$	$= B_7$	1	B_7
25	+	$IV_1 + IV_8$	IV_8	$\{IV_3 = IV_8\}$ $\{0V_6 = 0V_6\}$ $\{8V_7 = 0V_7\}$	$= n + 1 = 4 + 1 = 5$	1	...	$n + 1$	0	0	B_7

ARTIFICIAL INTELLIGENCE

Early artificial intelligence stirs excitement.



1950's

1960's

1970's

1980's

1990's

2000's

2010's

MACHINE LEARNING

Machine learning begins to flourish.



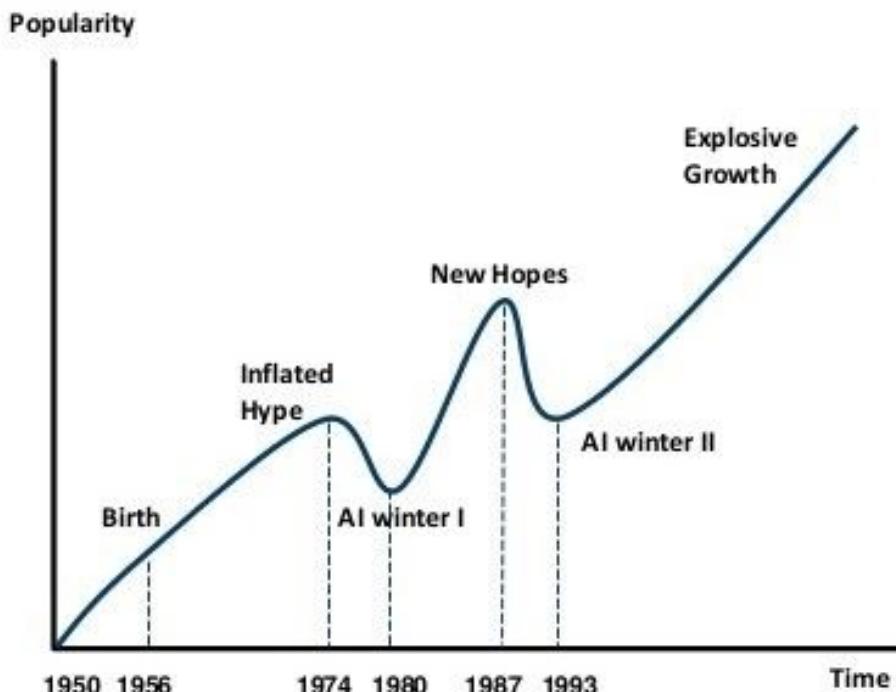
DEEP LEARNING

Deep learning breakthroughs drive AI boom.



Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

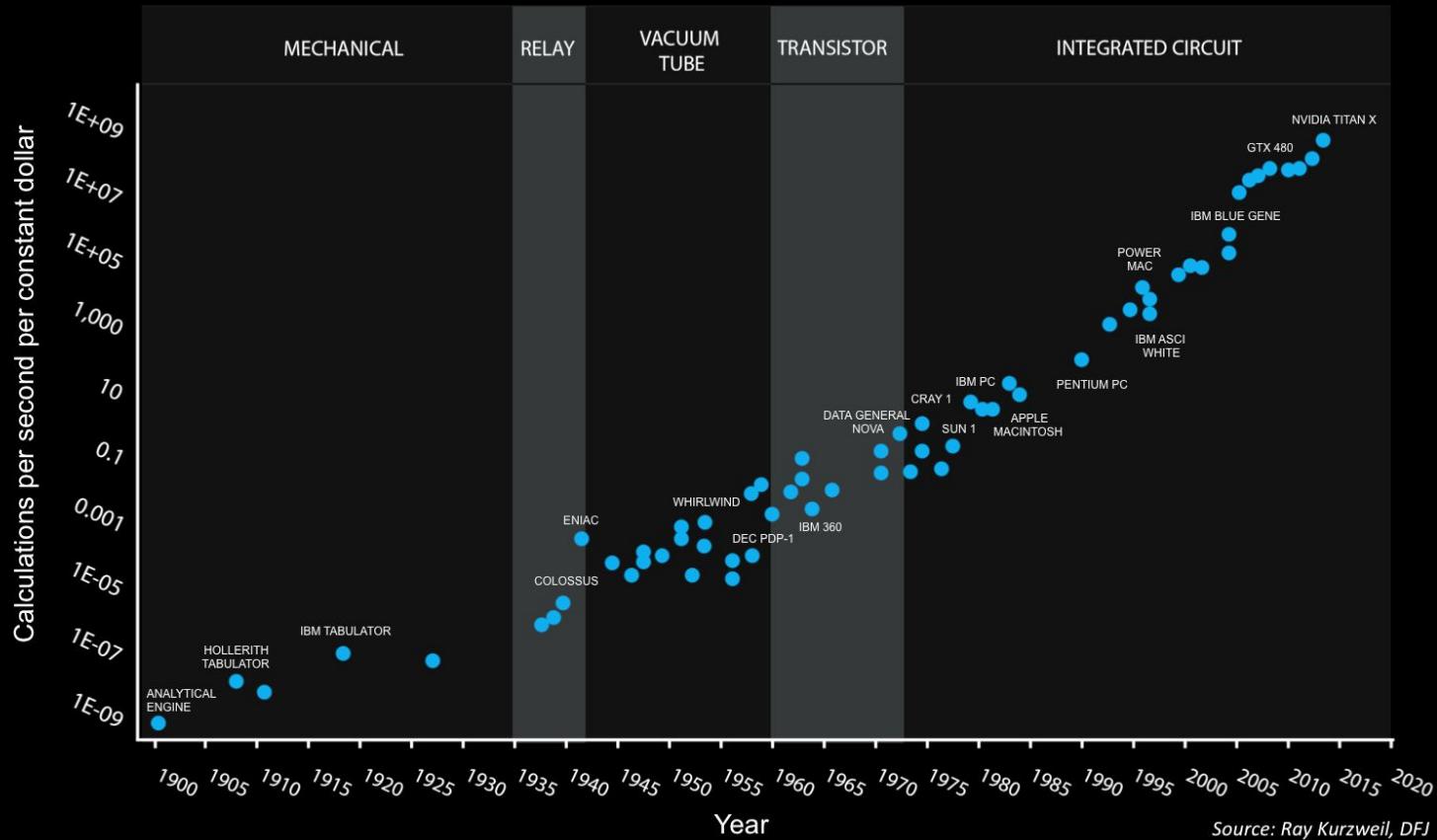
AI HAS A LONG HISTORY OF BEING “THE NEXT BIG THING”...



Timeline of AI Development

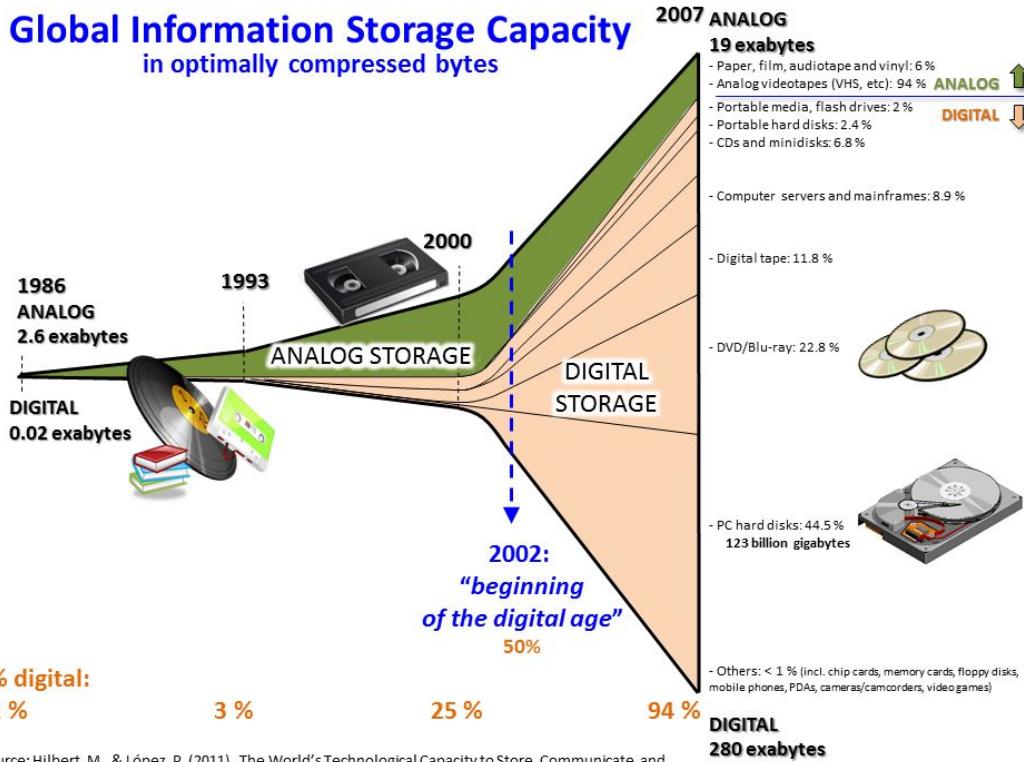
- 1950s-1960s: First AI boom - the age of reasoning, prototype AI developed
- 1970s: AI winter I
- 1980s-1990s: Second AI boom: the age of Knowledge representation (appearance of expert systems capable of reproducing human decision-making)
- 1990s: AI winter II
- 1997: Deep Blue beats Gary Kasparov
- 2006: University of Toronto develops Deep Learning
- 2011: IBM's Watson won Jeopardy
- 2016: Go software based on Deep Learning beats world's champions

120 Years of Moore's Law



Global Information Storage Capacity

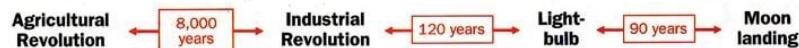
in optimally compressed bytes



Source: Hilbert, M., & López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. *Science*, 332(6025), 60–65. <http://www.martinhilbert.net/WorldInfoCapacity.html>

Mark Liberman calculated the storage requirements for all human speech ever spoken at 42 zettabytes if digitized as 16 kHz 16-bit audio.
By 2025, according to an IDC study commissioned by Seagate, "the global datasphere will grow to 163 zettabytes".[

1 The accelerating pace of change ...



2 ... and exponential growth in computing power ...

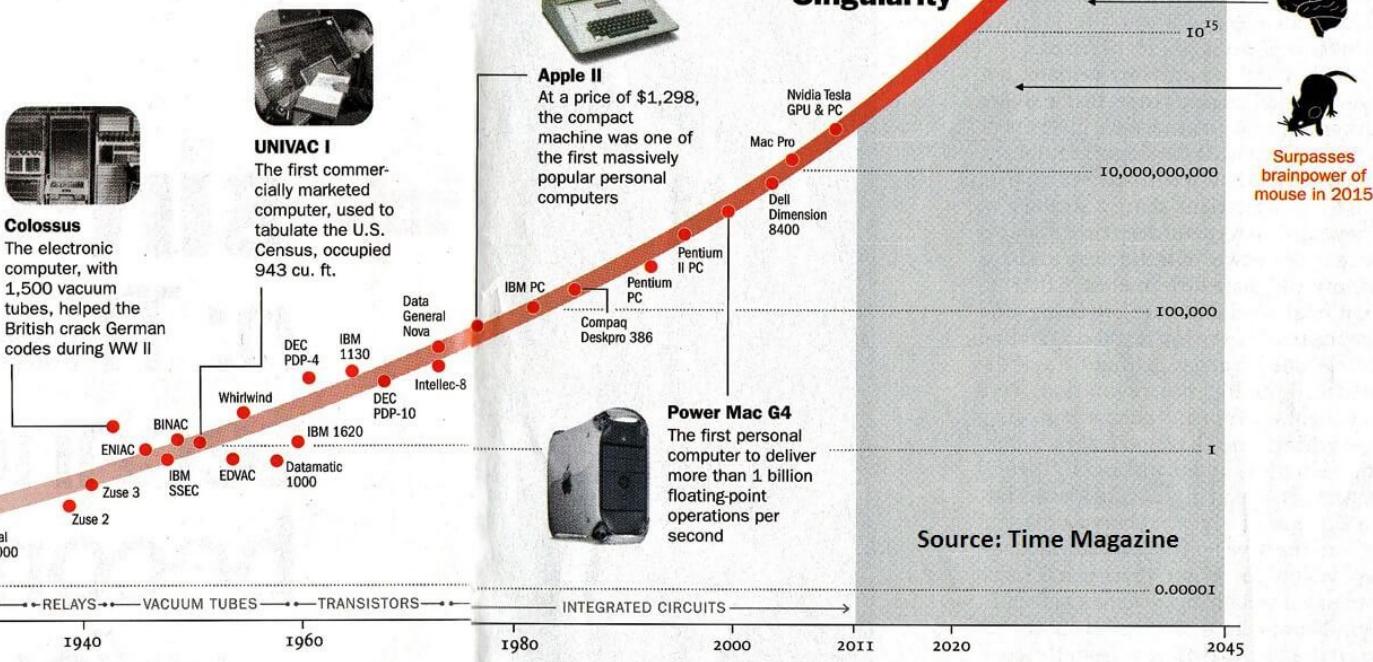
Computer technology, shown here climbing dramatically by powers of 10, is now progressing more each hour than it did in its entire first 90 years

COMPUTER RANKINGS

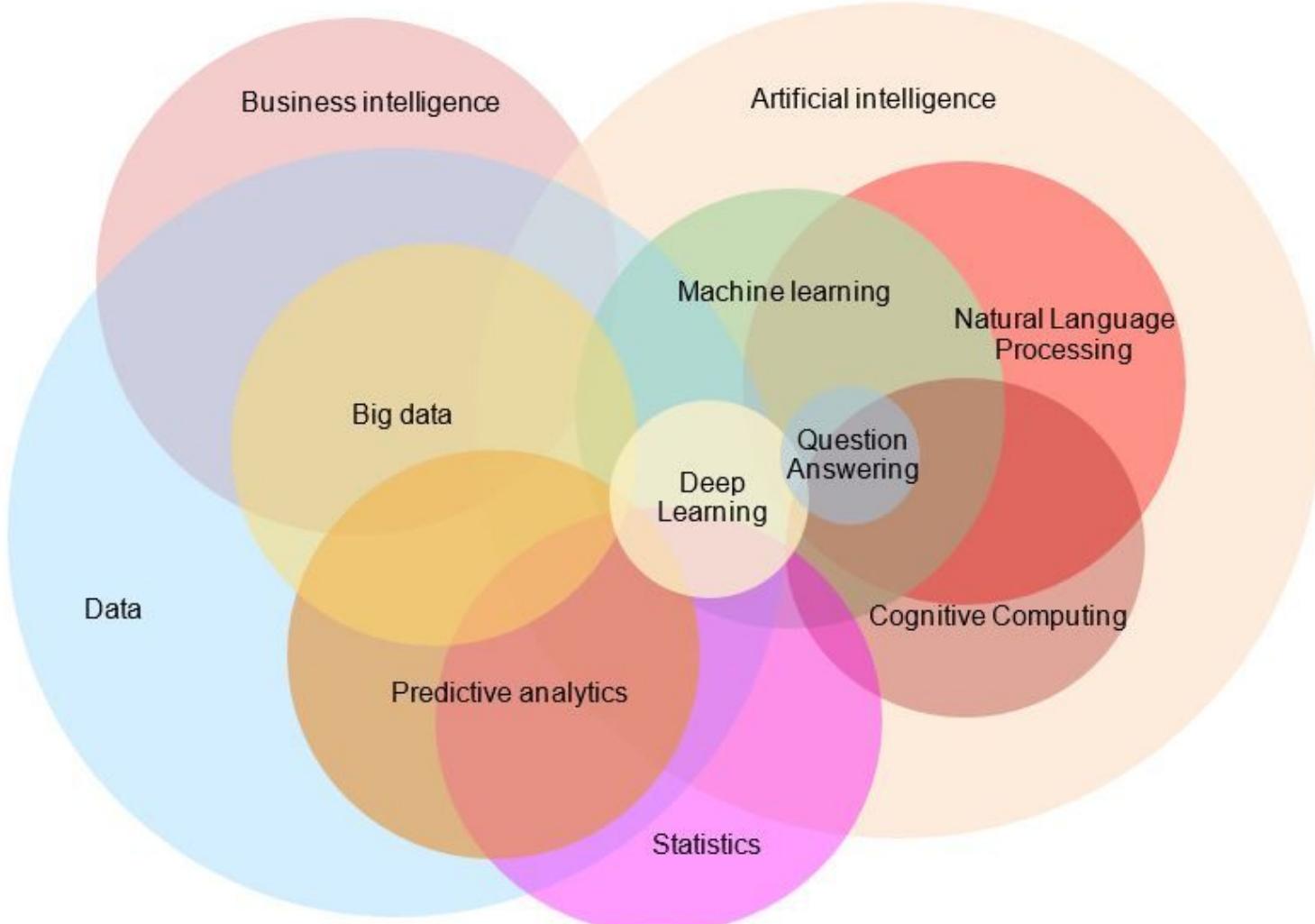
By calculations per second per \$1,000



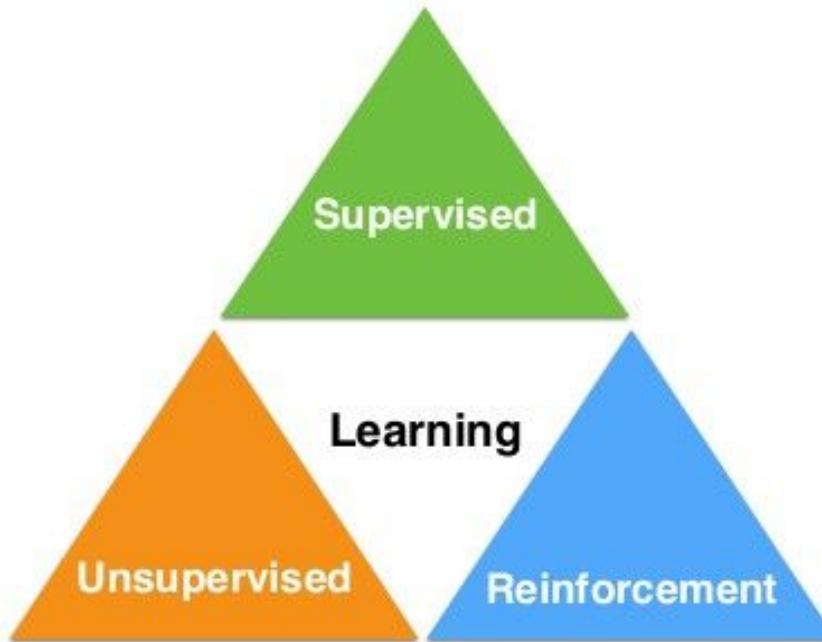
Analytical engine
Never fully built, Charles Babbage's invention was designed to solve computational and logical problems



Machine Learning



- Labeled data
- Direct feedback
- Predict outcome/future



- No labels
- No feedback
- “Find hidden structure”

- Decision process
- Reward system
- Learn series of actions

Supervised Learning



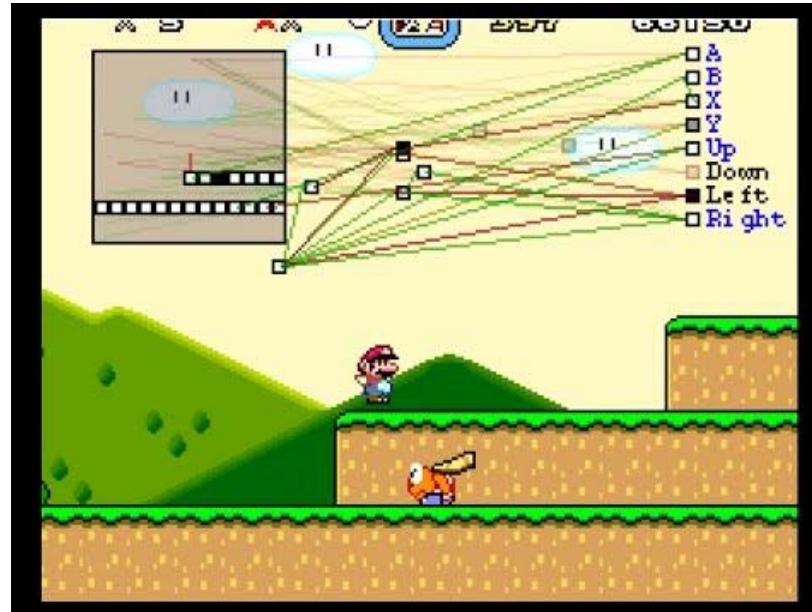
<https://youtu.be/MPU2HistivI>

Unsupervised Learning



Figure 3. Example results by our proposed StackGAN, GAWWN [20], and GAN-INT-CLS [22] conditioned on text descriptions from CUB test set. GAWWN and GAN-INT-CLS generate 16 images for each text description, respectively. We select the best one for each of them to compare with our StackGAN.

Reinforcement Learning



<https://www.youtube.com/watch?v=qv6UVQ0F44>