

Artificial Intelligence (IT3160E)

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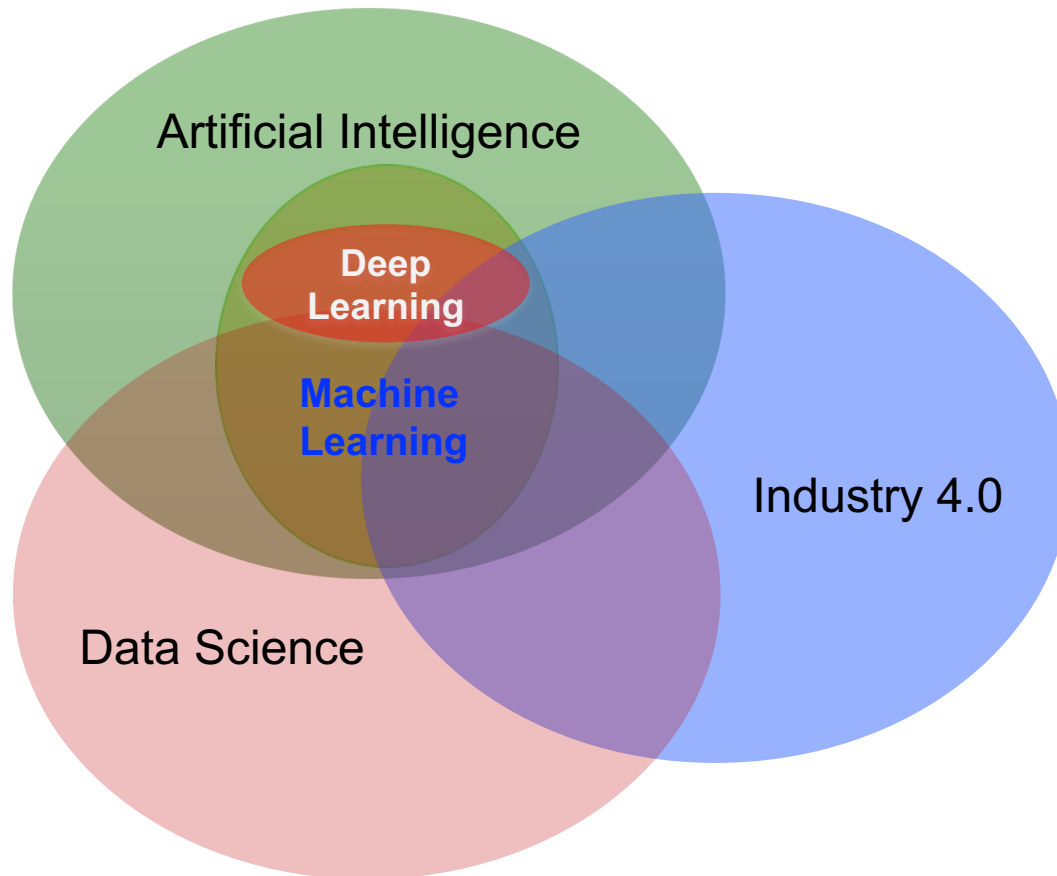
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2022

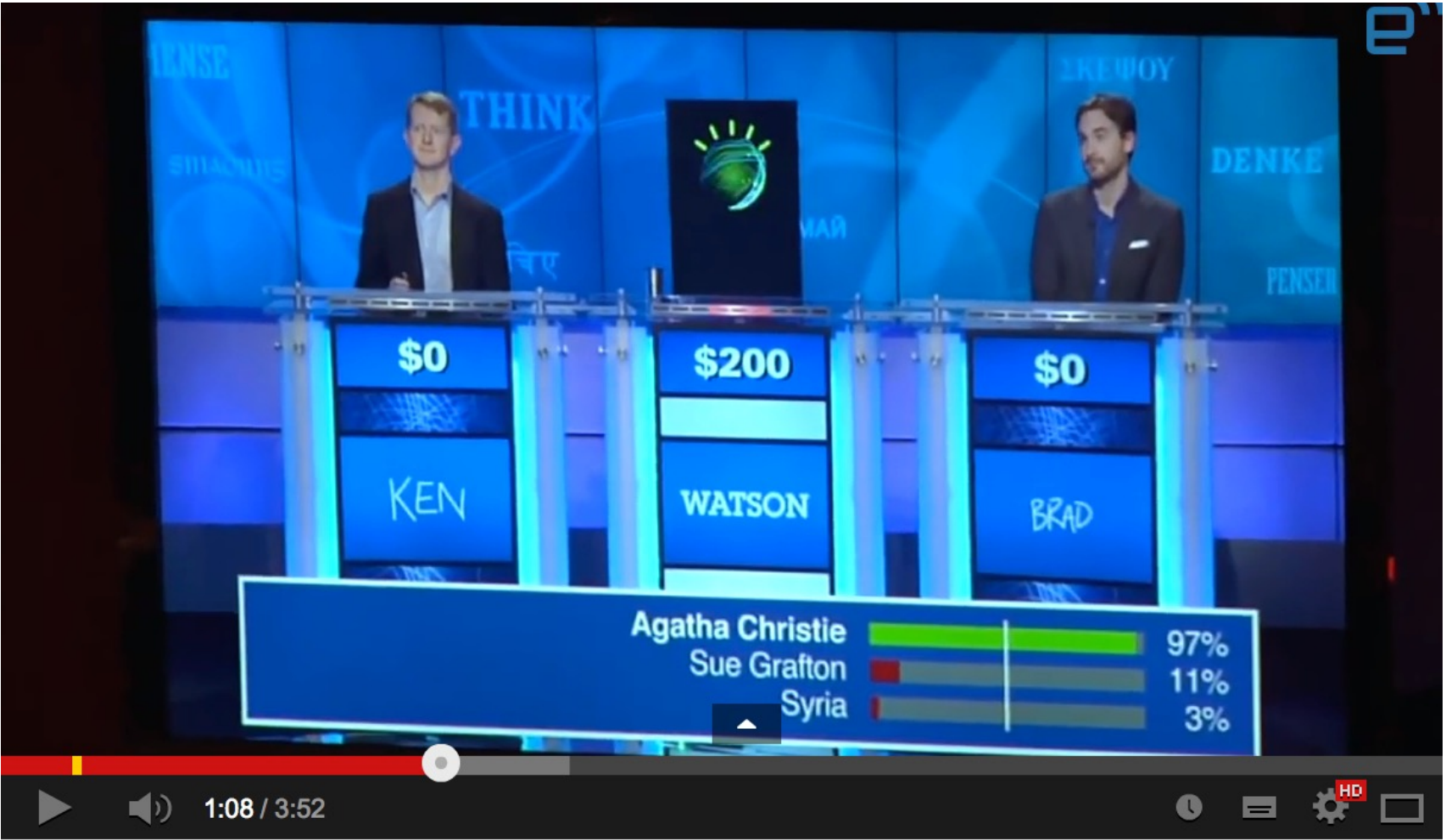
Content:

- **Introduction of Artificial Intelligence**
 - **Definition**
 - **Foundation fields**
 - **Brief history**
 - **Successful practical applications**
 - **Software frameworks and libraries**
- Intelligent agent
- Problem solving: Search, Constraint satisfaction
- Logic and reasoning
- Knowledge representation
- Machine learning

AI & DS & Industry 4.0



Some successes: Watson (2011)

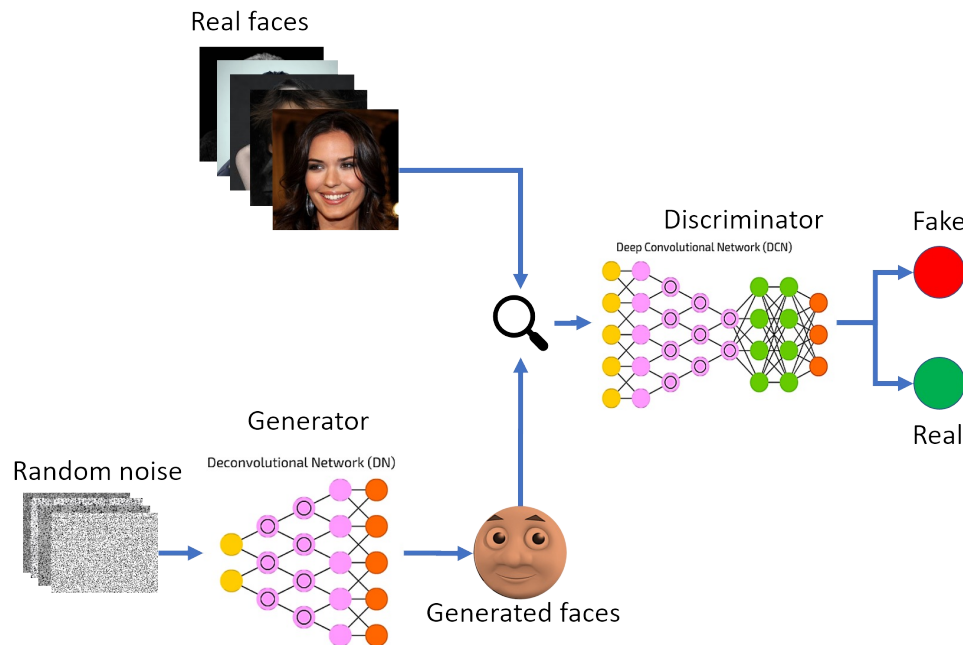


IBM's Watson Supercomputer Destroys Humans in Jeopardy

Some successes: GAN (2014)

- ❖ Enable **imagination** for a machine

Ian Goodfellow

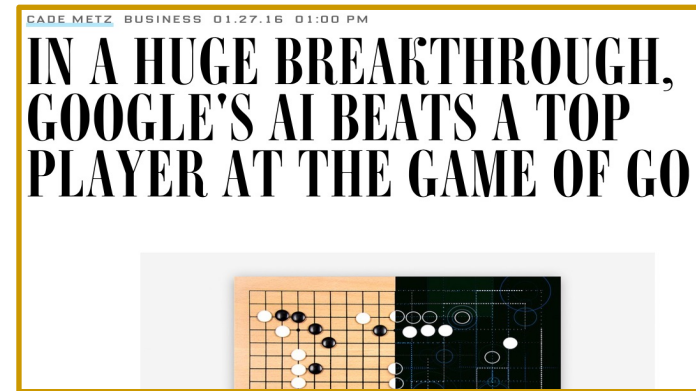


Artificial faces



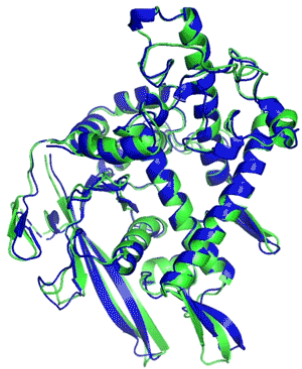
Some successes: AlphaGo (2016)

- AlphaGo of Google has just beaten a top player at Go (cờ vây), 3/2016
 - Go is a 2500 year-old game.
 - Go is one of the most complex games.
- AlphaGo learns from 30 millions human moves, and plays itself to find new moves.
- It beat Lee Sedol (World champion)
 - <http://www.wired.com/2016/03/two-moves-alphago-lee-sedol-redefined-future/>
 - <http://www.nature.com/news/google-ai-algorithm-masters-ancient-game-of-go-1.19234>



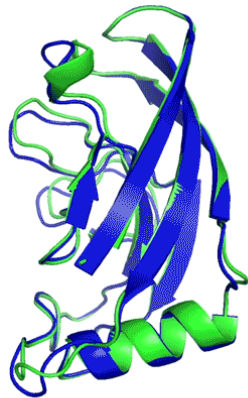
Some successes: AlphaFold (2021)

■ Accurate prediction of protein folding



T1037 / 6vr4
90.7 GDT

(RNA polymerase domain)



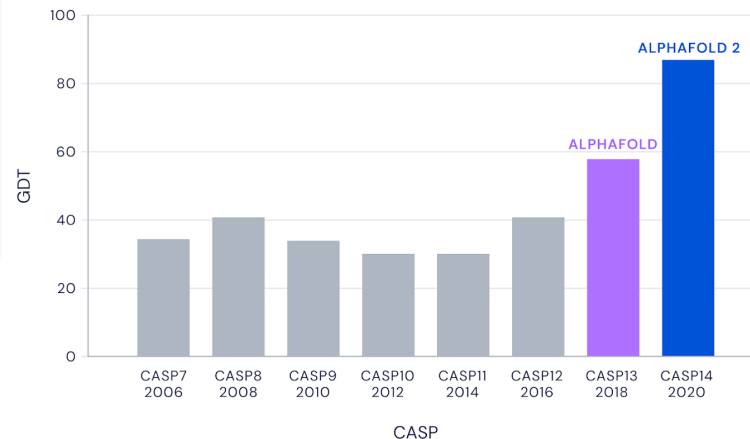
T1049 / 6y4f
93.3 GDT
(adhesin tip)

● Experimental result
● Computational prediction

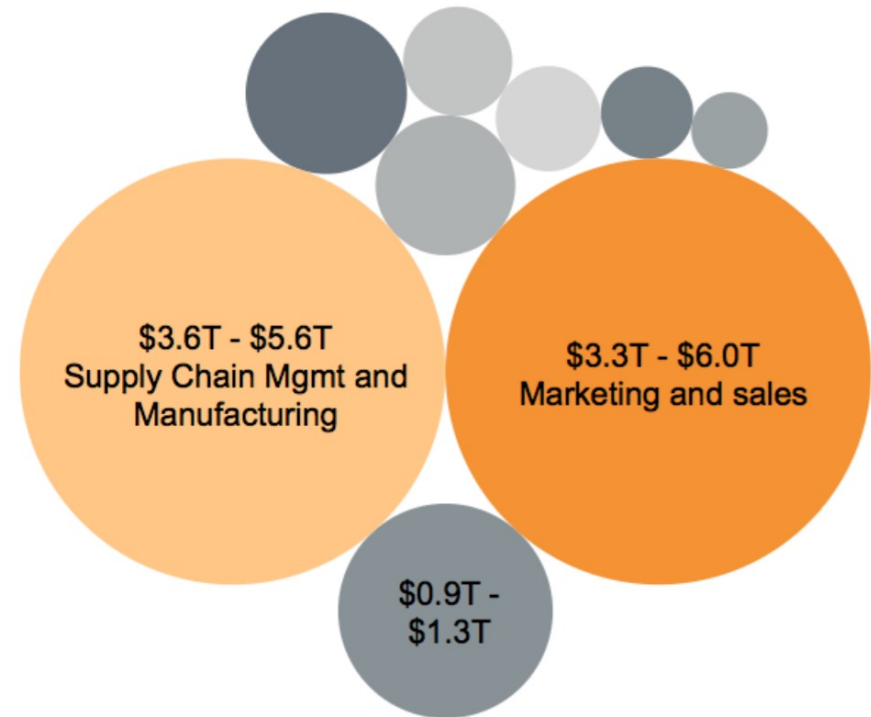
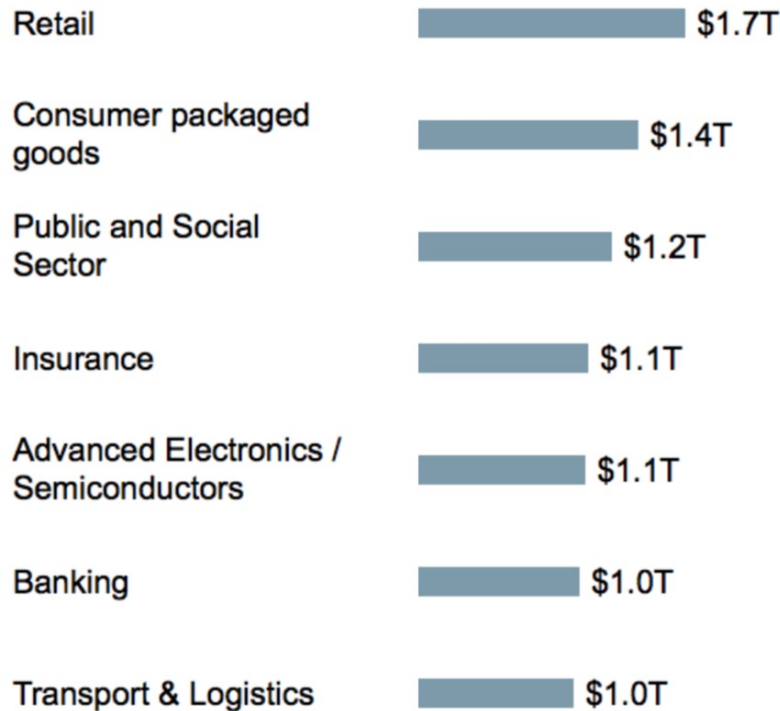
This computational work represents a stunning advance on the protein-folding problem, **a 50-year-old grand challenge in biology.**

— Venki Ramakrishnan, Nobel Laureate

Median Free-Modelling Accuracy

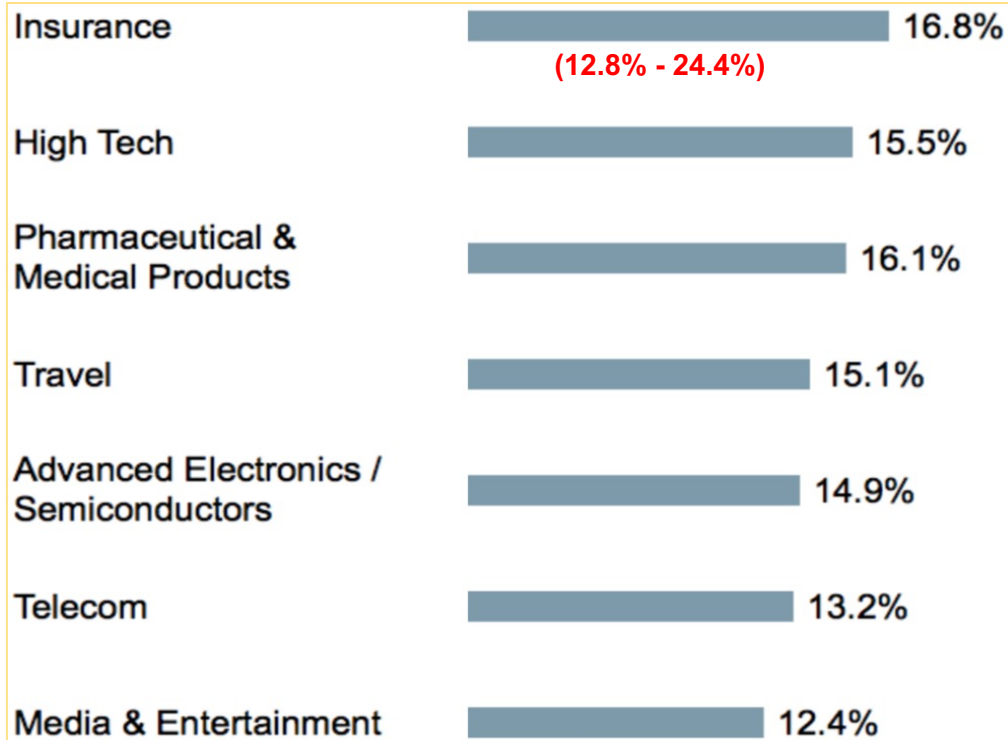


Global impact of AI



Until 2030, AI can create **\$15000 billions**

Impact on Growth of other areas



<https://www.mckinsey.com/featured-insights/artificial-intelligence/visualizing-the-uses-and-potential-impact-of-ai-and-other-analytics>

Definition of AI (1)

- The definitions (i.e., point of view) of Artificial Intelligence (AI) can be categorized in 4 groups:
 - (1) 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)
 - (2) 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)

Definition of AI (2)

□ (3) System 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)

□ (4) System 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)

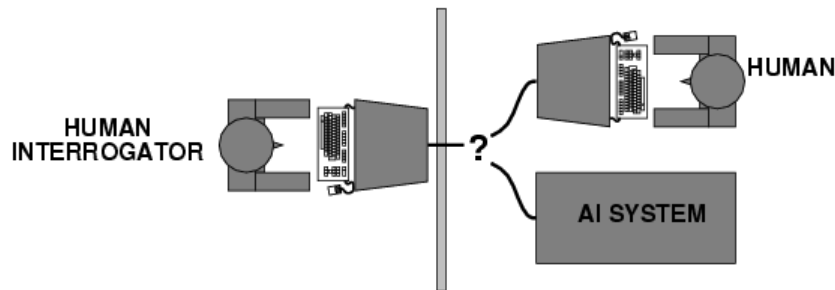
Definition of AI (3)

- The definitions (1) and (2) relate to *thinking and inference processes*
- The definitions (3) and (4) relate to *actions*
- The definitions (1) and (3) assess the success (i.e., intelligence) *at the level of human intelligence*
- The definitions (2) and (4) assess the success (i.e., intelligence) at the level of rationality
 - A system is considered acting rationally if it does its jobs according to what it (the system) knows
- **Artificial Intelligence (AI) is the science and engineering of making intelligent machines, especially intelligent computer programs** [John McCarthy, Stanford University, <http://www-formal.stanford.edu/jmc/whatisai/node1.html>]

Acting humanly: Turing test

Turing (1950) "Computing machinery and intelligence":

- "Can machines think?" → "Can machines behave intelligently?"
- Operational test for intelligent behavior: the Imitation Game

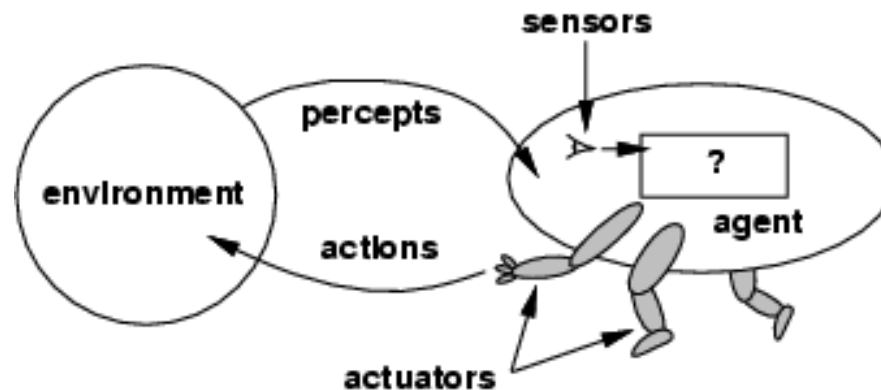


- Predicted that by 2000, a machine might have a 30% chance of surpassing a non-expert person for a Turing test in 5 minutes
- Anticipated (by 1950) all major arguments against AI in following 50 years
- Suggested major components of AI: knowledge, reasoning, language understanding, learning

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
 - E.g., blinking reflex
- But *thinking* should be in the service of rational action
- The rationality should take the computation cost into account
 - If the computation resource and time costs are too high, then it is impractical (i.e., not applicable in practice)

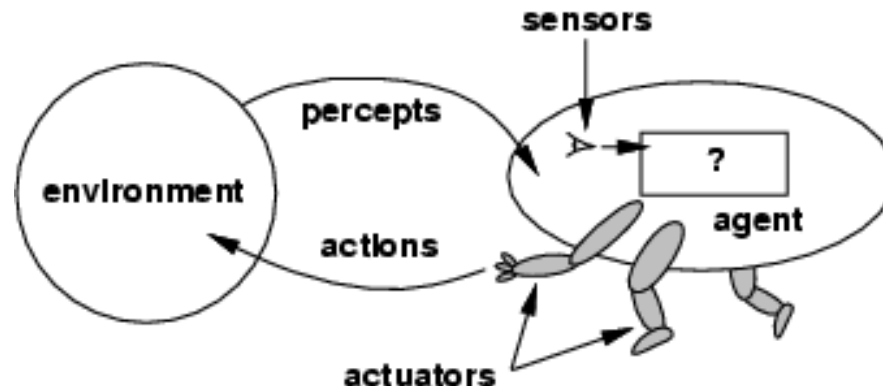
Rational agents (1)



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

$$f: P^* \rightarrow A$$

Rational agents (2)



- For an environment and a task, we need to find out an agent that has the best performance
- An intelligent agent is the one that can **act rationally (i.e., intelligently)**
 - Action that helps maximize the achievement of the goal(s), given the perceived information
- Important note: Limits of computation (of the computer) do not allow perfect (optimal) rationality to be achieved
 - Intelligence vs. computation cost (practicality)

Related fields of AI (1)

■ Philosophy

- ❑ Logic
- ❑ Methods of reasoning
- ❑ Foundations of learning
- ❑ Language
- ❑ Rationality

■ Mathematics

- ❑ Formal representation and Proof algorithms
- ❑ Computation
- ❑ Decidable vs. undecidable problems
- ❑ Tractable vs. intractable problems (i.e., computational complexity, especially time cost)
- ❑ Probability

Related fields of AI (2)

■ Economics

- Utility function
- Decision making theory

■ Neuroscience

- Natural basis of mental activities

■ Psychology

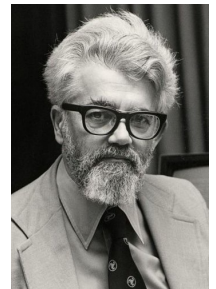
- Adaptivity
- Phenomena of perception and motor control
- Experimental techniques (psychophysics, etc.)

Related fields of AI (3)

- Computer technology
 - Build high-speed computers
 - High performance computing
- Control theory
 - Design systems to maximize a certain objective function
- Linguistics
 - Knowledge representation
 - Grammar (of a language)

Brief history of AI (1)

- 1943: McCulloch & Pitts presented the first research on AI, which proposed modeling of two-state (i.e., on/off) artificial neurons
- 1950: The concept of AI was first mentioned by Turing in his article "Computing Machinery and Intelligence"
- **1956**: The first workshop (taking place in 2 months) in Dartmouth (USA) discussing the field of AI. **AI was born.**
- 1952-1969: The initial achievements in AI
- 1950s: First AI programs
 - Samuel's chess program
 - Newell & Simon's logic reasoning program
 - Gelernter's geometric theorem proving program



John
McCarthy

Brief history of AI (2)

- 1965: Robinson proposed the complete algorithm for logic reasoning
- 1966-1973: the first AI winter
 - AI researchers realized the difficulty of computational complexity
 - Artificial neural networks are heavily influenced, and are developed very slowly
- 1969-1979: Introduction and early development of knowledge-based systems
- 1980: AI became an industry (AI systems and programs were used commercially)
- 1980-1988: The emergence of expert systems
- 1986: Artificial neural networks became popularly
- 1987: AI became a scientific field
- 1987-1993: the second AI winter

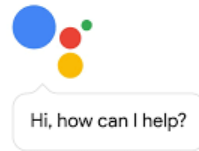
The main subfields of AI

- **Search & Planning:** giải quyết vấn đề có mục tiêu bằng tìm kiếm
- **Knowledge representation & Reasoning:** biểu diễn tri thức và sử dụng chúng hiệu quả
 - Expert systems, Knowledge-based systems, ...
- **Machine Learning (1959):** giúp máy tính có khả năng học từ dữ liệu
 - Reinforcement Learning, Deep Learning, ...
- **Machine perception:** giúp máy có khả năng nhận thức hình ảnh, ngôn ngữ, ...
 - Computer Vision, Natural Language Processing, Speech Recognition
- **Robotics:** máy có khả năng tự hoạt động và ứng xử hiệu quả
- **Multi-agent systems:** giúp các máy tương tác với nhau

Important achievements in AI (1)

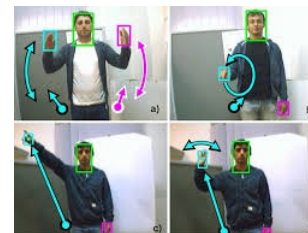
■ Information retrieval

- Virtual assistant: Siri, Google Now, Cortana, Bixby, etc.



■ Human-machine communication

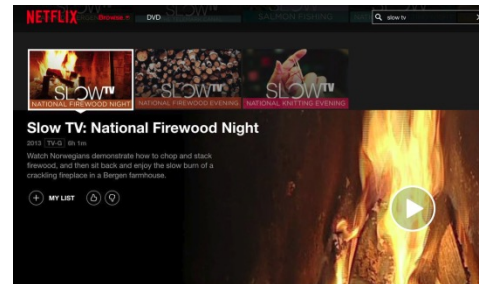
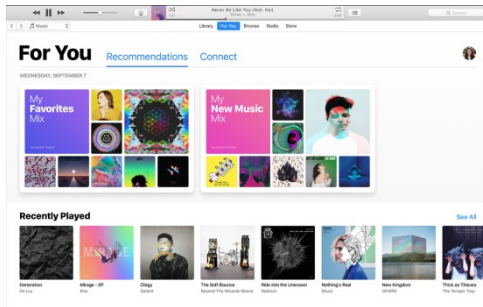
- Voice, Gesture, Natural language understanding, etc.



Important achievements in AI (2)

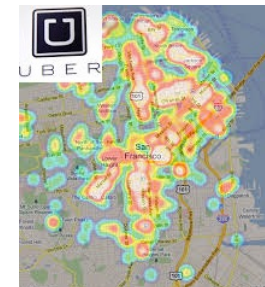
■ Entertainment

- ❑ Music, Movies, Games, News, Social networks, etc.



■ Transportation

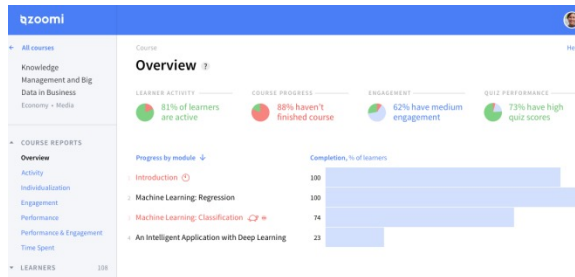
- ❑ Shelf-driving car, Traffic law enforcement, Prediction of demand for car/motorbike ride, etc.



Important achievements in AI (3)

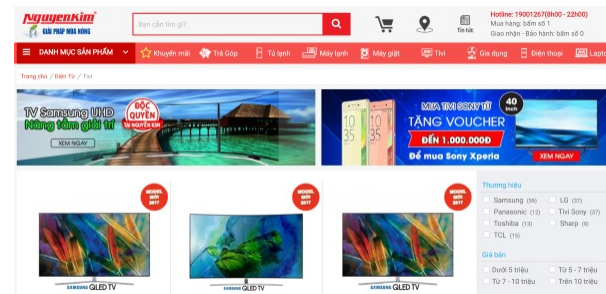
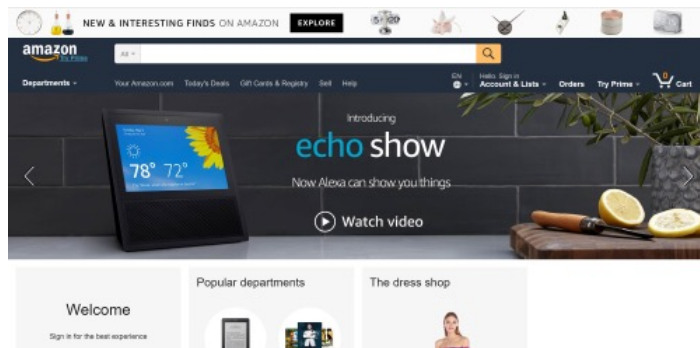
■ Education and learning

- Learning materials, Learning path, Knowledge dissemination, etc.



■ E-commerce

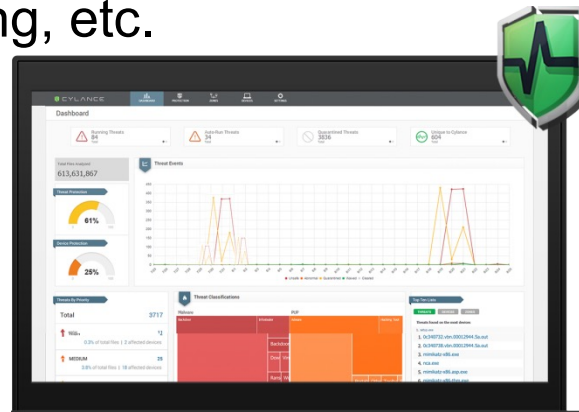
- Product/service recommendations, Demand prediction, Promotion campaign, etc.



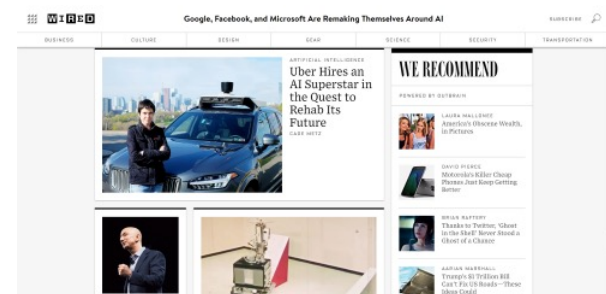
Important achievements in AI (4)

■ System security

- ❑ Computer virus detection, Network intrusion detection, Email spam filtering, etc.



■ Marketing and advertisement



Successful application fields of AI (1)

■ E-commerce

- Personalized/target advertisement, Product and service recommendation, etc.

■ Entertainment

- Games, Music, Movies, News, etc.

■ Finance

- Market analysis, Stocks investment, Loan risk estimation, Card fraud detection, etc.

■ Manufacturing

- Defect product detection, Maintenance status prediction, Robots work in production lines, etc.

■ Medicine and health

- Disease diagnostics, Interpretation of x-ray images, Heart rate/brain wave/blood vessel analysis, Micro-surgery robot, etc.

Successful application fields of AI (2)

- Telecommunications
 - Automatic customer support, Data routing and transmission, etc.
- Aeronautics and space
 - Planning the operations of spacecraft, Universe station maintenance prediction, Satellite control, etc.
- Nuclear plant management
 - Problem/risk prediction and warning, etc.
- Military
 - Object recognition and classification, etc.
- ... *And there are many other application fields ...*

Software frameworks and libraries (1)

- **TensorFlow** (www.tensorflow.org)
 - ❑ OS: Linux, Mac OS, Windows, Android
 - ❑ Languages: Python, C++, Java
- **Caffe** (caffe.berkeleyvision.org)
 - ❑ OS: Linux, Mac OS, Windows
 - ❑ Languages: Python, Matlab
- **Caffe2** (caffe2.ai), **PyTorch** (pytorch.org)
 - ❑ In march 2018, Caffe2 and PyTorch were merged in the unified architecture
 - ❑ OS: Linux, Mac OS, Windows, iOS, Android, Raspbian
 - ❑ Languages: C++, Python
- **Keras** (keras.io)
 - ❑ OS: Linux, Mac OS, Windows
 - ❑ Language: Python
- **Theano** (deeplearning.net/software/Theano)
 - ❑ OS: Linux, Mac OS, Windows
 - ❑ Language: Python

Software frameworks and libraries (2)

- **CNTK** (www.microsoft.com/en-us/research/product/cognitive-toolkit/)
 - ❑ OS: Windows, Linux
 - ❑ Languages: Python, C++, C#
- **Deeplearning4j** (deeplearning4j.org)
 - ❑ OS: Linux, Mac OS, Windows, Android
 - ❑ Languages: Java, Scala, Clojure, Python
- **Apache Mahout** (mahout.apache.org)
 - ❑ OS: Any OS with JVM installed
 - ❑ Languages: Java, Scala
- **Weka** (<http://www.cs.waikato.ac.nz/ml/weka/>)
 - ❑ OS: Any OS with JVM installed
 - ❑ Language: Java

Open debates about AI (1)

- The ability of AI?
 - ❑ Play correctly a table-tennis game?
 - ❑ Discover and prove a new mathematical theory?
 - ❑ Can converse with one person in 1 hour?
 - ❑ Automatically perform a complicated surgery?
 - ❑ Instantly translate between bilinguals in a conversation?
 - ❑ etc.
- Can computers think like humans?

Open debates about AI (2)

- If computers can replace what is being done by humans, the fewer jobs (**unemployed**)
- Humans will have **too much spare time** (compared to too little, as it is today)
- People feel a loss of their dominant (highest) intelligence
- Since computers do (and interfere with) many human everyday things, they will feel their **privacy** is compromised
- The use of multiple AI systems can reduce (loose) accountability at work
- The (perfect) success of AI is **the end of the human race?**

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