COE206 – Principles of Artificial Intelligence

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http://mustafamisir.github.io
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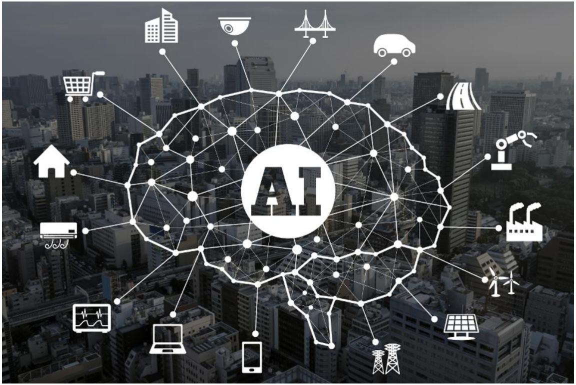
L0: About COE206

Description

A broad view of Artificial Intelligence (AI) will be covered while introducing various use-cases and application domains.



Outline

- Introduction to Artificial Intelligence
- Intelligent Agents
- Search Strategies: Blind (Uninformed) Search
- Search Strategies: Heuristic (Informed) Search
- Search Strategies: Local Search
- Adversarial Search – Games
- Constraint Satisfaction Problems
- Logic & Logical Agents
- Machine Learning: Concepts & Algorithms

Schedule

February 19 - **Mayıs 28, 2020** (14 Weeks)

- Theory (Wednesday): 08:35 – 10:10 (T-125)
- Practice (Thursday): 08:30 – 10:10 (UNIX Lab)

Course Management: Piazza

piazza COE 206 Q & A Resources Statistics **Manage Class**

Class Information

Course Number:

COE 206

Course Name:

Principles of Artificial Intelligence

Class Term: Spring 2020

↳ To use Piazza for COE 206 for a different term, click here to create a new class for that term.

Course Start Date:

02/17/2020

Signup Link:

piazza.com/istinye.edu.tr/spring2020/coe206

↳ Direct students and fellow instructors to this URL, where they can sign up for this class.

Access Code:

oq!019ix2m Remove access code

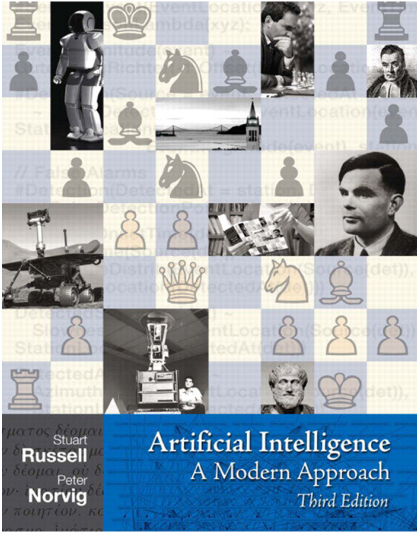
↳ You understand by adding an access code, students won't be able to self-sign up for this class and you will have to enroll them manually.

Class Link:

piazza.com/istinye.edu.tr/spring2020/coe206/home

↳ This is the link to your course page on Piazza.

Course Book



Artificial Intelligence: A Modern Approach[1] by Stuart Russel & Peter Norvig (3rd Edition), 2010, Prentice Hall

[1] http://aima.eecs.berkeley.edu/

Supplementary Books I

- **Artificial Intelligence - With an Introduction to Machine Learning**[2] by Richard E. Neapolitan, Xia Jiang (2nd Edition), 2018, CRC Press
- **The Quest of Artificial: a History of Ideas and Achievements**[3] by Nils J. Nilsson (1st Edition), 2018, Cambridge University Press
- **Artificial Intelligence: Foundations of Computational Agents**[4] by David L. Poole, Alan K Mackworth (2nd Edition), 2017, Cambridge University Press
- **Artificial Intelligence Basics: A Non-Technical Introduction**[5] by Tom Taulli (1st Edition), 2019, Apress
- **Artificial Intelligence: A Guide to Intelligent Systems**[6] by Michael Negnevitsky (2nd Edition), 2004, Addison-Wesley
- **Artificial Intelligence Safety and Security**[7] by Roman V. Yampolskiy (Ed. – 1st Edition), 2019, CRC Press

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[2] https://www.crcpress.com/Artificial-Intelligence-With-an-Introduction-to-Machine-Learning-Second/Neapolitan-Jiang/p/book/9781138502383

[3] Free Book: https://ai.stanford.edu/~nilsson/

[4] Free Book: https://artint.info/2e/html/ArtInt2e.html

[5] https://www.apress.com/gp/book/9781484250273

[6] https://www.amazon.com/Artificial-Intelligence-Guide-Intelligent-Systems/dp/0321204662/

[7] https://www.crcpress.com/Artificial-Intelligence-Safety-and-Security/Yampolskiy/p/book/9780815369820

Supplementary Books II

- **Artificial Intelligence: Structures and Strategies for Complex Problem Solving**[8] by George F. Luger (6th Edition), 2009, Addison-Wesley
- **Intelligent Systems: A Modern Approach**[9] by Crina Grosan, Ajith Abraham (1st Edition), 2011, Springer
- **Artificial Intelligence: A New Synthesis**[10] by Nils J. Nilsson (1st Edition), 1998 Morgan Kaufmann
- **Artificial Intelligence Illuminated**[11] by Ben Coppin (1st Edition), 2004, Jones and Bartlett

[8] https://www.cs.unm.edu/~luger/ai-final/

[9] https://www.springer.com/gp/book/9783642210037

[10] https://www.sciencedirect.com/book/9781558604674/artificial-intelligence-a-new-synthesis

[11] https://www.jblearning.com/catalog/productdetails/9780763732301

Supplementary Books III

- **Introduction to Algorithms**[12] by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein (3rd Edition), 2009, MIT Press
- **Algorithms**[13] by Robert Sedgewick, Kevin Wayne (4th Edition), 2011, Addison-Wesley

[12] https://mitpress.mit.edu/books/introduction-algorithms-third-edition

[13] https://algs4.cs.princeton.edu/

Other Books / Resources

- **The AI Advantage: How to Put the Artificial Intelligence Revolution to Work**[14] by Thomas H. Davenport (1st Edition), 2018, MIT Press

[14] https://mitpress.mit.edu/books/ai-advantage

Grade Distribution

Labs / Assignments / Quizzes	:	30%
Midterm Exam	:	30%
Final Exam	:	40%

Office Hours

Office: 203/G – No restrictions, anytime I am in the office ...

Ethics

Unless it is specifically allowed, doing a given task:

- with your classmates or by the help of someone from outside of your class
- by directly taking the whole or most of your task content from different sources like internet / book etc. and presenting it as if yours
- asking someone to do your task for you
- achieving the given task by yourself yet sharing the outcome with others
- ...

The exemplified scenarios above will be considered **cheating**.

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L1: Introduction to Artificial Intelligence

What is Artificial Intelligence?

Artificial Intelligence – AI[15,16]

Thinking Humanly	Thinking Rationally
"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 …" (Bellman, 1978)	"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)
Acting Humanly	**Acting Rationally**
"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)	"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)

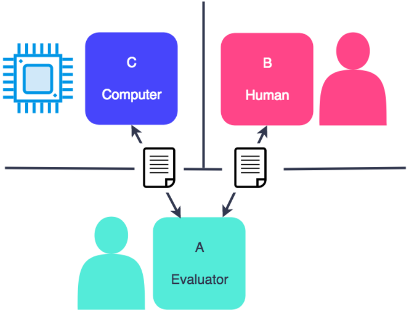
15 https://en.wikipedi0.org/wiki/Timeline_of_artificial_intelligence

16 MIT 6.S099: Artificial General Intelligence: https://agi.mit.edu/

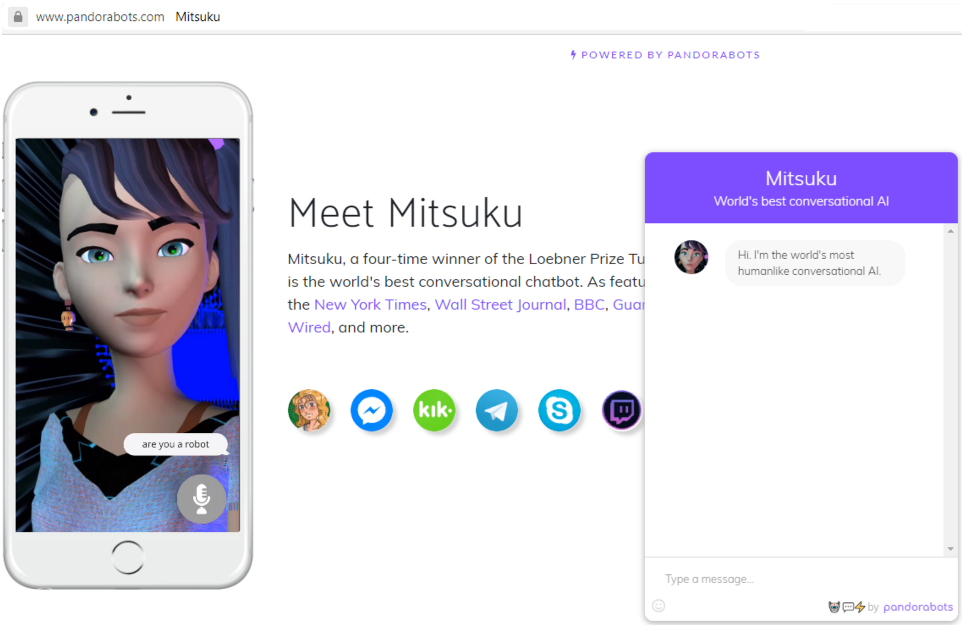
Acting Humanly

The Turing Test[17] proposed by Alan Turing (1950), was designed to provide a satisfactory operational definition of intelligence.

- Instead of asking whether the machines can think, it is aimed to question whether the machines can pass a behavioral intelligence test.



[17] A. M. Turing (1950) Computing Machinery and Intelligence. Mind 49: 433-460 – http://cogprints.org/499/1/turing.html — passing the Turing Test means that chatting with some for 5 minutes while giving the impression of being human by more than 30% of the time.


www.pandorabots.com Mitsuku
POWERED BY PANDORABOTS
Meet Mitsuku
Mitsuku, a four-time winner of the Loebner Prize Tu
is the world's best conversational chatbot. As featu
the New York Times, Wall Street Journal, BBC, Guar
Wired, and more.
are you a robot
Mitsuku
World's best conversational AI
Hi. I'm the world's most humanlike conversational AI.
Type a message...
by pandorabots

What Needed for Passing the Turing Test?

Acting Humanly

The following abilities are largely essential for passing the **Turing Test**:

- **Natural Language Processing** (NLP) to enable it to communicate successfully in a specific languge, e.g. English
- **Knowledge Representation** to store what it knows or hears;
- **Automated Reasoning** to use the stored information to answer questions and to draw new conclusions;
- **Machine Learning** (ML)[18] to adapt to new circumstances and to detect patterns.

[18] Introduction to Machine Learning by Ethem Alpaydın (3. Edition), 2014, MIT Press

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Total Turing Test further requires the following skills:

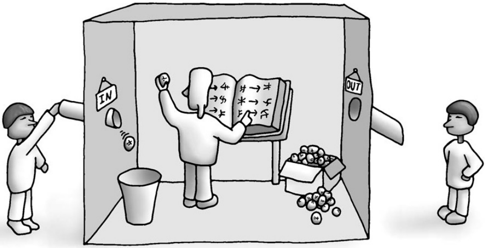
- **Computer Vision** to perceive objects, and
- **Robotics** to manipulate objects and move about.

[18] Introduction to Machine Learning by Ethem Alpaydın (3. Edition), 2014, MIT Press

Acting Humanly

Turing Test vs. **Chinese Room Argument**[19]

- There is someone who does not speak Chinese in a room alone with a Chinese rule book. Give written questions in Chinese through a slot and collect the written answers.
  - Claim: A computer executing a program cannot be shown to have a **mind**, **understanding** or **consciousness**



[19] `https://plato.stanford.edu/entries/chinese-room/` – Searle, J.R., 1982. The Chinese room revisited. Behavioral and brain sciences, 5(2), pp.345-348. – `https://www.youtube.com/watch?v=18SXA-G2peY`

Thinking Humanly: Cognitive Science

If we are going to say that a given program thinks like a human, we must have some way of determining how humans think. Can be achieved by:

- introspection – trying to catch our own thoughts as they go by;
- psychological experiments – observing a person in action;
- brain imaging – observing the brain in action.

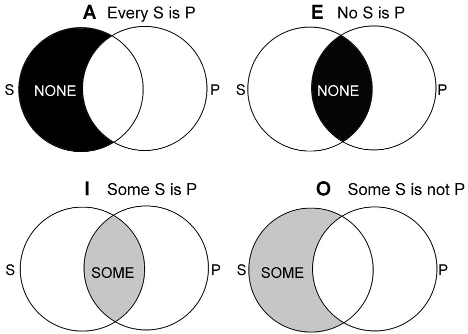
The interdisciplinary field of **cognitive science** brings together computer models from **AI** and experimental techniques from **psychology** to construct precise and testable **theories of the human mind**.

Thinking Rationally: Laws of Thought

Aristotle: what are correct arguments/thought processes?

- logic: notation and rules of derivation for thoughts

Socrates is a man; all men are mortal; therefore, Socrates is mortal.



Acting Rationally

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 but thinking should be in the service of rational action

Acting Rationally: Rational Agents

An **agent** is an entity that perceives and acts. Abstractly, an agent is a function from percept histories to actions:

$$f : \mathcal{P}^* \to \mathcal{A}$$

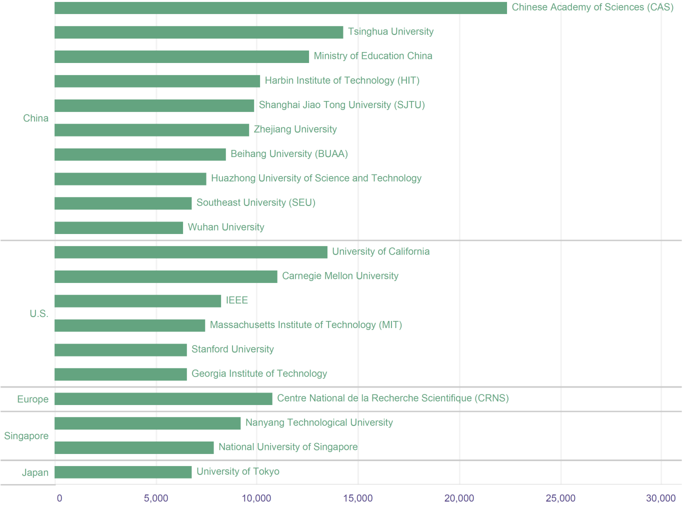
For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

Caveat: computational limitations make perfect rationality unachievable

- design the best program for given machine resources

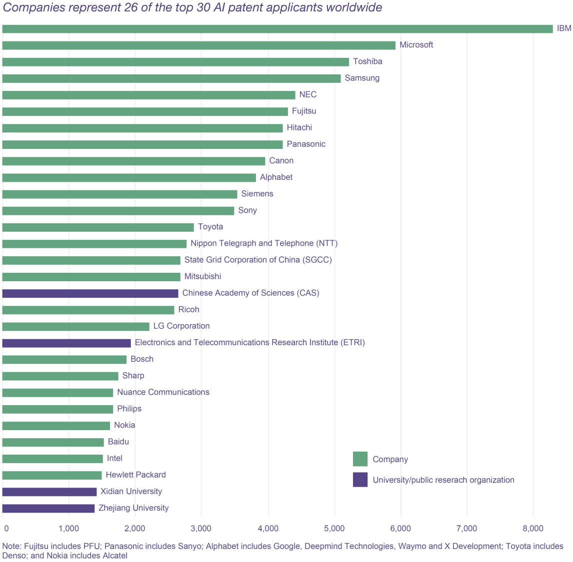
AI in Academia[20]

10 of the top 20 organizations in AI scientific publications are in China, six in the U.S., two in Singapore and one each in Japan and France



20 WIPO Technology Trends 2019 – Artificial Intelligence – https://www.wipo.int/publications/en/details.jsp?id=4386

AI in Industry[21]



[21] WIPO Technology Trends 2019 – Artificial Intelligence – https://www.wipo.int/publications/en/details.jsp?id=4386

A SHORT HISTORY OF AI...

1956
The term “artificial intelligence” is coined at Dartmouth conference and AI is founded as an academic discipline.

1956-1974
Golden years of AI enjoy government funding in promising, logical-based problem-solving approaches.

1974-1980
Overly high expecatations and limited capacities of AI programs leads to the first "AI winter" with reduced funding and interest.

1980-1987
The rise of knowledge-based expert systems brings new successes and a change in focus of research funding towards this form of AI.

1987-1993
The second "AI winter" starts with a collapse in the specialized hardware industry. The AI hype brings negative perceptions by governments and investors.

1993-2011
Optimism about AI returns, marked with the help of increased computational power and AI becomes data-driven.

2012-TODAY
Increased availability of data, connectedness and computational power allow for breakthroughs in machine learning, mainly neural networks and deep learning.

[22] WIPO Technology Trends 2019 – Artificial Intelligence – https://www.wipo.int/publications/en/details.jsp?id=4386

A Proposal for the

DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

June 17 - Aug. 16

We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

The following are some aspects of the artificial intelligence problem:

1) Automatic Computers

If a machine can do a job, then an automatic calculator can be programmed to simulate the machine. The speeds and memory capacities of present computers may be insufficient to simulate many of the higher functions of the human brain, but the major obstacle is not lack of machine capacity, but our inability to write programs taking full advantage of what we have.

2) How Can a Computer be Programmed to Use a Language

[23] Moor, J. (2006). The Dartmouth College artificial intelligence conference: The next fifty years. AI Magazine, 27(4), 87 – https://www.aaai.org/ojs/index.php/aimagazine/article/view/1911/1809; McCarthy, J., Minsky, M. L., Rochester, N., Shannon, C. E. (2006). A proposal for the dartmouth summer research project on artificial intelligence, august 31, 1955. AI magazine, 27(4), 12 – http://jmc.stanford.edu/articles/dartmouth/dartmouth.pdf ++ https://wvvw.aaai.org/ojs/index.php/aimagazine/article/view/1904/1802

Dartmouth Summer Research Project on Artificial Intelligence (1955/1956)[24]

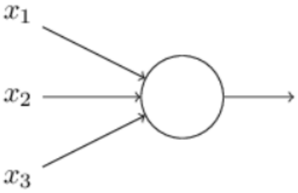
- Automatic computers
- How can a Computer be programmed to use a Language
- Neuron Nets
- Theory of the Size of a Calculation
- Self-Improvement
- Abstractions
- Randomness and Creativity

[24] Moor, J. (2006). The Dartmouth College artificial intelligence conference: The next fifty years. AI Magazine, 27(4), 87 – https://www.aaai.org/ojs/index.php/aimagazine/article/view/1911/1809; McCarthy, J., Minsky, M. L., Rochester, N., & Shannon, C. E. (2006). A proposal for the Dartmouth summer research project on artificial intelligence, august 31, 1955. AI magazine, 27(4), 12 – http://jmc.stanford.edu/articles/dartmouth/dartmouth.pdf ++ https://wvvw.aaai.org/ojs/index.php/aimagazine/article/view/1904/1802

1943: Artificial Neurons

Warren MuCulloch and Walter Pitts proposed the first computational model of a neuron, inspiring perceptrons developed in the 1950s/60s by Frank Rosenblatt.

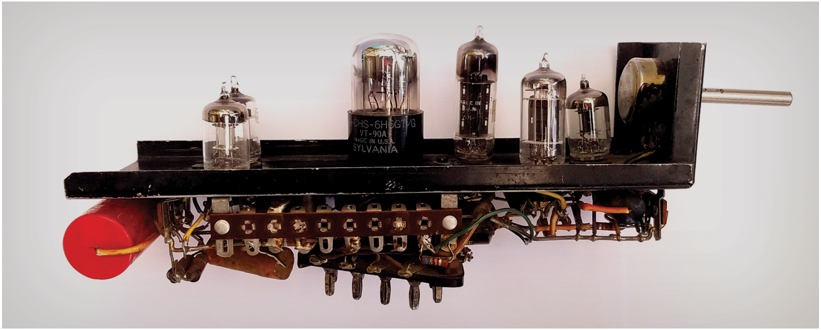
- A perceptron takes several binary inputs, x_1, x_2, . . ., and produces a single binary output:



$$\text{output} = \begin{cases} 0 & \text{if } \sum_j w_j x_j \leq \text{ threshold} \\ 1 & \text{if } \sum_j w_j x_j > \text{ threshold} \end{cases}$$

1950: First Neural Network Computer

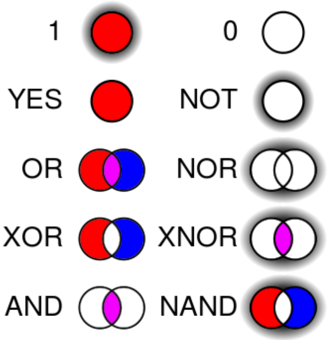
Marvin Minsky[25] engineered the first known artificial neural network, solving a maze[26].



[25] a mathematician and cognitive scientist – https://en.wikipedia.org/wiki/Marvin_Minsky

[26] https://www.the-scientist.com/foundations/machine--learning--1951-65792

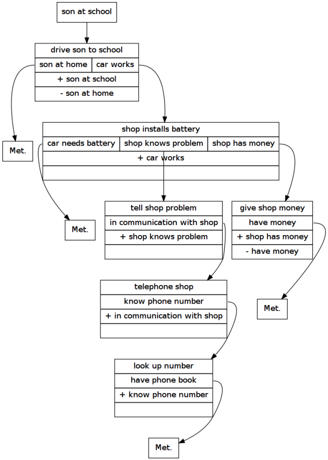
1955/1956: First AI Program – Logic Theorist[27]



The first artificial intelligence program – for theorem proving – by Herbert Simon, Allen Newell and John Shaw.

[27] https://history-computer.com/ModernComputer/Software/LogicTheorist.html

1959: General Problem Solver (GPS)[28]

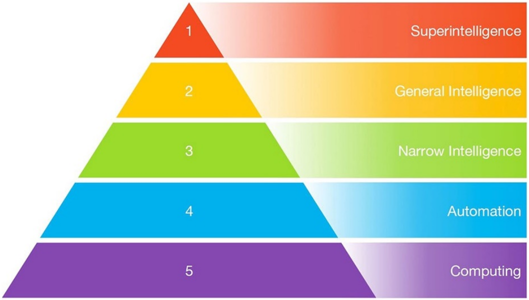


A computer program created in 1959 by Herbert A. Simon, J. C. Shaw, and Allen Newell intended to work as a universal problem solver machine.

[28] https://en.wikipedia.org/wiki/General_Problem_Solver

ANI vs. AGI vs. ASI[29]

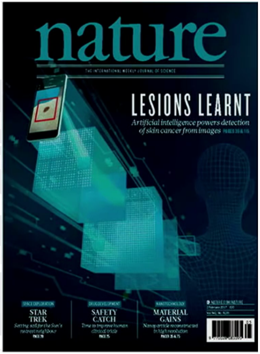
- **Narrow/Weak AI** (ANI): single-task oriented
- **General/Strong/Full AI** (AGI): human-level multi-tasking
- **Super AI** (ASI): beyond human



[29] image source: https://blog.produvia.com/curated-news-1-93527fda6808

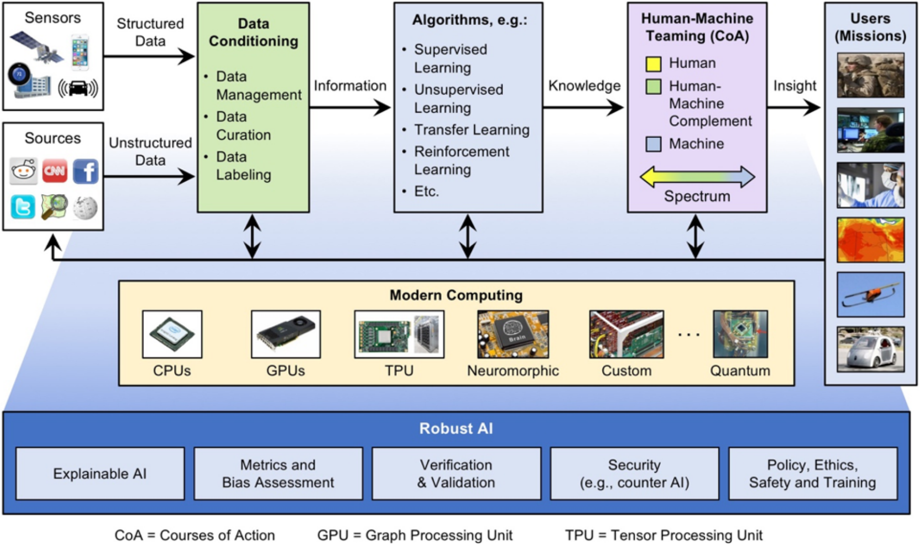
Dar YZ (Narrow/Weak AI - ANI)

Today's AI mostly falls into ANI, i.e. single-task oriented[30].



30 image source: https://towardsdatascience.com/what-happened-at-the-tensorflow-dev-summit-2017-part-1-3-community-applications-77fb5ce03c52

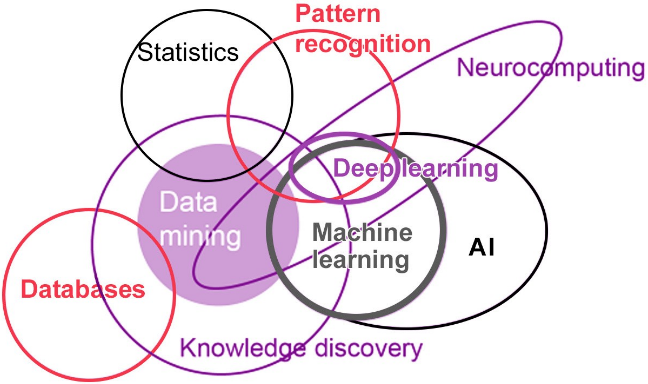
General AI Architecture[31]



[31] Reuther, A., Michaleas, P., Jones, M., Gadepally, V., Samsi, S. and Kepner, J., 2019. Survey and Benchmarking of Machine Learning Accelerators. arXiv preprint arXiv:1908.11348 – https://arxiv.org/abs/1908.11348

Taxonomy

Don't take them too seriously[32] ...



[32] https://medium.com/enabled-innovation/artificial-general-intelligence-too-much-or-too-little-too-soon-9c0dd7bd1c2d

Taxonomy[33]

POINTS OF SIGNIFICANCE

Statistics versus machine learning

Statistics draws population inferences from a sample, and machine learning finds generalizable predictive patterns.

Two major goals in the study of biological systems are inference and prediction. Inference creates a mathematical model of the data-generation process to formalize understanding or test a hypothesis about how the system behaves. Prediction aims at forecasting unobserved outcomes or future behavior, such as whether a mouse with a given gene expression pattern has a disease. Prediction makes it possible to identify best courses of action (e.g., treatment choice) without requiring understanding of the underlying mechanisms. In a typical research project, both inference and prediction can be of value—we want to know how biological processes work and what will happen next. For example, we might want to infer which biological processes are associated with the dysregulation of a gene in a disease, as well as detect whether a subject has the disease and predict the best therapy.

Many methods from statistics and machine learning (ML) may, in principle, be used for both prediction and inference. However, statistical methods have a long-standing focus on inference, which is achieved through the creation and fitting of a project-specific probability model. The model allows us to compute a quantitative measure of confidence that a discovered relationship describes a 'true' effect that is unlikely to result from noise. Furthermore, if enough data are available, we can explicitly verify assumptions (e.g., equal variance) and refine the specified model, if needed.

By contrast, ML concentrates on prediction by using general-purpose learning algorithms to find patterns in often rich and unwieldy data[1,2]. ML methods are particularly helpful when one is dealing with 'wide data', where the number of input variables exceeds the number of subjects, in contrast to 'long data', where the number of subjects is greater than that of input variables. ML makes minimal assumptions about the data-generating systems; they can be effective even when the data are gathered without a carefully controlled experimental design and in the presence of complicated nonlinear interactions. However, despite convincing prediction results, the lack of an explicit model can make ML solutions difficult to directly relate to existing biological knowledge.

Classical statistics and ML vary in computational tractability as the number of variables per subject increases. Classical statistical modeling was designed for data with a few dozen input variables and sample sizes that would be considered small to moderate today. In this scenario, the model fills in the unobserved aspects of the system. However, as the numbers of input variables and possible associations among them increase, the model that captures these relationships becomes more complex. Consequently, statistical inferences become less precise and the boundary between statistical and ML approaches becomes hazier.

To compare traditional statistics to ML approaches, we'll use a simulation of the expression of 40 genes in two phenotypes (−/+). Mean gene expression will differ between phenotypes, but we'll set up the simulation so that the mean difference for the first 30 genes is not related to phenotype. The last ten genes will be dysregulated, with systematic differences in mean expression between phenotypes. To achieve this, we assign each gene an average log expression that is the same for both phenotypes. The dysregulated genes (31–40, labeled A–J) have their mean expression perturbed in the + phenotype (**Fig. 1a**). Using these average expression values, we simulate an RNA-seq experiment in which the observed counts for each gene are sampled from a Poisson distribution with mean $\exp(x + \varepsilon)$, where x is the mean log expression, unique to the gene and phenotype, and $\varepsilon \sim N(0, 0.15)$ acts as biological variability that varies from subject to subject (**Fig. 1b**). For genes 1–30, which do not have differential expression, the z-scores are approximately $N(0, 1)$. For the dysregulated genes, which do have differential expression, the z-scores in one phenotype tend to be positive, and the z-scores in the other tend to be negative.

Our goal in the simulation is to identify which genes are associated with the abnormal phenotype. We'll formally test the null hypothesis that the mean expression differs by phenotype with a

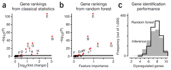


Figure 2 | Analysis of gene ranking by classical inference and ML. (**a**) Unadjusted log-scaled P values from statistical differential expression analysis as a function of effect size, measured by fold change in expression. (**b**) Log-scaled P values from **a** as a function of gene importance from random forest classification. In **a** and **b**, red circles identify the ten differentially expressed genes from **Figure 1**; the remaining genes are indicated by open circles. (**c**) Distribution of the number of dysregulated genes correctly identified in 1,000 simulations by inference (gray fill) and random forest (black line).

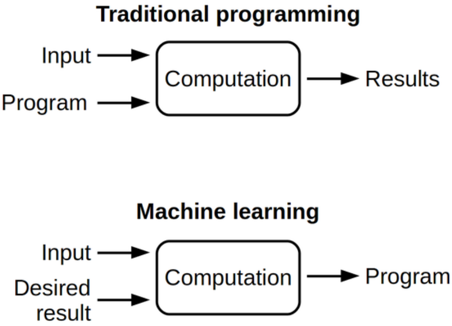
Figure 1 | Simulated expression and RNA-seq read counts for 40 genes in which the last 10 genes (A–J) are differentially expressed across two phenotypes (−/+). Simulated quantities and heat maps are log-scaled. (**a**) Simulated log mean expression levels for the genes generated by sampling from the normal distribution with mean 4 and s.d. 2. In the + phenotype the differential expression of genes A–J was created by the addition of a standard normal to each mean expression in the − phenotype. (**b**) The simulated RNA-seq read counts for ten subjects in each phenotype generated from an overdispersed Poisson distribution based on mean expression in **a** with biological variation. The heat map shows z-scores of the read counts normalized across all 20 subjects for a given gene.

Statistics vs. Machine Learning

33 Bzdok, D., Altman, N. and Krzywinski, M., 2018. Statistics versus machine learning. Points of significance, Nature Methods 15, Nature – https://www.nature.com/articles/nmeth.4642

Machine Learning (ML)

ML[34]: learning without being explicity programmed[35].

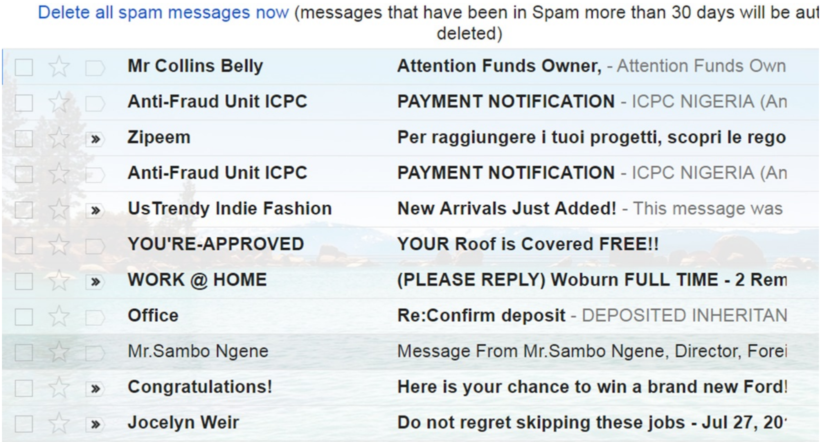


[34] https://en.wikipedi0.org/wiki/Machine_learning

[35] image source: ,https://www.futurice.com/blog/differences-between-machine-learning-and-software-engineering/

ML: Spam Filtering

Determine the junk e-mails[36]



[36] https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/

ML: Recommender Systems

Search, advertisement, movies, songs[37], products, news...

[37] https://towardsdatascience.com/how-spotify-recommends-your-new-favorite-artist-8c1850512af0

ML: Speech Recognition + Natural Language Processing + Machine Translation

Google Pixel Kulaklıklar

Skype Çevirici

Google Hoparlörler

Google Duplex:
https://www.youtube.com/watch?v=bh84hWukDdQ

ML: Face Recognition

Pay KFC by your face with **Alipay**[38]

[38] http://money.cnn.com/2017/09/01/technology/china-alipay-kfc-facial-recognition/index.html

ML: Autonomous Vehicles[43]

Self-driving Cars: NVIDIA[39][40]

- **Temmuz 2019**: Baidu has 2 million km real autonomous driving experience[41]; Waymo is with 16 billion km driving experience via simulation[42]

[39] https://www.nvidia.com/en-us/self-driving-cars/

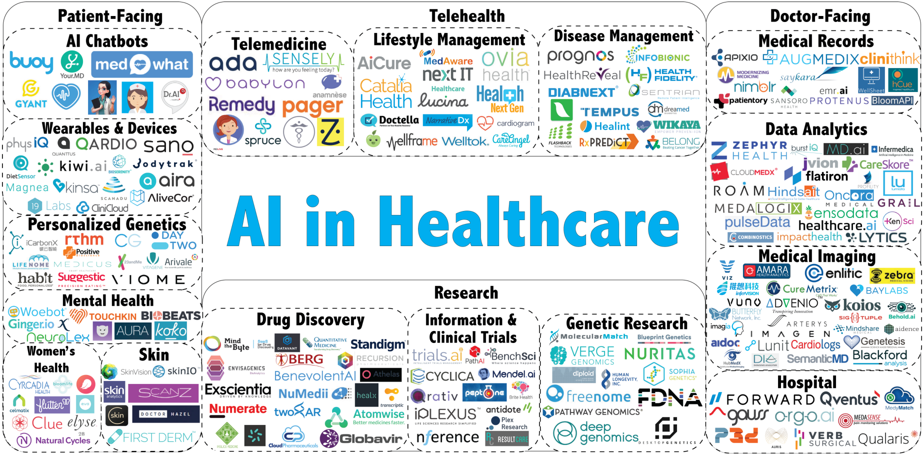
[40] Ride in NVIDIA's Self-Driving Car: https://www.youtube.com/watch?v=1W9q5SjaJTc

[41] https://venturebeat.com/2019/07/02/baidus-autonomous-cars-have-driven-more-than-1-million-miles-across-13-cities-in-china/

[42] https://techcrunch.com/2019/07/10/waymo-has-now-driven-10-billion-autonomous-miles-in-simulation/

[43] MIT Self-Driving Cars: State of the Art (2019): https://www.youtube.com/watch?v=sRxaMDDMWQQ – MIT 6.S094: Deep Learning for Self-Driving Cars: https://selfdrivingcars.mit.edu/

ML: Healthcare[44,45]



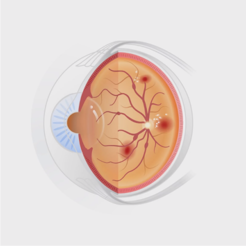
44 https://techburst.io/ai-in-healthcare-industry-landscape-c433829b320c

45 Chen, P.H.C., Liu, Y. and Peng, L., 2019. How to develop machine learning models for healthcare. Nature materials, 18(5), p.410 – https://www.nature.com/articles/s41563-019-0345-0

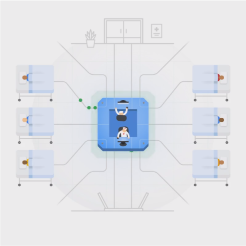
46

Using AI to give doctors a 48-hour head start on life-threatening illness

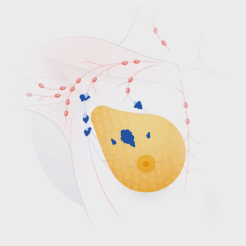
A promising step forward for predicting lung cancer



Using AI to help doctors address eye disease



Deep Learning for Electronic Health Records

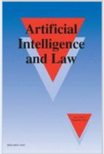


Applying Deep Learning to Metastatic Breast Cancer Detection

Highly Accurate Genomes With Deep Neural Networks

46 Google Health: https://health.google/ – https://www.youtube.com/watch?v=Q2UeoWow8yA ++ https://www.youtube.com/watch?v=P3SYqcPXqNk

ML: Law[47][48]



Artificial Intelligence and Law

This journal seeks papers that address the development of formal or computational models of legal knowledge, reasoning, and decision making. It also includes in-depth studies of innovative artificial intelligence systems that are being used in the legal domain, and gives space to studies addressing the legal, ethical and social implications of the use of artificial intelligence in law. It welcomes interdisciplinary approaches including not only artificial intelligence and jurisprudence, but also logic, machine learning, cognitive psychology, linguistics, or philosophy.

[47] https://www.springer.com/journal/10506

[48] https://www.thelawyerportal.com/blog/artificial-intelligence-law/

ML: Journalism[51]

- News writing, fake news detection[49]
- %20 work power gain, news accuracy and quality increase[50]

[49] https://emerj.com/ai-sector-overviews/automated-journalism-applications/

[50] https://www.forbes.com/sites/nicolemartin1/2019/02/08/did-a-robot-write-this-how-ai-is-impacting-journalism/#709f48d47795

[51] https://www.tandfonline.com/doi/full/10.1080/21670811.2014.976412?journalCode=rdij20

ML: Finance / Insurance

Risk assessment, fraud detection, financial advising[52][53]

52 https://marutitech.com/ways-ai-transforming-finance/

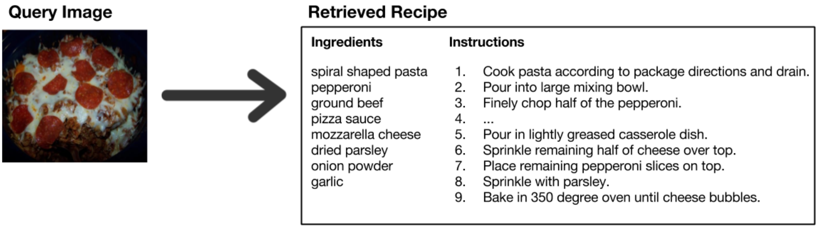
53 image source: https://medium.com/activewizards-machine-learning-company/top-7-data-science-use-cases-in-finance-303c05a3cb58

ML: Gastronomy

Chef Watson[54]: Which ingredients should be used to make the perfect dish beloning to a specific cuisine...

Pic2Recipe[55]: Recipe extraction from meal photos[56]

- Recipe1M+[57]: More than 1 million recipes and 13 million related food images



[54] https://www.ibm.com/blogs/watson/2016/01/chef-watson-has-arrived-and-is-ready-to-help-you-cook/

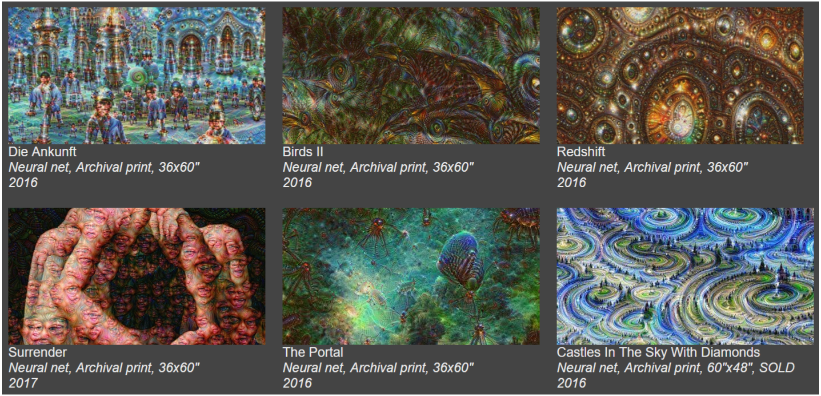
[55] https://www.digitaltrends.com/photography/pics2recipe-mit-research/

[56] https://www.youtube.com/watch?v=qp5y0fcBXq0

[57] http://pic2recipe.csail.mit.edu/

ML: Even Art[59]

Image produced by AI sold for $ 432,500 at auction[58]



[58] https://www.theverge.com/2018/10/25/18023266/ai-art-portrait-christies-obvious-sold

[59] http://www.miketyka.com/?s=deepdream

Yet, Immense Processing Power Might be Needed...

Personal computers are not good enough to perform certain (more of realistic and complex) ML tasks – **supercomputers** era

More Processing Power...

Top 500 @ November 2019:

https://www.top500.org/lists/2019/11/

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	**Summit** - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband , IBM DOE/SC/Oak Ridge National Laboratory United States	2,414,592	148,600.0	200,794.9	10,096
2	**Sierra** - IBM Power System AC922, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband , IBM / NVIDIA / Mellanox DOE/NNSA/LLNL United States	1,572,480	94,640.0	125,712.0	7,438
3	**Sunway TaihuLight** - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway , NRCPC National Supercomputing Center in Wuxi China	10,649,600	93,014.6	125,435.9	15,371
4	**Tianhe-2A** - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000 , NUDT National Super Computer Center in Guangzhou China	4,981,760	61,444.5	100,678.7	18,482
5	**Frontera** - Dell C6420, Xeon Platinum 8280 28C 2.7GHz, Mellanox InfiniBand HDR , Dell EMC Texas Advanced Computing Center/Univ. of Texas United States	448,448	23,516.4	38,745.9	
6	**Piz Daint** - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interconnect , NVIDIA Tesla P100 , Cray/HPE	387,872	21,230.0	27,154.3	2,384

More Processing Power...

IBM Power System AC922: 2.41 million cores[60]

[60] https://www.top500.org/system/179397

Supercomputers: Machine Outperforms Human – 1997[62]

Garry Kasparov vs. **IBM Deep Blue**[61]

61 Deep Blue vs Kasparov: How a computer beat best chess player in the world – https://www.youtube.com/watch?v=KF6sLCeBj0s

62 Korf, R.E., 1997, January. Does Deep Blue use AI?. In Deep Blue Versus Kasparov: The Significance for Artificial Intelligence (pp. 1-2) – https://www.aaai.org/Papers/Workshops/1997/WS-97-04/WS97-04-001.pdf [Expert Systems + MinMax Search + Processing Power (1996: ability to evaluate 100 million chess positions per second; 1997: being able to evaluate 200 million chess positions per second)] – 1996 (6 games): Kasparov = 3, Deep Blue = 1, Draw = 2; 1997 (6 games): Kasparov = 1, Deep Blue = 2, Draw = 3

Supercomputers: Machine Outperforms Human – 2011

IBM Watson[63] can process **500 gigabayt** which is equivalent of 1 million books in **one second** – Jeopardy![64] 2011

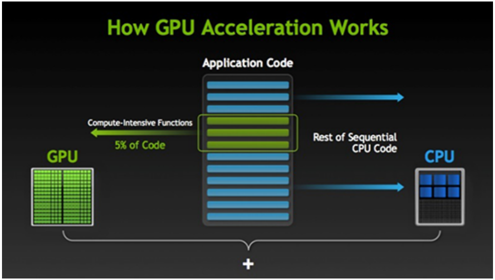
[63] https://en.wikipedi0.org/wiki/Watson_(computer)

[64] https://en.wikipedi0.org/wiki/Jeopardy!

More Processing Power... CPU ve GPU

Do we need really large supercomputers?[65]

- **GPU**-accelerated calculation, using one or more graphics processing units (GPUs) together with a CPU.
- While one **CPU** is composed of a few cores optimized for **sequential batch processing**, **GPU** is particularly suitable for **parallel processing**.



[65] http://www.nvidia.com/object/what-is-gpu-computing.html

CPU vs. GPU

A PC with an end-user GPU can perform better than a supercomputer in complex mathematical calculations[66]

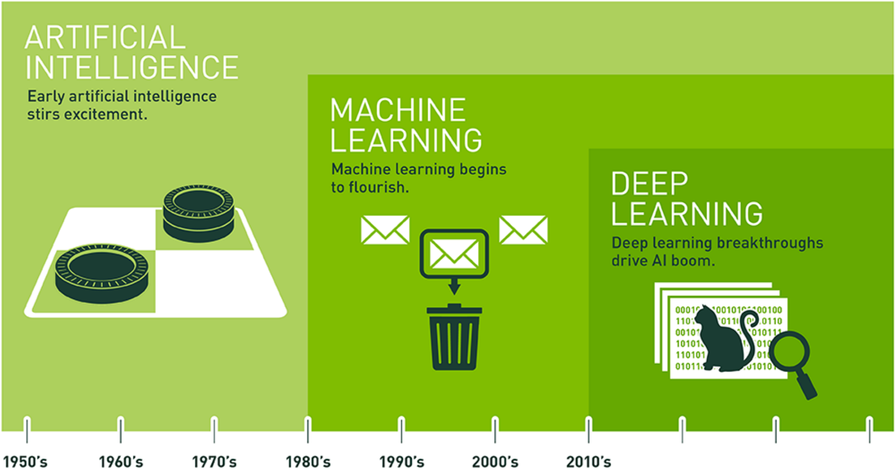
[66] http://newatlas.com/nvidia-gpu-outperforms-supercomputer/44112/

CPU vs. GPU: Have No Money to Buy

Buy cloud services or go for free cloud services like Google Colab[67]

...

[67] https://colab.research.google.com/

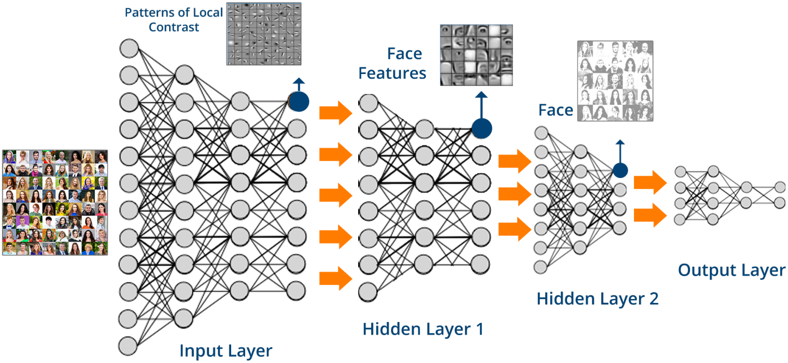


Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

[68] resim kaynağı: What's the Difference Between Artificial Intelligence, Machine Learning and Deep Learning? – https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/

Deep Learning[69] (DL)[70]

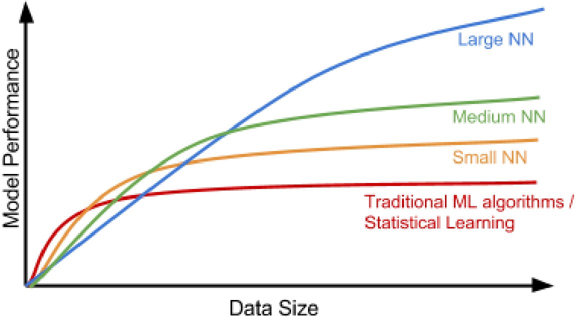
Very efficient on GPUs ...



69 http://deeplearning.net/

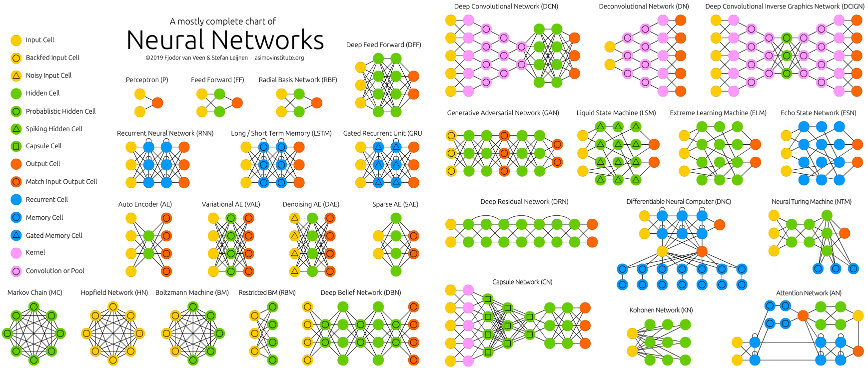
70 Goodfellow, I., Bengio, Y. and Courville, A., 2016. Deep learning. MIT press: http://www.deeplearningbook.org/

DL[71]



[71] Nuts and Bolts of Applying Deep Learning (Andrew Ng): https://www.youtube.com/watch?v=F1ka6a13S9I – https://lilianweng.github.io/lil-log/2017/06/21/an-overview-of-deep-learning.html

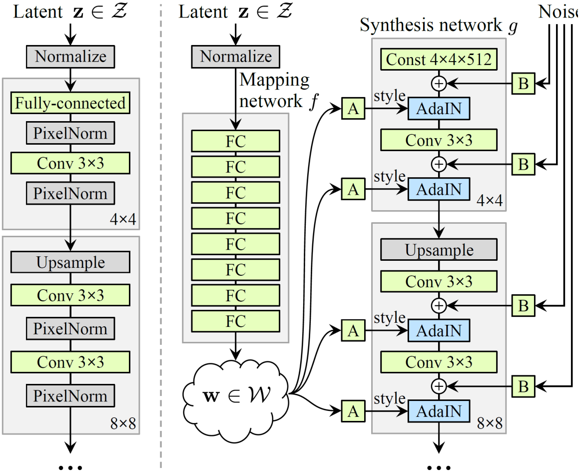
DL Architectures



[72]

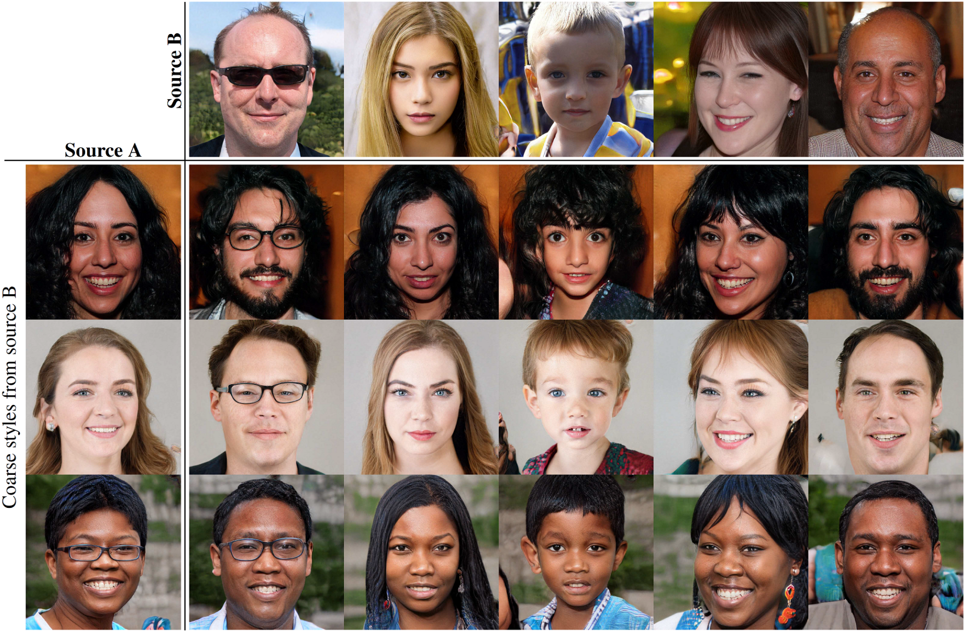
72 https://www.asimovinstitute.org/neural-network-zoo/

DL Architectures – e.g. Style-based GAN

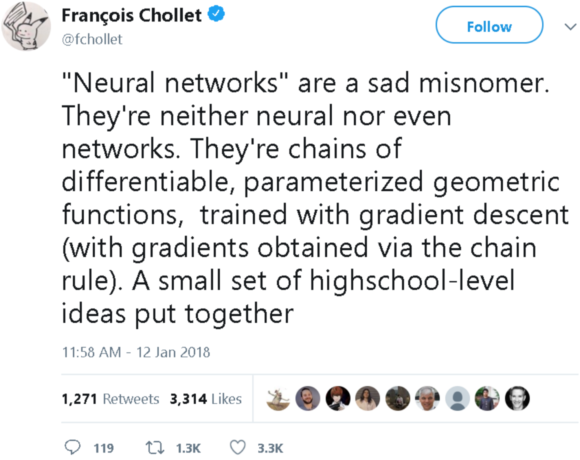


(a) Traditional (b) Style-based generator

[73] Karras, T., Laine, S. and Aila, T., 2019. A style-based generator architecture for generative adversarial networks. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 4401-4410) – http://openaccess.thecvf.com/content_CVPR_2019/papers/Karras_A_Style-Based_Generator_Architecture_for_Generative_Adversarial_Networks_CVPR_2019_paper.pdf – https://www.youtube.com/watch?v=o46fcRl2yxE


Source B
Source A
Coarse styles from source B

DL – Artificial Neural Networks



[74]

[74] Francois Chollet who made Keras: https://fchollet.com/ – Deep Learning with Python - 2018 Manning

Which GPU for DL?[75]

GPU for Starters – GTX 1050 Ti

- 768 CUDA cores (1354 MHz Core Speed)

[75] http://timdettmers.com/2017/04/09/which-gpu-for-deep-learning/

NVIDIA DGX-1: DL Supercomputer

- 28672 / 40960 CUDA cores

AlexNet[76] network training lasts 150 hours with 250 Xeon CPU server, 2 hours with DGX-1

[76] https://en.wikipedi0.org/wiki/AlexNet

Atlas 900: DL Supercomputer[78]

The fastest AI supercomputer[77]

- equivalent of ∼500.000 PCs' processing power

[77] https://e.huawei.com/en/products/cloud-computing-dc/atlas/atlas-900-ai

[78] https://www.huawei.com/en/press-events/news/2019/9/huawei-computing-strategy-atlas-900-ai-training-cluster

AI-Focused Specialized Chips - Neuromorphic Computing[80]

Tianjic[79]: Simultaneous real-time object detection, monitoring, sound control, obstacle avoidance and balance control in the unmanned bike system with a single chip

[79] Pei, J., Deng, L., Song, S., Zhao, M., Zhang, Y., Wu, S., Wang, G., Zou, Z., Wu, Z., He, W. and Chen, F., 2019. Towards artificial general intelligence with hybrid Tianjic chip architecture. Nature, 572(7767), pp.106-111 – https://www.nature.com/articles/s41586-019-1424-8, https://www.youtube.com/watch?v=VjSs6KCLTC0

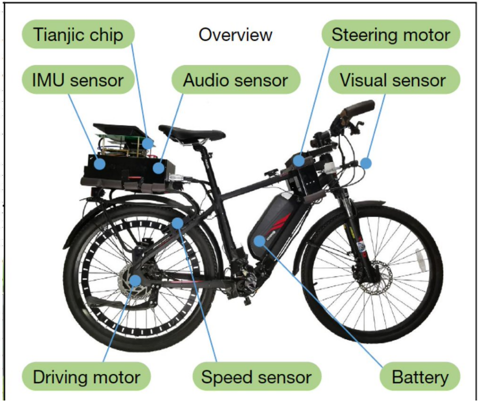
[80] https://bdtechtalks.com/2019/10/28/neuromorphic-chips-artificial-intelligence/

AI-Focused Specialized Chips - Neuromorphic Computing[81]

Towards artificial general intelligence with hybrid Tianjic chip architecture

Jing Pei[1,2,13], Lei Deng[1,13], Sen Song[3,4,13], Mingguo Zhao[5,13], Youhui Zhang[6,13], Shuang Wu[1,2,13], Guanrui Wang[1,2,13], Zhe Zou[1,2], Zhenzhi Wu[7], Wei He[1,2], Feng Chen[5], Ning Deng[8], Si Wu[9], Yu Wang[10], Yujie Wu[1,2], Zheyu Yang[1,2], Cheng Ma[1,2], Guoqi Li[1,2], Wentao Han[6], Huanglong Li[1,2], Huaqiang Wu[8], Rong Zhao[11], Yuan Xie[12] & Luping Shi[1,2]*

There are two general approaches to developing artificial general intelligence (AGI)[1]: computer-science-oriented and neuroscience-oriented. Because of the fundamental differences in their formulations and coding schemes, these two approaches rely on distinct and incompatible platforms[2–8], retarding the development of AGI. A general platform that could support the prevailing computer-science-based artificial neural networks as well as neuroscience-inspired models and algorithms is highly desirable. Here we present the Tianjic chip, which integrates the two approaches to provide a hybrid, synergistic platform. The Tianjic chip adopts a many-core architecture, reconfigurable building blocks and a streamlined dataflow with hybrid coding schemes, and can not only accommodate computer-science-based machine-learning algorithms, but also easily implement brain-inspired circuits and several coding schemes. Using just one chip, we demonstrate the simultaneous processing of versatile algorithms and models in an unmanned bicycle system, realizing real-time object detection, tracking, voice control, obstacle avoidance and balance control. Our study is expected to stimulate AGI development by paving the way to more generalized hardware platforms.



[81] https://bdtechtalks.com/2019/10/28/neuromorphic-chips-artificial-intelligence/

Where are quantum computers?[85]

Google's quantum computers is 100 folds faster than consumer grade PCs[82]

- Attempts for effective use of quantum computers[83] [84]

[82] http://www.wired.co.uk/article/google-quantum-computing-d-wave

[83] https://ai.googleblog.com/2019/10/quantum-supremacy-using-programmable.html

[84] https://www.nature.com/articles/s41586-019-1666-5

[85] IBM Quantum cloud service: https://quantum-computing.ibm.com/

DL – Success Stories

AlphaGO[86]: The first computer program to beat a professional Go player on a 19X19 Go board (Google DeepMind, 2015)

[86] https://deepmind.com/research/alphago/

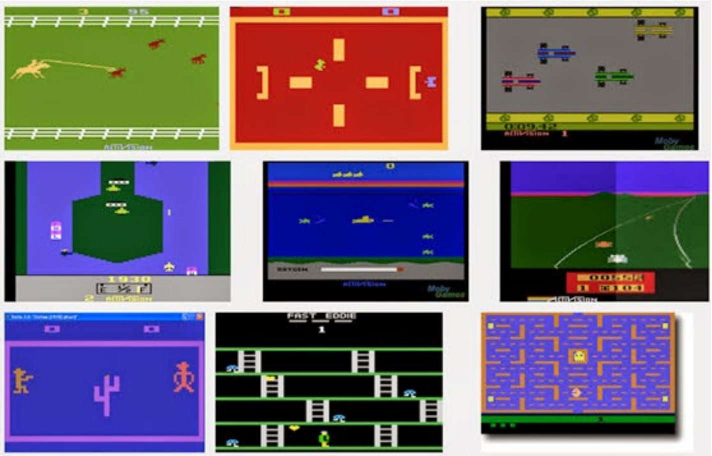
DL – Success Stories

Ex-GO champion retired after defeated by DeepMind, declaring AI is unbeatable[87]

[87] https://www.theverge.com/2019/11/27/20985260/ai-go-alphago-lee-se-dol-retired-deepmind-defeat

DL – Success Stories

Playing the 1980s Atari games without any instructions or prior knowledge of how to play those video games[88] (Google DeepMind)



[88] http://www.businessinsider.com/artificial-intelligence-playing-video-games-2015-11

DL – Success Stories

A speech recognition system developed by Baidu that knows English and Chinese (Mandarin) better than people (**Deep Speech 2**)[89]

Deep Speech 2: End-to-End Speech Recognition in English and Mandarin

Baidu Research – Silicon Valley AI Lab*
Dario Amodei, Rishita Anubhai, Eric Battenberg, Carl Case, Jared Casper, Bryan Catanzaro, Jingdong Chen, Mike Chrzanowski, Adam Coates, Greg Diamos, Erich Elsen, Jesse Engel, Linxi Fan, Christopher Fougner, Tony Han, Awni Hannun, Billy Jun, Patrick LeGresley, Libby Lin, Sharan Narang, Andrew Ng, Sherjil Ozair, Ryan Prenger, Jonathan Raiman, Sanjeev Satheesh, David Seetapun, Shubho Sengupta, Yi Wang, Zhiqian Wang, Chong Wang, Bo Xiao, Dani Yogatama, Jun Zhan, Zhenyao Zhu

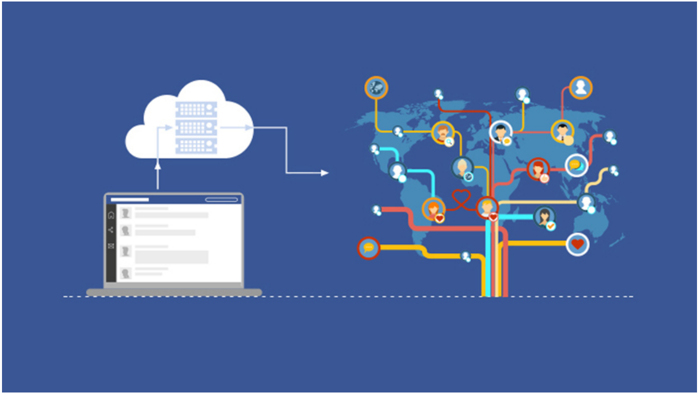
Abstract

We show that an end-to-end deep learning approach can be used to recognize either English or Mandarin Chinese speech—two vastly different languages. Because it replaces entire pipelines of hand-engineered components with neural net-

[89] https://www.technologyreview.com/s/544651/baidus-deep-learning-system-rivals-people-at-speech-recognition/

What shall we do? - Focus on Data

- **Facebook**[90]: **Every minute**, while 510,000 comments are posted, 293,000 status updates and 136,000 photo uploads take place



[90] https://zephoria.com/top-15-valuable-facebook-statistics/

What shall we do? - Focus on Data

Facebook has enough data to know us better than terapists![91]

- Processing messages and preferences
- Emotion analysis
- ...

[91] https://www.simplilearn.com/how-facebook-is-using-big-data-article

Where do we get data? – Google Dataset Search[92]

[92] https://datasetsearch.research.google.com/

NEWS ·

Google health-data scandal spooks researchers

Scientists fear the controversy over the Nightingale project will undermine trust in research.

nature

Heidi Ledford

19 NOVEMBER 2019

[93] Google health-data scandal spooks researchers: https://www.nature.com/articles/d41586-019-03574-5

How home assistants ruined us, an explanation

Violet Blue, @violetblue
12.31.19 in Security

It's the rise -- and revenge -- of the machines.

[94] How home assistants ruined us, an explanation: https://www.engadget.com/2019/12/31/home-assistants-listening-ruined-us-an-explanation/

Conclusion... Benefits of AI[95]

- Fast decision making (+ data processing)
- Less errors (similar to or better than experts)
- Standardization and Objectivity (data based ...)
- Accessibility to high quality services (e.g. medical services)
- Ability to work 24/7

[95] AI ADVANTAGE: How to Put the Artificial Intelligence Revolution to Work by Thomas H Davenport, MIT Press, 2018

Conclusion... Pitfalls of AI / Potential Damages[99]

- Unemployment (actually new employment opportunities...)[96]
- Laziness (especially in full autonomy cases...)
- Black-box Nature (New Goal: Explainable AI (XAI)[97] ...)
- Ethical Cocnerns (e.g. who is responsible for an autonomous vehicle crash?)[98]

96 https://mitibmwatsonailab.mit.edu/research/publications/paper/?id=The-Future-of-Work-How-New-Technologies-Are-Transforming-Tasks

97 https://www.darpa.mil/program/explainable-artificial-intelligence

98 http://moralmachine.mit.edu/

99 AI ADVANTAGE: How to Put the Artificial Intelligence Revolution to Work by Thomas H Davenport, MIT Press, 2018