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CMPE 258-01 Deep Learning

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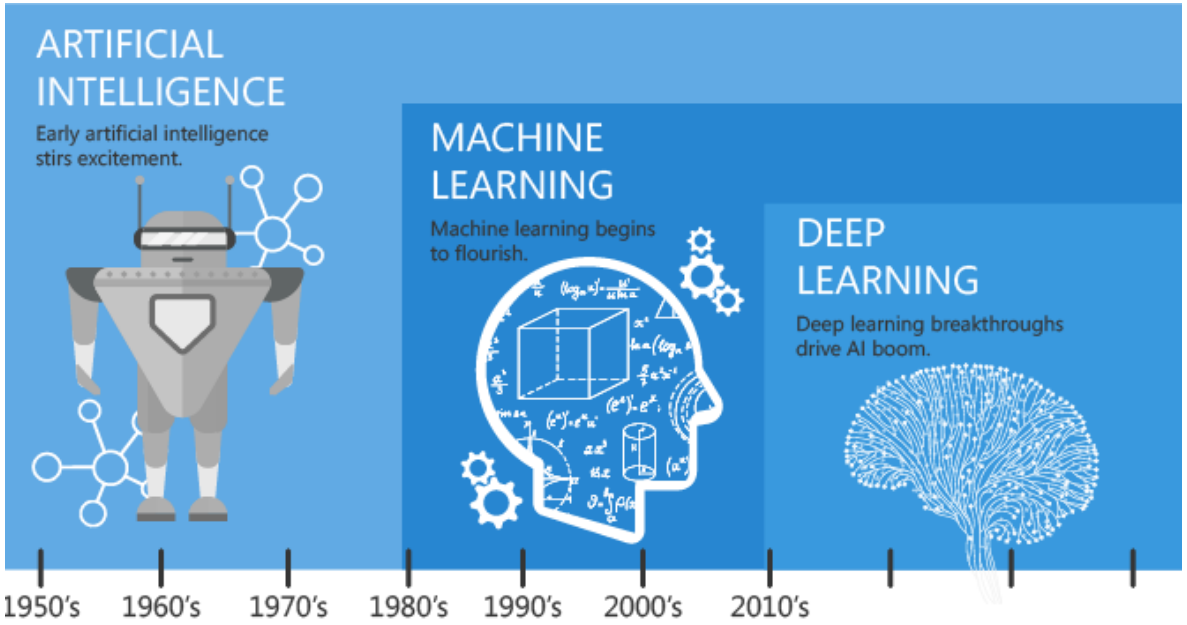
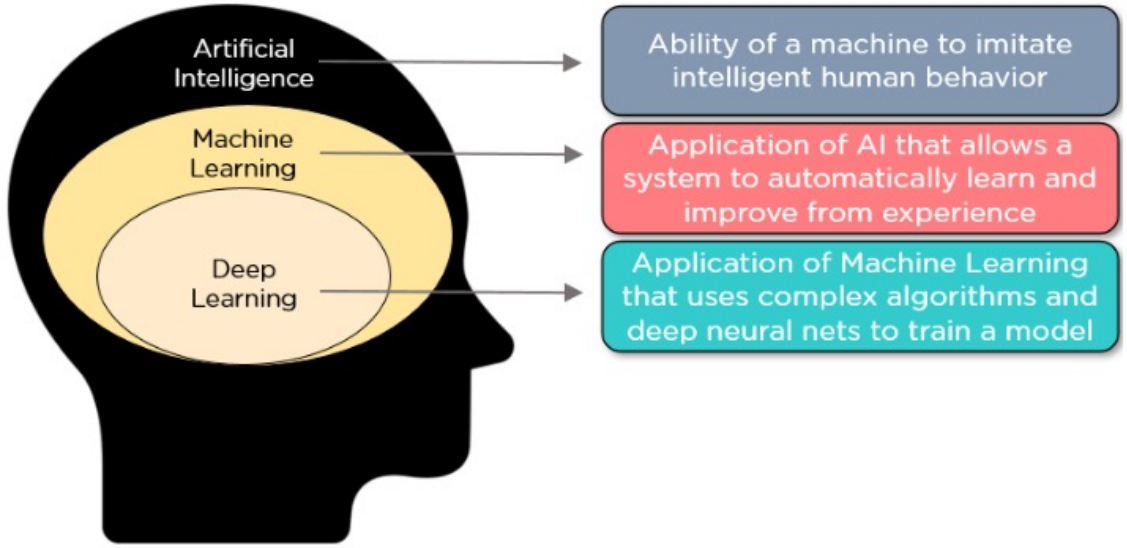
What is Deep Learning

- Deep Learning is a part of machine learning that deals with algorithms inspired by the structure and function of the human brain. It uses artificial neural networks to build intelligent models and solve complex problems.





What is Artificial Intelligence – old answer

- AI textbooks list
  - http://aima.cs.berkeley.edu/2nd-ed/books.html
- Artificial Intelligence: A Modern Approach
  - http://aima.cs.berkeley.edu/2nd-ed/books.html
  - http://aima.cs.berkeley.edu/newchap00.pdf

Author	Lisp Programming	Year	Pages	Amazon	Code
Graham	ANSI Common Lisp	1995	432	10,000	46K Lisp
Sussman, Abelson	The Structure and Interpretation of Computer Programs	1996	657	30,000	Scheme
Norvig	Paradigms of AI Programming	1992	946	74,000	481K Lisp
Winston, Horn	Lisp	1989	611	76,000	Lisp
Graham	On Lisp	1994	413	90,000	56K Lisp
Wilensky	Common LispCraft	1986	500	243,000	None
Forbus, de Kleer	Building Problem Solvers	1993	716	337,000	Lisp
Charniak, Riesbeck, McDermott	AI Programming	1987	533	939,000	?

Author	Prolog Programming	Year	Pages	Amazon	Code
Bratko	Prolog Programming for AI (3rd ed.)	1990	678	69,000	Prolog
Clocksin, Mellish	Programming in Prolog (3rd edition)	1987	281	108,000	?
O'Keefe	The Craft of Prolog	1990	411	269,000	?
Shoham	AI Techniques in Prolog	1994	327	836,000	Prolog

Author	C++/Java/Python	Year	Pages	Amazon	Code
Tracy, Bouthoorn	Object-Oriented AI in C++	1996	468	338,000	179K C++

Part I: Artificial Intelligence

Chapter 1 Introduction ... 1

What is Artificial Intelligence – old answer

Artificial Intelligence: A Modern Approach, 4th US ed.

by Stuart Russell and Peter Norvig

The authoritative, most-used AI textbook, adopted by over **1500** schools.

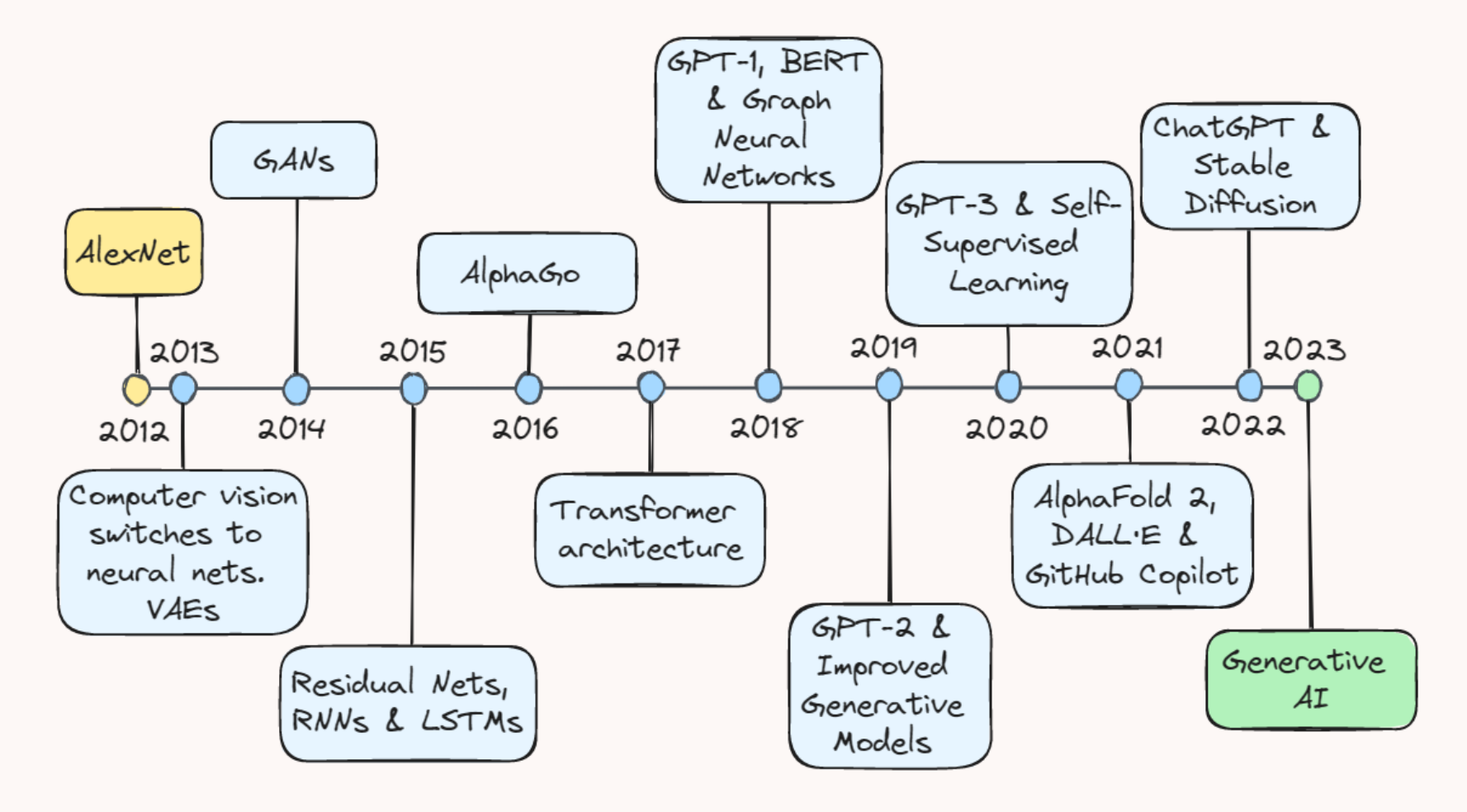
Table of Contents for the US Edition (or see the Global Edition)

https://aima.cs.berkeley.edu

- Peter Norvig is a Director of Research at Google Inc
  - http://www.norvig.com
- SJSU EIAC Membership

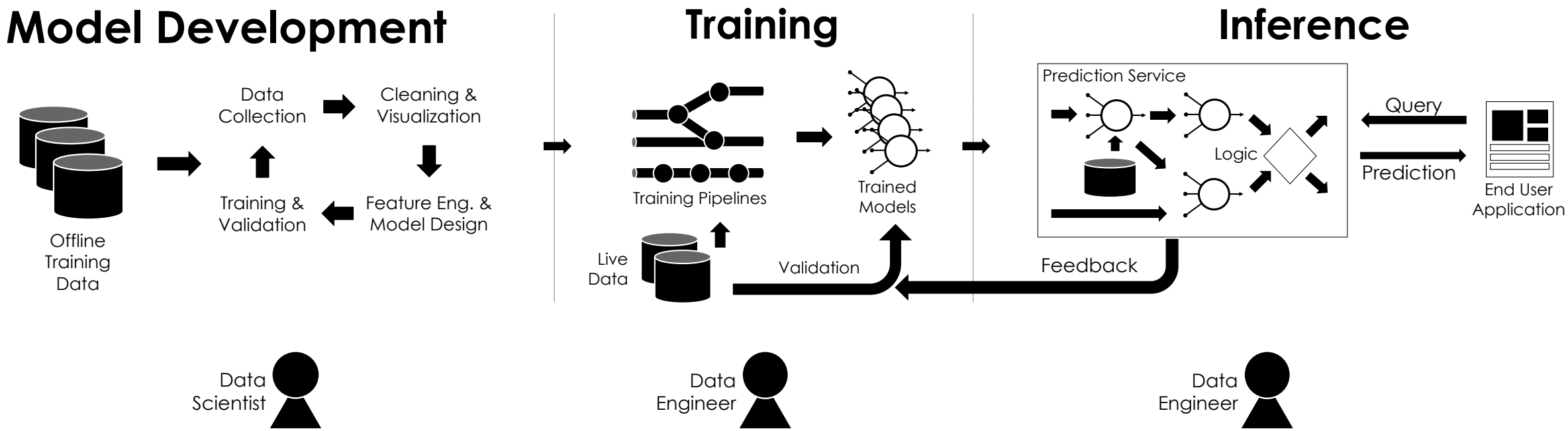
What is Artificial Intelligence – new answer

- The Present advancements in AI



Machine Learning Lifecycle

- Machine Learning play with all ‘Data’

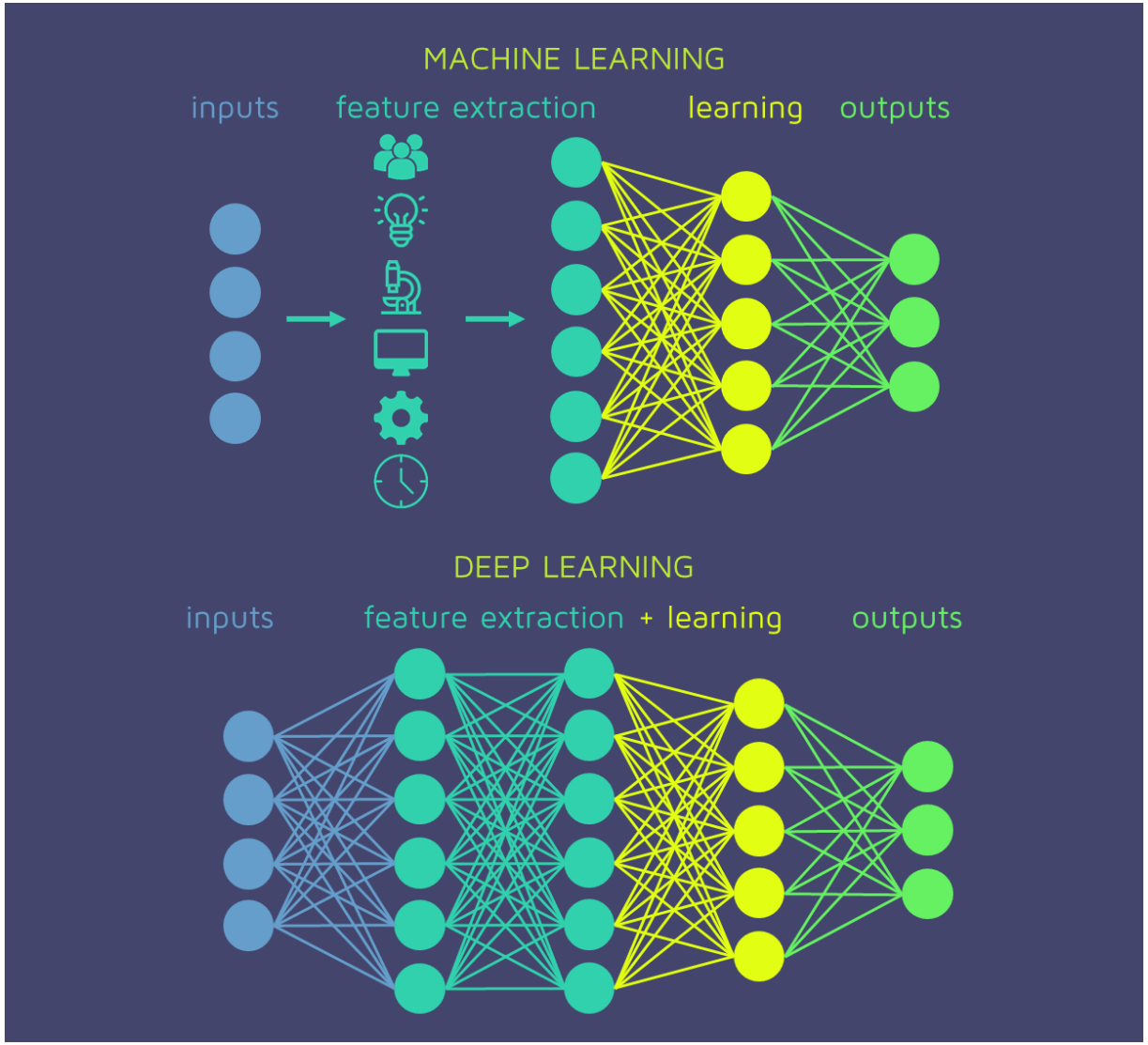


Deep Learning vs Machine Learning

- Deep Learning is a sub-class of Machine Learning algorithms whose peculiarity is a higher level of complexity.
  - Deep Learning belongs to Machine Learning and they are absolutely not opposite concepts. We refer to **shallow learning** to those techniques of machine learning that are not deep
- Why is this complexity an advantage?
  - As humans, the information is learnt step by step. First layers focus on learning more specific concepts while the deeper layers will use the information already learnt to soak in more abstract concepts. This procedure of constructing representations of the data is known as feature extraction.
  - Their complex architecture provides deep neural nets with the ability to perform a feature extraction automatically.

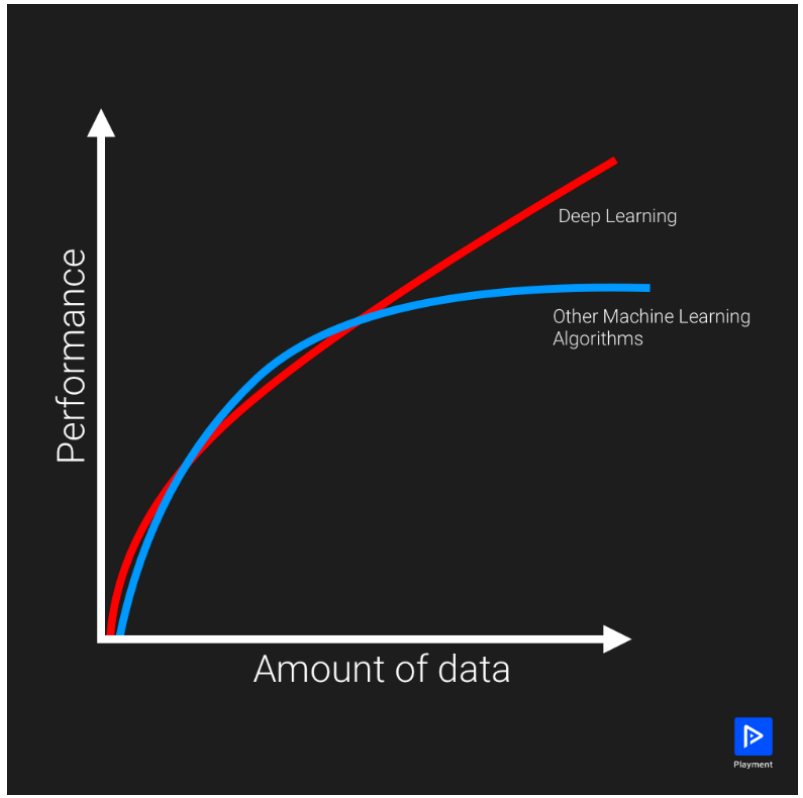
Deep Learning vs Machine Learning

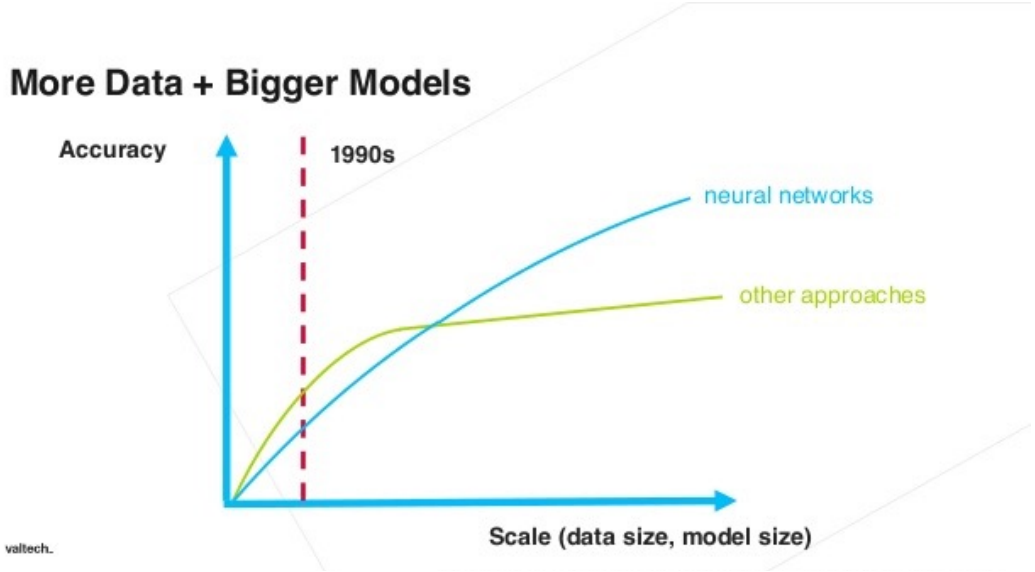
- In conventional machine learning, or shallow learning, this task is carried out outside the algorithmic stage. People, data scientists' teams and not machines, are in charge of analyzing raw data and change it into valuable features.
- Deep learning is a black box.

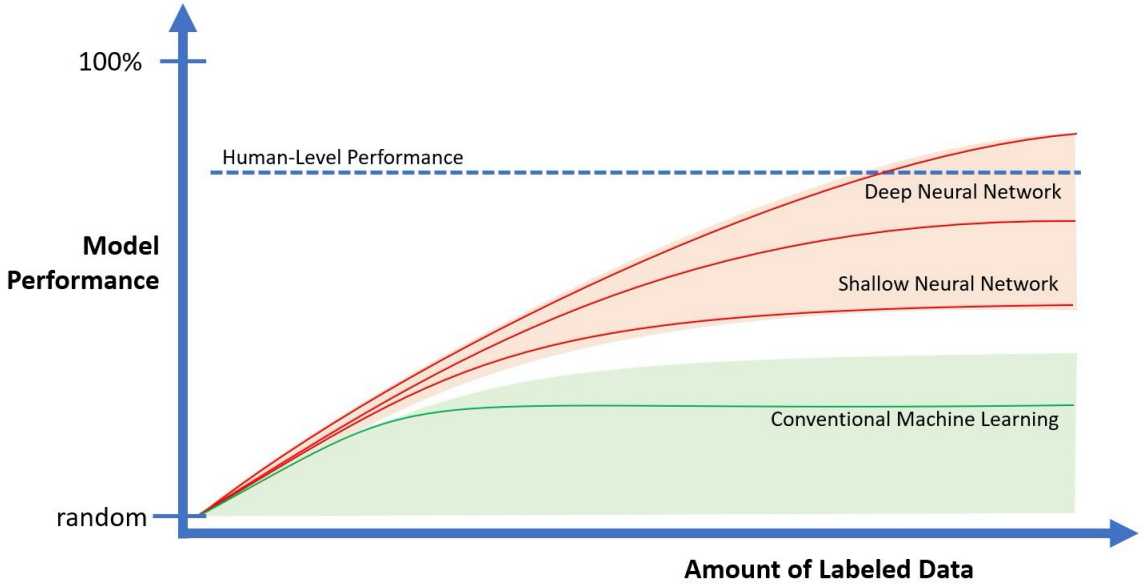


More Data Better Performance

- More Data Better Performance

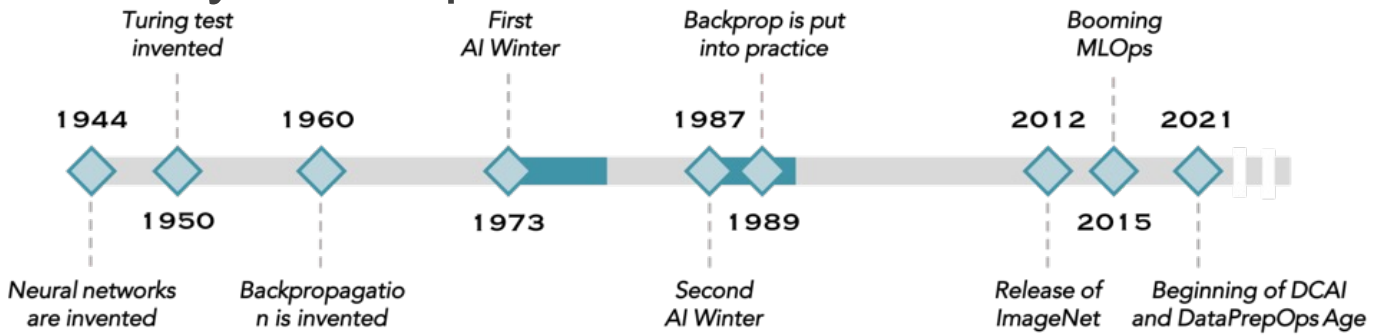


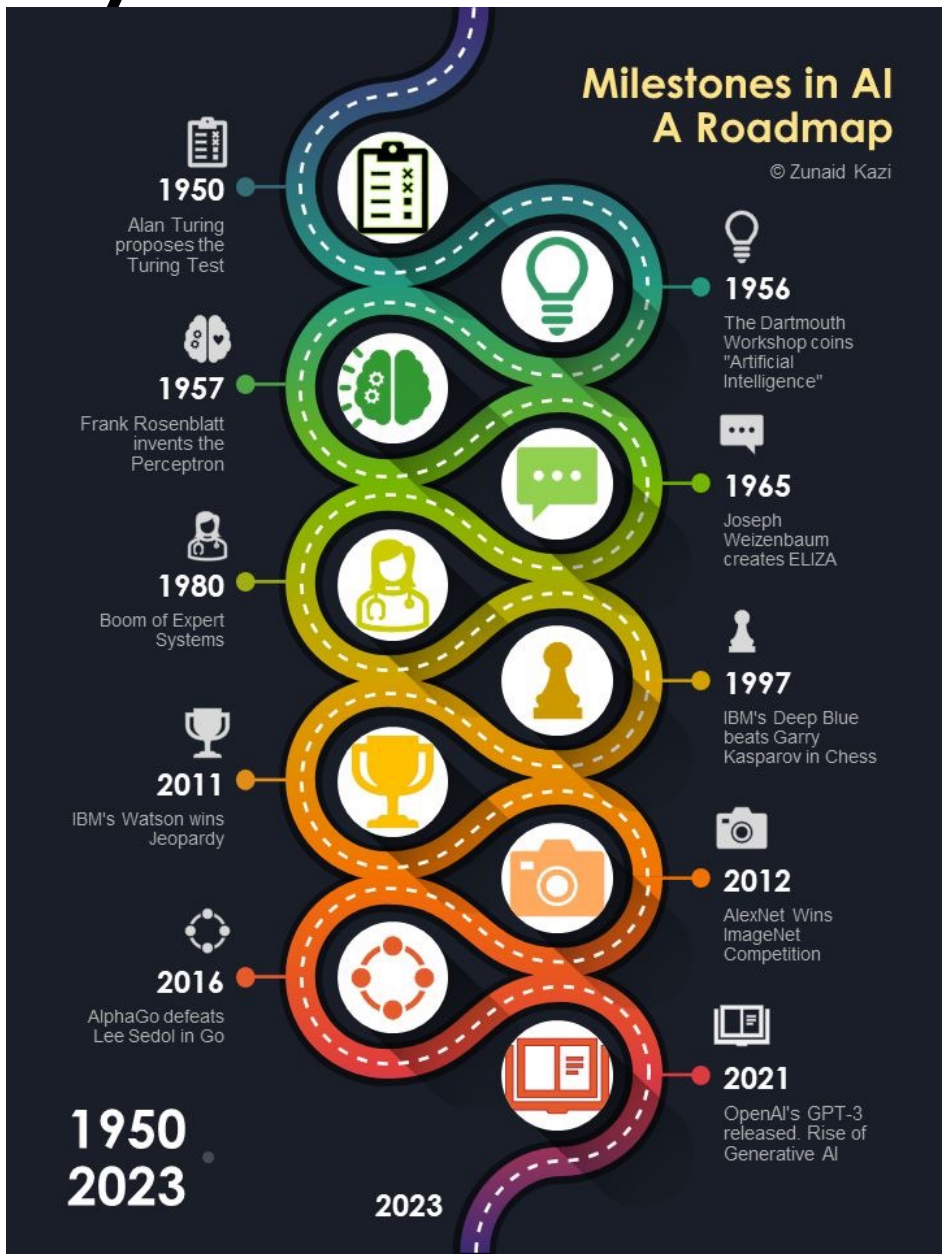




Deep Learning History

- The theory of AI is fairly old
  - The backpropagation algorithm, for example, was invented more than 40 years ago, and the first computation model for neural networks was proposed for the first time almost 80 years back.
  - AI Winters: the general public lost interest and funding for AI research dried out.
  - The history of AI has been a chain of boom-and-bust cycles. We're currently immersed in the third cycle of optimism



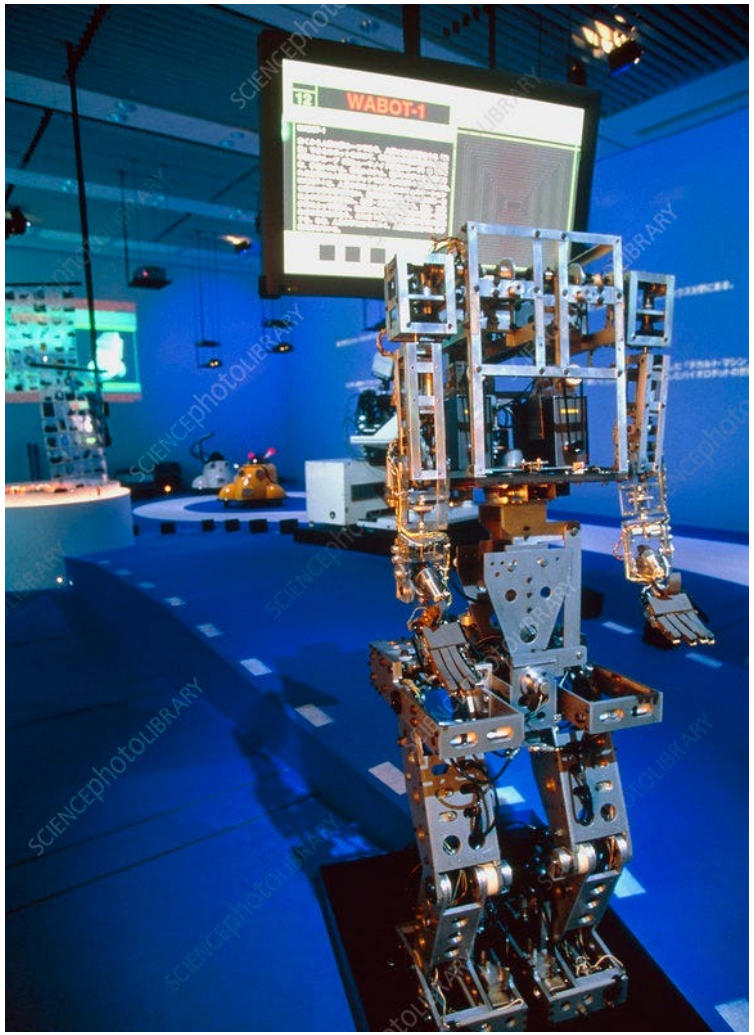


Deep Learning History

- The Birth of AI (1943–1956)
  - 1943: Warren McCulloch and Walter Pitts, proposed a model of artificial neurons
  - In 1949, Donald Hebb introduced the Hebbian learning rule
  - Year 1950: The Turing Test
  - The term “Artificial Intelligence” was officially coined in 1956 by American computer scientist John McCarthy during the Dartmouth Conference. Establishing AI as a distinct area of research and study. At this time, high-level computer languages like FORTRAN, LISP, and COBOL were also invented, fueling enthusiasm for AI research and development.
- The first AI boom took place in the late 50s and 60s when efforts focused on answering if machines could actually think
  - The search for the so-called general or strong AI
  - The invention of the **perceptron** (an early example of artificial neuron or machine learning classifier) in 1957 by Frank Rosenblatt was, for some, an unambiguous indication that general or strong AI was very close.

Deep Learning History

- Year 1969: Limitations of Perceptron was released: it could not learn to solve problems that were not linearly separable.
- Year 1972: WABOT-1 — The First Humanoid Robot
- The AI Winter of 1973-1980
  - UK Parliament analyze the state of AI research after two decades of disappointing progress in AI (and specifically in Machine Translation): Lighthill Report
  - DARPA's frustration with the Speech Understanding Research program at Carnegie Mellon University
  - DARPA shifting its focus on “mission-oriented”, actionable research which led many AI research groups to lose critical funding



Deep Learning History

- The AI in the limelight again (80s)
  - The emergence of expert systems: the developments revolved around the idea of creating knowledge bases that an inference engine (following logical rules) used to answer questions about a specific domain of knowledge, e.g. medical diagnosis.
  - Recurrent neural networks and the backpropagation algorithm (1986) were also developed.
- The Second AI Winter (1987–1993)
  - The computational power at the time hampered remarkable improvements which brought the second AI winter.
  - 1987: collapse of the LISP machine market (general-purpose computers designed to efficiently run Lisp as their main software and programming language)
  - 1988: cancellation of new spending on AI by the Strategic Computing Initiative
  - 1993: resistance to new expert systems deployment and maintenance

Deep Learning History

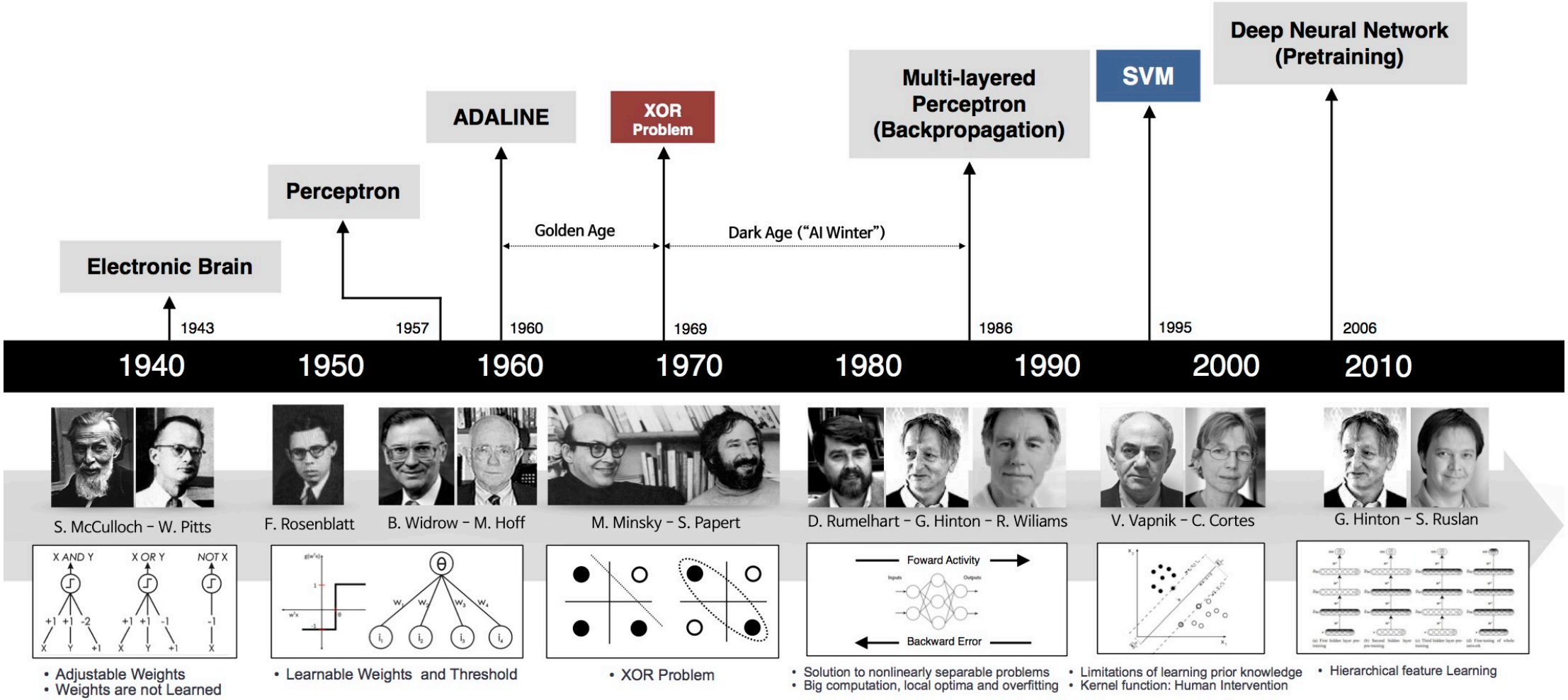
- In the 90s, a new vision brought fresh air to AI
  - Moravec's paradox is the observation in artificial intelligence and robotics that, contrary to traditional assumptions, reasoning requires very little computation, but sensorimotor and perception skills require enormous computational resources.
  - The **more difficult tasks**, however, were indeed those that we do innately, almost effortlessly, like recognising faces and moving around.
    - They advocated building intelligence “from the bottom up” and taking into account the role of “the body” in human intelligence.
    - Consequently, the quest for general AI lost momentum and efforts were redirected to solve **specific isolated problems**. This gave rise to the so-called narrow or weak AI.
  - It was also the time when advanced ML algorithms like Support Vector Machines, Random Forests, and the area of Reinforcement Learning were developed.

Deep Learning History

- 2006: birth of deep learning
  - While everybody moved to the algorithms like SVM and all, Geoffrey Hinton still believed that true intelligence would be achieved only through Neural Networks. So for almost 20 years i.e. from 1986 to 2006, he worked on neural networks.
  - And in 2006 he came up with a phenomenal paper on training a deep neural network. This is the beginning of the era known as Deep Learning. This paper by Geoffrey Hinton did not receive much popularity until 2012.

Deep Learning Milestones

- MILESTONES IN THE DEVELOPMENT OF NEURAL NETWORKS



Current “AI Spring”

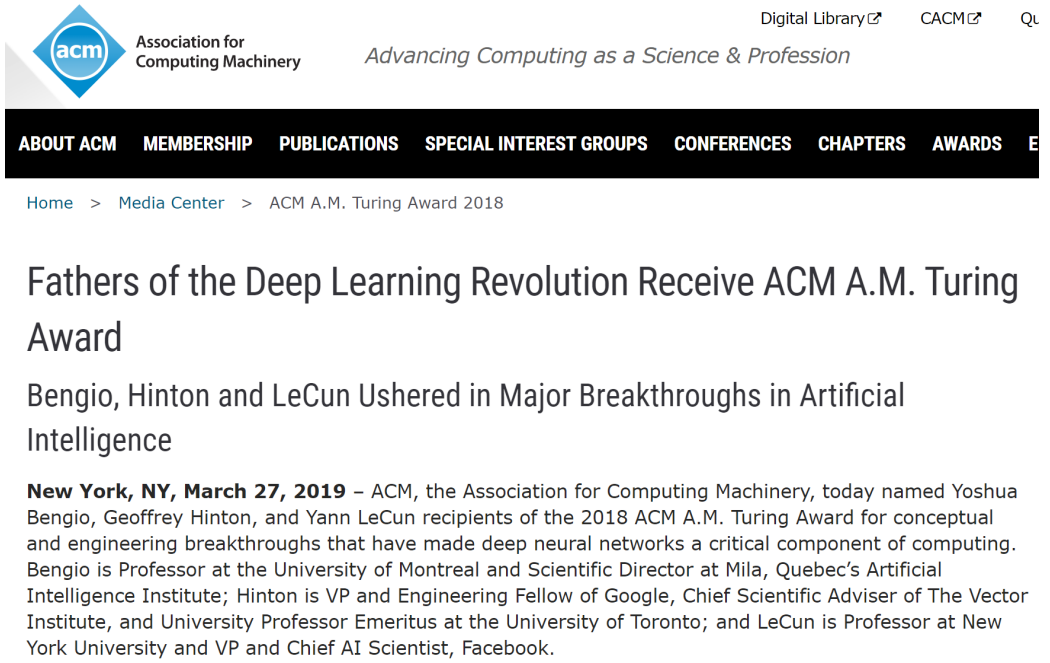
- The successes of the current "AI spring" or "AI boom" are advances in language translation (in particular, Google Translate), image recognition (spurred by the ImageNet training database) as commercialized by Google Image Search, and in game-playing systems such as AlphaZero (chess champion) and AlphaGo (go champion), and Autonomous Driving. Most of these advances have occurred since 2010.
- Year 1997: IBM Deep Blue’s Triumph
- Year 2000: Google Search uses AI
- Year 2002: AI in Homes — Roomba
- Year 2005: DARPA autonomous driving challenge: Stanford Stanley
- By 2006, AI had made its way into the business world. Companies like Facebook, Twitter, and Netflix began using AI algorithms to improve user experience, personalized content, and recommendation systems.
- Year 2006: Neural Networks into Deep Learning
- Year 2009: Introduction to ImageNet

Current “AI Spring”

- Year 2009-2015: Google self-driving car
- Year 2012: AlexNet
- Year 2012: Google Now — Predictive AI
- Year 2013: Deep Learning used to Understand words (Word2Vec)
- Year 2014: AlphaGo
- Year 2015: TensorFlow was built for DL
- Year 2016: DeepMind’s AlphaGO defeated Champion
- Year 2015: Tesla Autopilot
- Year 2018: Waymo(Self Driving Car)
- Year 2022: the release of OpenAI's AI chatbot ChatGPT has reinvigorated the discussion about artificial intelligence and its effects on the world.
- New AI winter could be triggered by overly ambitious or unrealistic promises by prominent AI scientists or overpromising on the part of commercial vendors.

Deep Learning

- Fathers of the Deep Learning Revolution Receive ACM A.M. Turing Award
  - Bengio, Hinton and LeCun Ushered in Major Breakthroughs in Artificial Intelligence
  - https://www.acm.org/media-center/2019/march/turing-award-2018
  - **Yoshua Bengio** is a Professor at the University of Montreal
  - **Geoffrey Hinton** is VP and Engineering Fellow of Google, Chief Scientific Adviser of The Vector Institute and a University Professor Emeritus at the University of Toronto.
  - **Yann LeCun** is Silver Professor of the Courant Institute of Mathematical Sciences at New York University, and VP and Chief AI Scientist at Facebook



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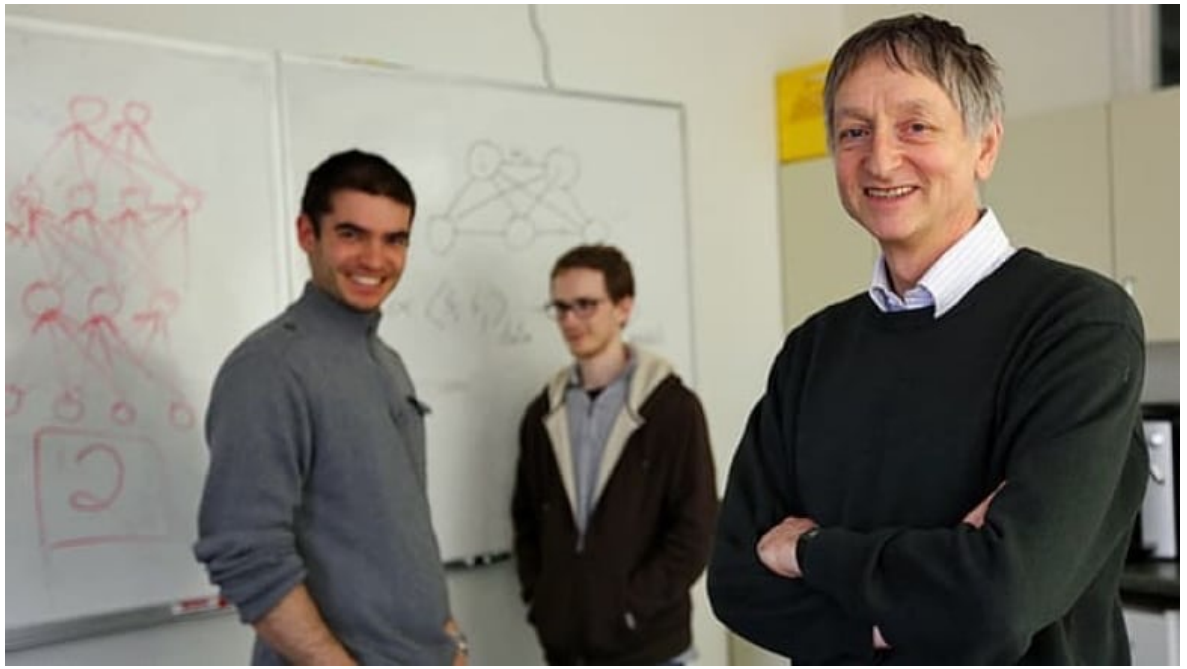
Fathers of the Deep Learning Revolution Receive ACM A.M. Turing Award

Bengio, Hinton and LeCun Ushered in Major Breakthroughs in Artificial Intelligence

New York, NY, March 27, 2019 – ACM, the Association for Computing Machinery, today named Yoshua Bengio, Geoffrey Hinton, and Yann LeCun recipients of the 2018 ACM A.M. Turing Award for conceptual and engineering breakthroughs that have made deep neural networks a critical component of computing. Bengio is Professor at the University of Montreal and Scientific Director at Mila, Quebec's Artificial Intelligence Institute; Hinton is VP and Engineering Fellow of Google, Chief Scientific Adviser of The Vector Institute, and University Professor Emeritus at the University of Toronto; and LeCun is Professor at New York University and VP and Chief AI Scientist, Facebook.

AlexNet won the ImageNet challenge in 2012

- Geoffrey Hinton and his students
  - **Ilya Sutskever** (MS 2007, Phd 2013)
    - In 2012, Sutskever built AlexNet in collaboration with Hinton and Alex Krizhevsky.
  - Krizhevsky and Sutskever joined Hinton's new research company DNNResearch, a spinoff of Hinton's research group. In March 2013, Google acquired DNNResearch for $5 million, shortly after winning the contest (after awarding the team of three $600,000 for their work in neural networks and language and image processing) – Google Brain
  - Baidu, Microsoft, DeepMind (acquired by Google in 2014) all want to buy



a University of Toronto startup that studies neural networks. The one-year-old company is launched by computer science professor Geoffrey Hinton (right) and two of his graduate students, Alex Krizhevsky and Ilya Sutskever (left).

AlexNet won the ImageNet challenge in 2012

- Geoffrey Hinton and his students
  - Hinton retired from Google in 2023.
  - Alex left Google in September 2017 after losing interest in the work, to work at the company Dessa in support of new deep-learning techniques. He is the creator of the CIFAR-10 and CIFAR-100 datasets
  - At the end of 2015, Ilya Sutskever left Google to become cofounder and chief scientist of the newly founded non-profit organization OpenAI
    - The actual collected total amount of contributions of OpenAI was only $130 million until 2019, $100 million from Musk.
    - Sutskever was formerly one of the six board members of the non-profit entity which controls OpenAI
    - In 2023, people speculated that the firing of Sam Altman in part resulted from a conflict over the extent to which the company should commit to AI safety.
    - Following these events, Sutskever stepped down from the board of OpenAI

Why Learning Deep Learning

- **Career Opportunities**: The demand for deep learning expertise is high, leading to rewarding career opportunities in research, development, and implementation across industries.
- **Advancements in AI**: Deep learning is at the forefront of advancements in artificial intelligence, shaping the evolution of AI technologies and capabilities.
- **Wide Applicability**: Deep learning is applicable to various domains, including computer vision, natural language processing, robotics, and more. This versatility allows you to address diverse challenges.
- **Skill Relevance**: As AI technologies become more pervasive, understanding deep learning is crucial for professionals across fields to stay relevant and harness AI's potential.

Why Learning Deep Learning

- **Unprecedented Performance**: Deep learning has shown exceptional performance across a wide range of tasks, from image and speech recognition to natural language understanding. Its ability to handle complex patterns and large datasets makes it a powerful tool in various domains.
- **Data Abundance**: In the era of big data, deep learning thrives by leveraging vast amounts of data to uncover insights, make predictions, and improve decision-making.
- **Automation and Efficiency**: Deep learning can automate tasks that traditionally required manual effort, leading to increased efficiency and reduced human error. This is particularly valuable in industries like healthcare, manufacturing, and finance.
- **Innovation**: Deep learning has fueled breakthroughs in fields such as self-driving cars, personalized medicine, and recommendation systems. Learning these techniques equips you to contribute to cutting-edge innovations.

Learning Objective

- Demonstrate a comprehensive understanding of deep neural networks, their architecture, and principles.
- Apply various deep learning algorithms and models to solve problems in different domains.
- Analyze and evaluate the performance of deep learning models using appropriate metrics and techniques.
- Implement, train, and fine-tune deep neural networks using popular deep learning frameworks.
- Collaborate effectively in both individual and group settings to tackle real-world deep learning challenges. Demonstrate ethical considerations and awareness of potential biases when working with deep learning applications.

Grading

Quiz (5%)
In-class mini-quiz

Homework&
Assignments (20%)

Midterm Exam (15%)+Final Exam (30%) = (45%)

Team Project (30%)

Grading policy for Homework Assignments

- Homework assignments will be assessed utilizing the EMRN rubrics, a four-level specification grading system.
  - "E" (excellent) and "M" (meets expectations) scores indicate successful completion (full marks). "R" (needs revision) and "N" (not assessable) scores correspond to lower marks, subject to assignment specifications.
  - Each homework assignment will have one revision period available.
  - Attaining an "E" does not affect the overall grade (full marks). However, students aiming for a final letter grade of "A" or "A+" must secure at least one "E" in homework assignments.
  - **Students got “E” in the homework, needs present their solution in the class.**

Determination of Grades

- The final grades will be calculated according to the final weighted score of all the assignments (exams, homework assignments, projects). The ABCDE grades will be determined by a set of thresholds that meets appropriate distribution and all required policies, which means what you perceive as a low score by summing up all your raw points will not necessarily prevent you from getting a good grade.
- No extra credit options.
- Assignment/exam re-evaluation request will not be considered unless the evaluation process is wrong.
- Peer ratings and comments will be considered for the project scores.
- The report will not be accepted when the Canvas assignment is closed. The assignment will receive zero grade.
- For turnitin-enabled assignment, the format of the submission should be acceptable to turnitin (such as WORD and PDF); otherwise the reports will be considered late and be penalized as above.

Classroom Protocol

- Students are responsible for lecture, book sections, project presentations, and any instructions given in the class.
- Avoid disturbing the class.
  - Students causing disruption in the class for other activities will be asked to leave the class and will be referred to the Judicial Affairs Officer of the University for disrupting the class after repeated offenses.
- Students should attend all meetings of the class.
  - Student Excused Absences: https://www.sjsu.edu/senate/docs/S22-2.pdf
  - Student shall notify the instructor in writing

The following are situations when an excused absence could become an incomplete or a course withdrawal. Students should consult with their instructor and advisor to determine the most suitable course of action.

- If the absence exceeds two consecutive weeks of class time.
- If the student returns to the class and attempts in good faith to complete the missing work but is overwhelmed and cannot finish.

Thank You

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