

**Instituto de
Computação**

UNIVERSIDADE ESTADUAL DE CAMPINAS



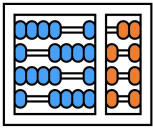
Capacitação profissional em tecnologias de Inteligência Artificial

Introduction to Artificial Intelligence

Prof. Edson Borin

<https://www.ic.unicamp.br/~edson>

Institute of Computing - UNICAMP



Introduction to Artificial Intelligence



What is Artificial Intelligence?



What is Artificial Intelligence?

AI in the Eyes of the Society

- AI can predict the effectiveness of breast cancer chemotherapy
- Demand for AI Programmers: up 35 Times! Salary: Top 1!
- 50% Jobs Will be Replaced by AI in the future
- Art by Artificial Intelligence: Artwork created by computers sells for \$430,000

News

- AI Applications
- AI industry outlook
- Challenges faced by AI
- ...

- The Terminator
- 2001: A Space Odyssey
- The Matrix
- I, Robot
- Blade Runner
- ...

Movies

- AI Control over human beings
- Fall in love with AI
- Self-awareness of AI
- ...

- Google search
- YouTube, Amazon, Netflix
- Siri, Alexa
- Waymo
- ...

Applications in daily life

- Web search engines
- Recommendation Systems
- Understanding Human speech
- Self-driving cars
- ...



What is Artificial Intelligence?

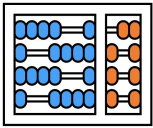


AI in the Eyes of Researchers

"I propose to consider the question `Can machines **think**?'"
– Alan Turing 1950

The branch of computer science concerned with making computers **behave** like humans
– John McCarthy 1956

The science of making machines do things that would require **intelligence** if done by men
– Marvin Minsky



What is Artificial Intelligence?

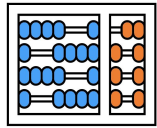


In "*Frames of Mind: The Theory of Multiple Intelligences*" (1983) and its sequels, Howard Gardner proposed several kinds of intelligence

- Linguistic/Verbal
- Logical/Mathematical
- Visual/Spatial
- Bodily/Kinesthetic
- Musical/Rhythmic and harmonic
- Interpersonal/Social
- Intrapersonal/Introspective
- Naturalistic

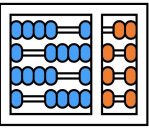


What is Artificial Intelligence?



What is Artificial Intelligence?

- Several definitions over the last few decades...
- John McCarthy
 - 1956: The branch of computer science concerned with making computers **behave** like humans
 - 2004: It is the science and engineering of making **intelligent** machines, especially computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable



What is Artificial Intelligence?



Artificial Intelligence

- *"Russel and Norvig: AI - A modern approach (3rd ed.)"*

Human approach

Ideal approach

Think

Systems that think like humans

“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)

Systems that think 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)

Act

Systems that act like humans

“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)

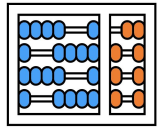
Systems that act rationally

“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)



What is Artificial Intelligence?

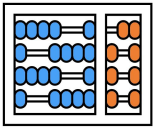


Main schools of AI

- Symbolism
- Connectionism
- Behaviorism



What is Artificial Intelligence?

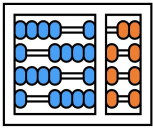


Schools of Thought: **Symbolism**

- Cognitive process of humans consists of the inference and processing of symbols
 - As a consequence, computers should be able to simulate human intelligent activities
- Knowledge and concepts can be represented by symbols and manipulated in an automated way by reasoning programs.
 - Part of AI that is concerned with thinking, and how thinking contributes to intelligent behavior.



What is Artificial Intelligence?

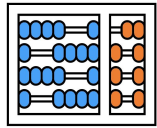


Schools of Thought: **Connectionism**

- Approach based on how the human brain works at the neural level.
 - Concepts are represented by a set of numbers, vectors, matrices, or tensors.
- Typical example: Artificial Neural Network



What is Artificial Intelligence?

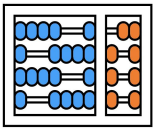


Schools of Thought: **Behaviorism**

- Intelligence has no connection with knowledge, representation, or inference.
 - AI can evolve like human intelligence
- Intelligence depends on perception and reaction
 - Intelligent agents evolve through the interaction with surround environment and can adapt to the environment better and better



What is Artificial Intelligence?



Types of AI

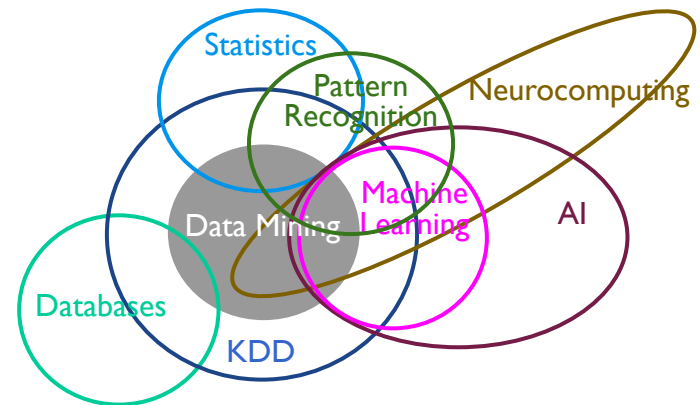
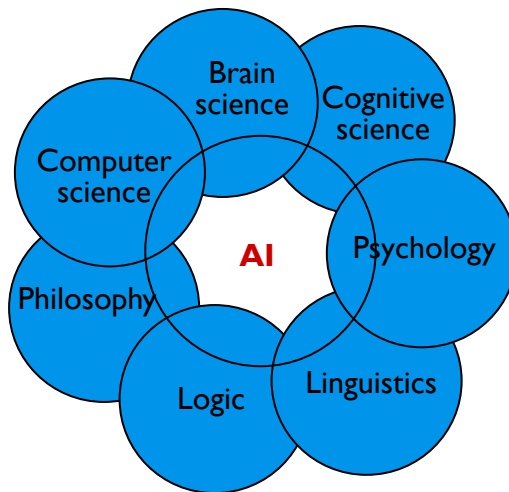
- **Weak AI:** is about developing machines that can act as if they were intelligent.
- **Strong AI:** about the possibility to create intelligent machines that can accomplish reasoning problem-solving tasks.
 - Conscious and self-aware machines, capable of thinking independently and to produce the best solutions to the problems.
 - Passing the Turing Test does not imply that the AI entity is thinking!



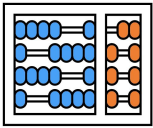
What is Artificial Intelligence?

Artificial Intelligence

- New technical science that studies and develops theories, methods, techniques, and application systems for simulating and extending human intelligence.
- Interdisciplinary subject

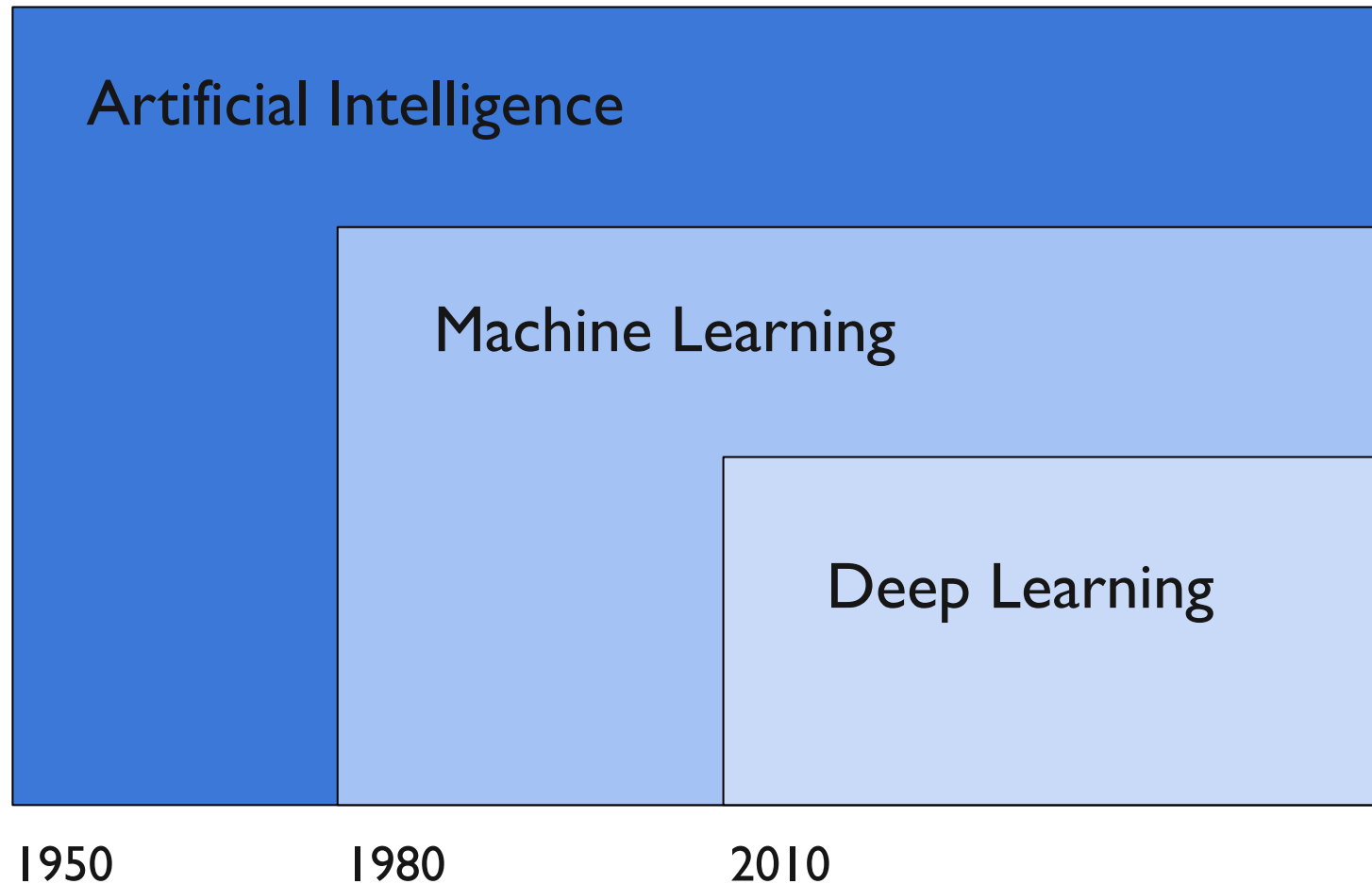


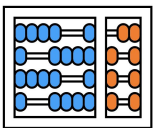
AI Development report 2020



What is Artificial Intelligence?

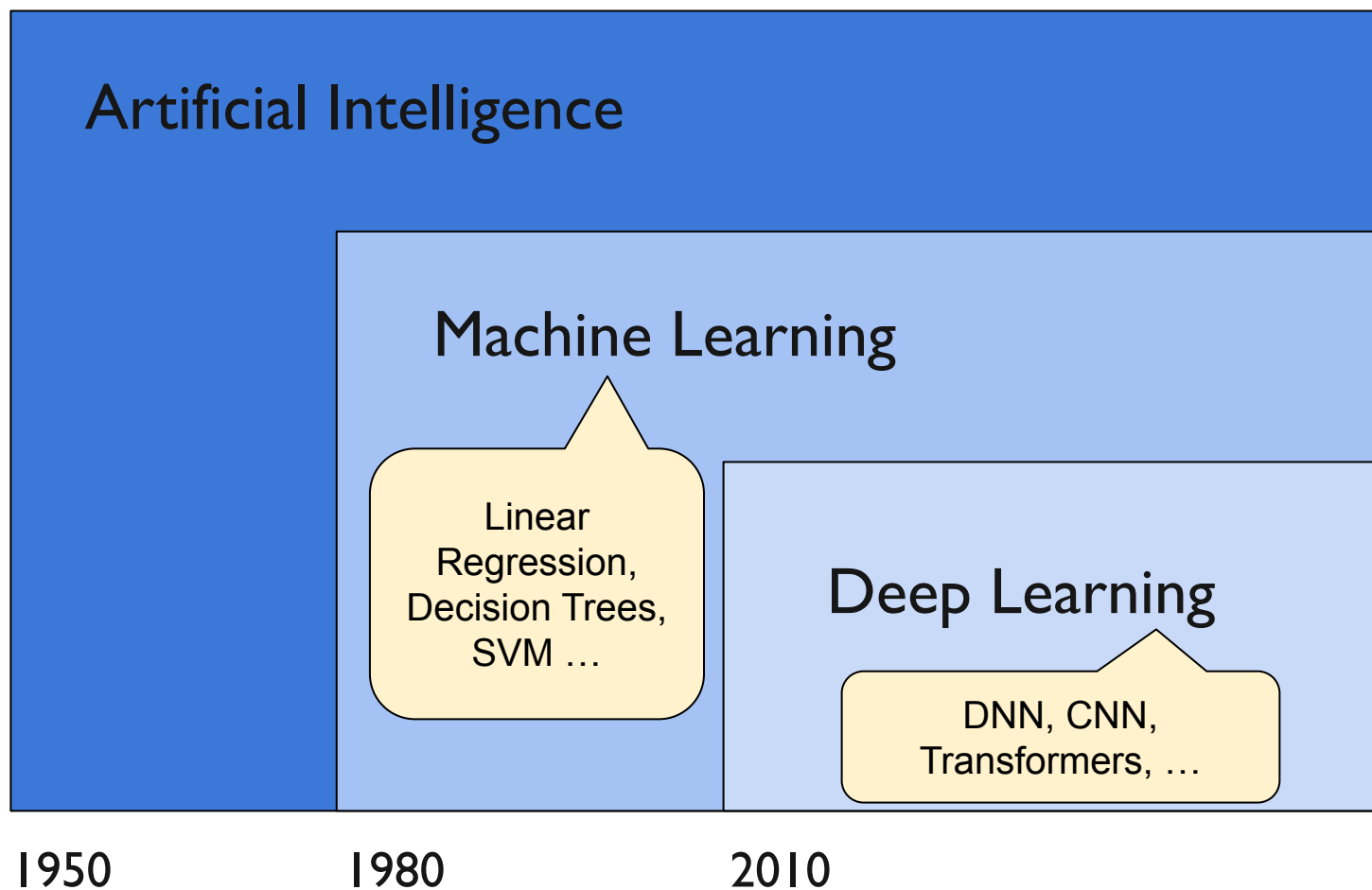
AI vs Machine Learning vs Deep Learning

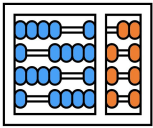




What is Artificial Intelligence?

AI vs Machine Learning vs Deep Learning





Introduction to Artificial Intelligence

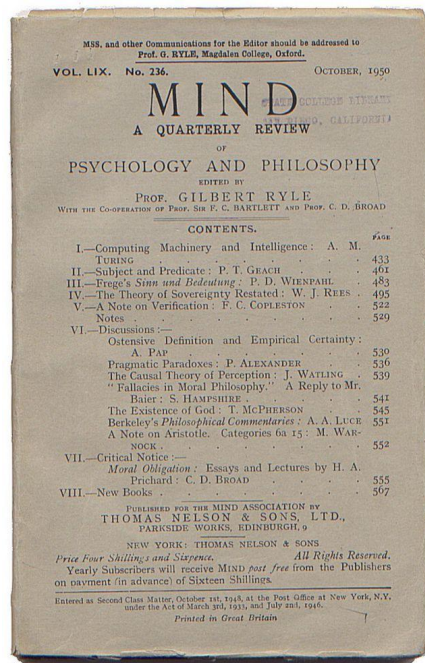


Artificial Intelligence History

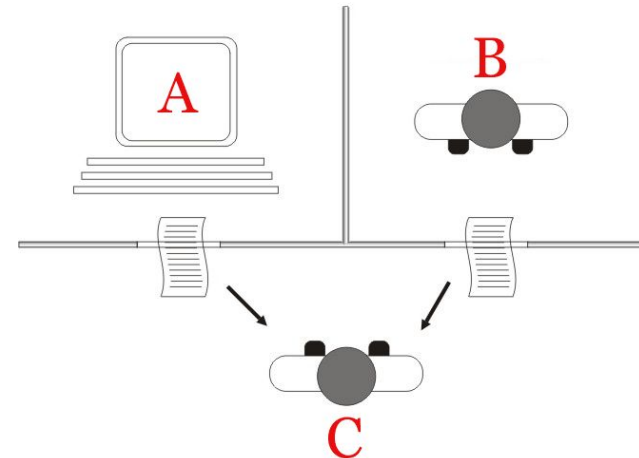


Artificial Intelligence History

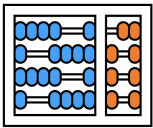
- 1950 – Dawn of AI
 - Alan Turing - Computing Machinery and Intelligence, 1950.



Imitation Game (a.k.a Turing Test)



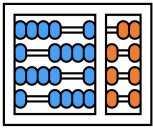
Wikipedia - J. A. S. Margallo - CC BY 2.5



Artificial Intelligence History



- 1956 - 1976: First Booming Period
 - 1956: Dartmouth Conference - The birth of AI
 - 6-8 week long workshop with a few selected researchers
 - John McCarthy coins the term 'artificial intelligence' at the first-ever AI conference
 - Several AI research groups emerged in the USA
 - Carnegie-RAND: Allen Newell and Herbert Simon
 - MIT: Marvin Lee Minsky and John McCarthy
 - IBM: Arthur Samuel's group
 - 1956: Machine Learning term was coined by Arthur Samuel
 - Arthur Samuel's group wrote the famous checkers-playing program, which learned how to play checkers and had its performance improved after several rounds.



Artificial Intelligence History



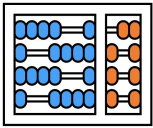
- **1956 - 1976: First Booming Period**
 - **1957: Pattern Recognition**
 - C.K. Chow proposed to adopt statistical decision theory to tackle pattern recognition tasks.
 - Invention of the perceptron (Frank Rosenblatt)
 - **1958: McCarthy developed LISP**
 - Dominant programming language for AI in the following decades
 - **1966: Pattern Matching**
 - ELIZA (MIT), the first conversation program in the world
 - Used pattern matching techniques to perform conversation



Artificial Intelligence History

- 1956 - 1976: First Booming Period

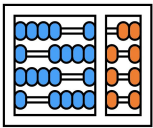
- 1957~1967: Perceptron machine
 - Psychologist Frank Rosenblatt implemented a perceptron machine to recognize images
 - First simulated on an IBM 704 computer
 - Then, he built the Mark I Perceptron, the first computer based on a neural network that 'learned' through trial and error
- 1969: Marvin Minsky and Seymour Papert published a book titled Perceptrons, which becomes both the landmark work on neural networks and, at least for a while, an argument against future neural network research projects.



Artificial Intelligence History



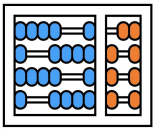
- 1970's – First AI Winter
 - Over-optimistic projections failed to be fulfilled as promised
 - Failure of several projects, such as machine translation
 - 1969: Marvin Minsky and others demonstrated the limitations of perceptrons in the XOR problem.
- 1973: AI suffered from severe criticism.
 - Including by the scientific community.
 - Fund of AI was decreased in general!
- AI developed slowly



Artificial Intelligence History



- 1980-1987 – Second booming Period
 - 1980: XCON - Complete Expert System developed by CMU was officially put into use => Huge success!
 - 60% of Fortune 500 companies embark on the development of Expert Systems
 - 1986: VaMoRs, developed by Bundeswehr University in Munich, was a Mercedes-Benz van with a computer and sensors to control the steering wheel, accelerator and brake => First self-driving car
 - Funding boomed from a few million dollars in 1980 to billions of dollars in 1988 (Russel and Norvig - AI: A Modern Approach)



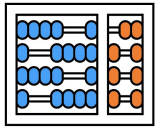
Artificial Intelligence History



- 1987-1997 – Second AI Winter
 - 1987: crash of sales market of LISP machine hardware
 - Hardware market collapsed and governments and institutions all over the world stopped investing in AI research.
 - Research on artificial intelligence algorithm theory had a slow progress, but
 - AI technology became gradually and deeply integrated with computer and software technologies
 - Work on machine learning shifts from a knowledge-driven approach to a data-driven approach



Artificial Intelligence History



- 1997-2010 – Recovery Period
 - 1995: Richard Wallace developed the chatbot A.L.I.C.E (Artificial Linguistic Internet Computer Entity), which is able to optimize the contents and enrich its datasets automatically through the Internet.

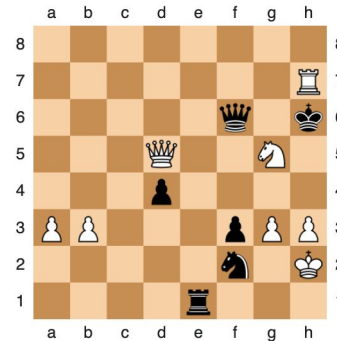


Artificial Intelligence History

- 1997-2010 – Recovery Period
 - 1997 – IBM's Deep Blue system defeated Garry Kasparov (world chess champion) on six-game chess matches



Wikipedia - James the photographer - CC BY 2.0

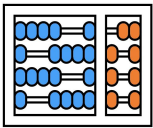


Wikipedia - S.M.S.I., Inc. - Owen Williams, The Kasparov Agency - CC BY-SA 3.0



Artificial Intelligence History

- 1997-2010 – Recovery Period
 - 2006 – Deep Learning technology proposed



Artificial Intelligence History



- 2010-Present – Rapid Growth Period
 - 2011: IBM's Watson system defeated two human champions on the quiz show *Jeopardy*
 - The system demonstrated outstanding natural language processing capabilities and powerful knowledge database



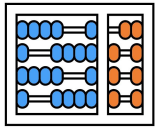


Artificial Intelligence History

- 2010-Present – Rapid Growth Period
 - 2011: A convolutional neural network (CNN) wins the German Traffic Sign Recognition competition with 99.46% accuracy (vs. humans at 99.22%)
 - Start of the machine getting the power of vision
 - 2012: A convolutional neural network designed by researchers at the University of Toronto achieve an error rate of only 16% in the ImageNet Large Scale Visual Recognition Challenge
 - Significant improvement over the 25% error rate achieved by the best entry the year before



Artificial Intelligence History



- 2010-Present – Rapid Growth Period
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Data-hungry deep learning methods started to dominate accuracy benchmarks



Artificial Intelligence History

- 2010-Present – Rapid Growth Period
 - 2014: Alexa was born
 - 2014: Tesla Autopilot - Model S cars capable of lane control with autonomous steering, braking, and speed limit adjustment based on signals image recognition

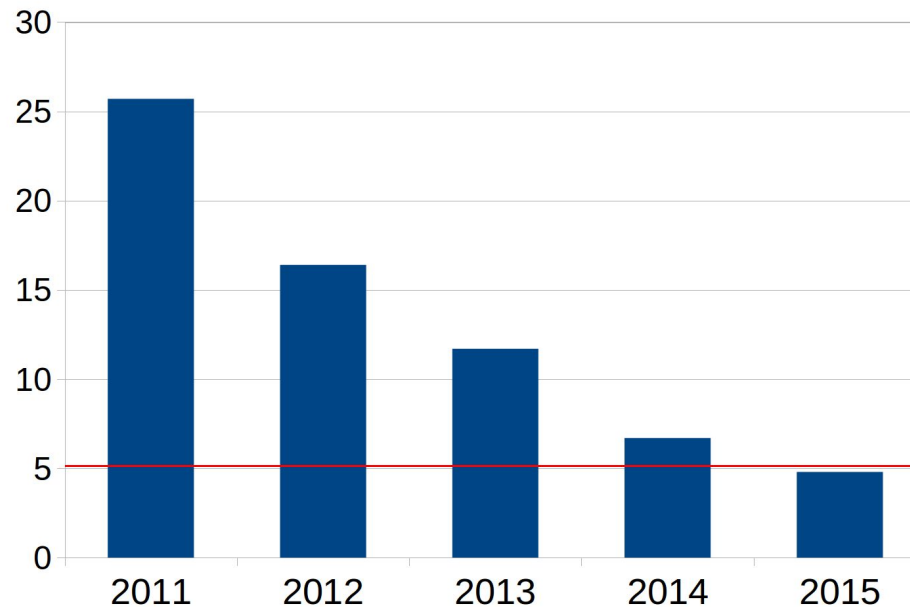


Source: David Paul Morris—Bloomberg/Getty Images



Artificial Intelligence History

- 2010-Present – Rapid Growth Period
 - 2015: Microsoft and Google deep-learning based programs beat humans at image recognition challenge



Source: Wikipedia - CC0



Artificial Intelligence History

- 2010-Present – Rapid Growth Period
 - 2015: Microsoft and Google deep-learning based programs beat humans at image recognition challenge
 - 2016/2017: Google DeepMind's AlphaGo program defeated Go world champion Lee Sedol (South Korea)



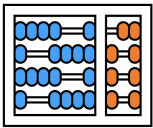
Source: Youtube



Artificial Intelligence History

- 2010-Present – Rapid Growth Period

- Deep-learning specialized frameworks and HW
 - 2015: TensorFlow released by Google
 - 2016: PyTorch released by Facebook
 - 2016: TPU was released by Google
- 2016: Google Personal assistant released
- 2018: Facebook-Cambridge Analytica data scandal
 - Major political scandal: Cambridge Analytica had harvested data from millions of Facebook accounts for political advertising purposes
- 2018: Deep-fakes
- ...



Artificial Intelligence History



- 2010-Present – Rapid Growth Period
 - 2022-Nov: ChatGPT launched (<https://openai.com/blog/chatgpt/>)
 - Built on top of OpenAI's GPT-3 family of large language models.

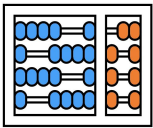
BO

What are the main advances in AI in the last three years?



There have been many significant advances in artificial intelligence (AI) in the last three years. Some of the most notable ones are:

1. **Advancements in Deep Learning:** Deep learning is a subset of AI that involves training deep neural networks to learn from large amounts of data. In recent years, deep learning has led to major advances in computer vision, natural language processing, and speech recognition. New techniques such as generative adversarial networks (GANs) and reinforcement learning have also been developed, enabling new applications such as realistic image synthesis and autonomous decision-making.



Artificial Intelligence History



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 - Built on top of OpenAI's GPT-3 family of large language models.

BO

What are the main advances in AI in the last three years?

2. Progress in Natural Language Processing: Natural language processing (NLP) is an area of AI that focuses on the interactions between computers and humans using natural language. In the last three years, there has been a lot of progress in NLP, including the development of models such as BERT, GPT-2, and GPT-3, which have significantly improved the accuracy of language translation, text summarization, and language generation.



Artificial Intelligence History

- 2010-Present – Rapid Growth Period
 - 2022-Nov: ChatGPT launched (<https://openai.com/blog/chatgpt/>)

AI by AI

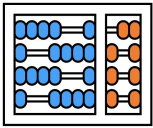
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What is AI?



AI stands for Artificial Intelligence. It is a broad field of computer science and engineering that aims to create machines that can perform tasks that would normally require human intelligence, such as understanding natural language, recognizing images and sounds, making decisions, and solving problems.

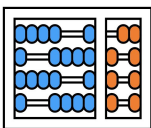




Introduction to Artificial Intelligence



Artificial Intelligence Enabling Technologies



AI Enabling Technologies



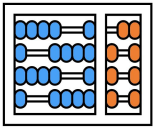
Overview of technologies enabling recent AI advances

- **AI Algorithms**

- **Machine learning models:** Neural networks, SVM, KNN, Bayesian algorithm, Decision Tree, ensemble learning, *etc.*
- **Deep learning models:** MLP, CNN, RNN, LSTM, Transformers, BERT, *etc.*
- **ML training algorithms:** Gradient descent, Newton's method, conjugate gradient, *etc.*

- **Software toolchains – ML/DL Frameworks**

- Several of the previously mentioned algorithms are coded and made available for use on ML/DL Frameworks => Ease of use
- Code generated by these frameworks are optimized to run on modern processors (including CPUs, GPUs, TPUs, and NPUs)

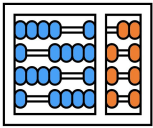


AI Enabling Technologies



Overview of technologies enabling recent AI advances

- Computing devices
 - Newer CPUs and GPUs are becoming more and more especilized to support the efficient execution of popular ML/DL frameworks
 - Specialized processing units (e.g., TPUs and NPUs) are being developed to optimize even further the execution of ML/DL code!

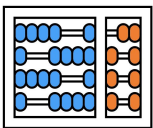


AI Enabling Technologies



Overview of technologies enabling recent AI advances

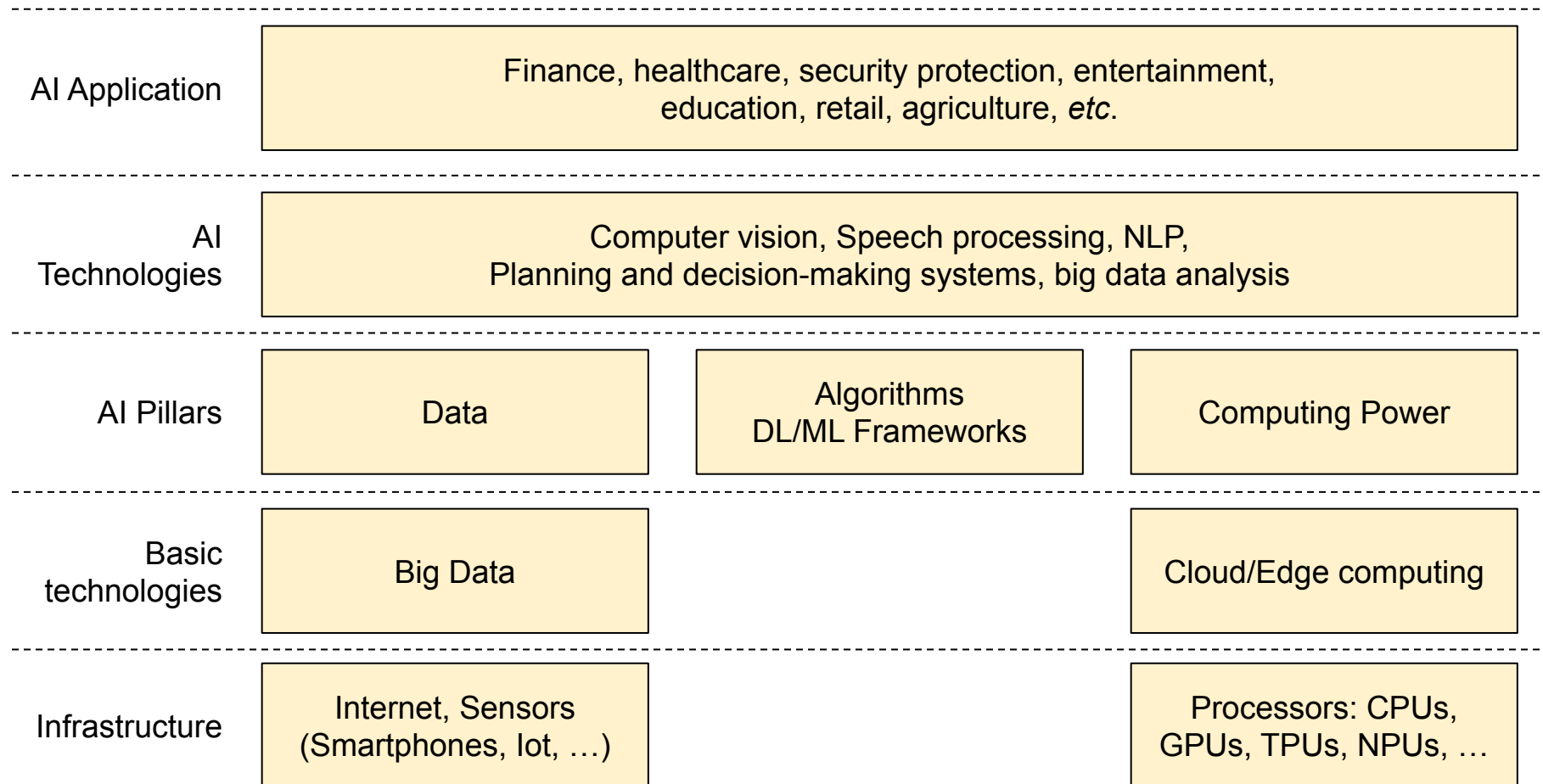
- Data storage/collection technologies
 - Modern smartphone/wearable sensors are collecting more and more data from users
 - IoT sensors are collecting more and more data from people and physical/real-world devices (e.g. industry equipments, car engines, etc.)

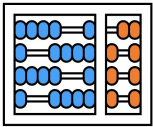


AI Enabling Technologies

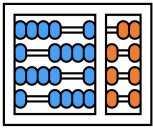


Overview of technologies enabling recent AI advances





Artificial Intelligence Applications

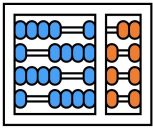


Artificial Intelligence Applications



AI Applications:

- Smart city
- Smart healthcare
- Smart retail
- Smart security
- Smart home
- Smart driving

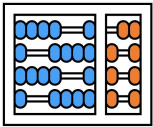


Artificial Intelligence Applications



Smart cities

- Environment
- Mobility
- Local economy
- Supply chain
- Government
- ...

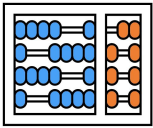


Artificial Intelligence Applications



Smart healthcare

- Drug discovery: quick development of personalized medicines by AI assistantes
- Health management: nutrition, and physical/mental health management
- Assistance for medical research: assistance for biomedical researchers in research
- Virtual assistant: electronic voice medical records, intelligent guidance, intelligent diagnosis, and medicine recommendation
- Medical imaging: medical image recognition, image marking, and 3D image reconstruction
- Assistance for diagnosis and treatment: diagnostic robot
- Disease risk forecast: disease risk forecast based on gene sequencing



Artificial Intelligence Applications



Smart home

- Comfort
- Security
- Energy Efficiency
- Entertainment
- ...



Artificial Intelligence Applications

Smart driving

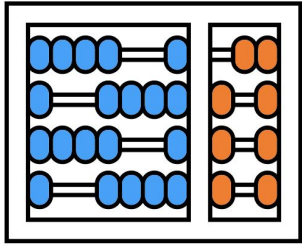
- Advanced Driving Assistance Systems
- Autonomous driving vehicles



Artificial Intelligence Applications

Key AI Technologies in these scenarios

- Computer Vision
- Speech Processing
- Natural Language Processing



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UNIVERSIDADE ESTADUAL DE CAMPINAS



Capacitação profissional em tecnologias de Inteligência Artificial

Introduction to Artificial Intelligence

Prof. Edson Borin

<https://www.ic.unicamp.br/~edson>

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