Overview of Artificial Intelligence

School of Electronic and Computer Engineering
Peking University

Wang Wenmin

Contents

What is Artificial Intelligence (AI)

AI

the intelligence exhibited by machines or software
机器或软件所展现的智能

the name of the academic field of research
学术研究领域的名称

how to create computers and computer software that are capable of intelligent behavior.
如何创建计算机和计算机软件使之具有智能行为。

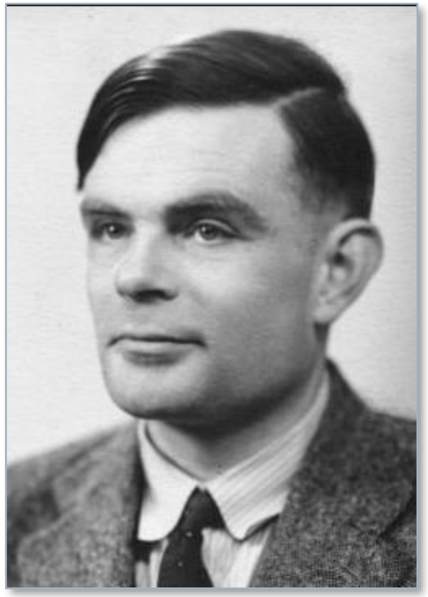
What is Artificial Intelligence (AI)

- The 1956 conference of “Dartmouth Summer Research Project on Artificial Intelligence” was the moment that AI gained its name, mission and major players, and is widely considered the birth of AI.
  1956年的“达特茅斯夏季人工智能研究计划”会议，是AI赢得其名称、使命和主要参与者的时刻，因此被广泛地认为是AI的诞生。

  OO

Turing Test

- Turing test was proposed by Alan Turing (1950) in his paper “Computing Machinery and Intelligence”.
  图灵测试是由艾伦·图灵在1950年发表的“计算机器与智能”论文中提出的。
- It is designed to provide a satisfactory operational definition of intelligence.
  旨在提供一种令人满意的关于智能的可操作定义。



Alan M. Turing
艾伦·图灵
English mathematician, logician, computer scientist and cryptanalyst.
英国数学家、逻辑学家、计算机科学家和密码学家

Cryptanalyst

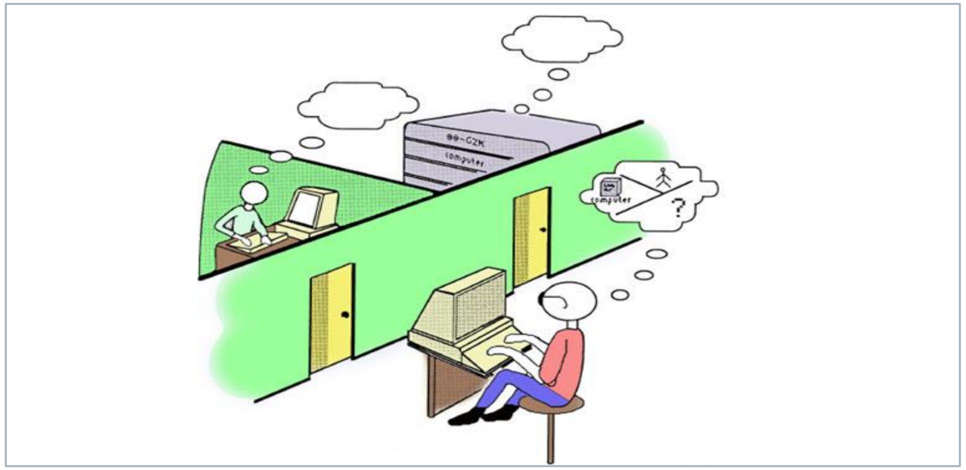
Turing Test

- A computer passes the test if a human interrogator, after posing some written questions, can not tell whether the written responses come from a person or from a computer.
  如果一个人类的提问官，在提出一些书面问题之后，无法分辨这些书面回答究竟是来自于人还是一台计算机，则认为计算机通过了该测试。

Turing Test

Turing Test

- Turing's prediction: by the year 2000, machines would be capable of fooling 30% of human judges after five minutes of questioning.
  图灵预言，2000年之前，经过5分钟的问题测试之后，机器将能够蒙骗30%的人类裁判。



Turing Test

Visual Turing Test

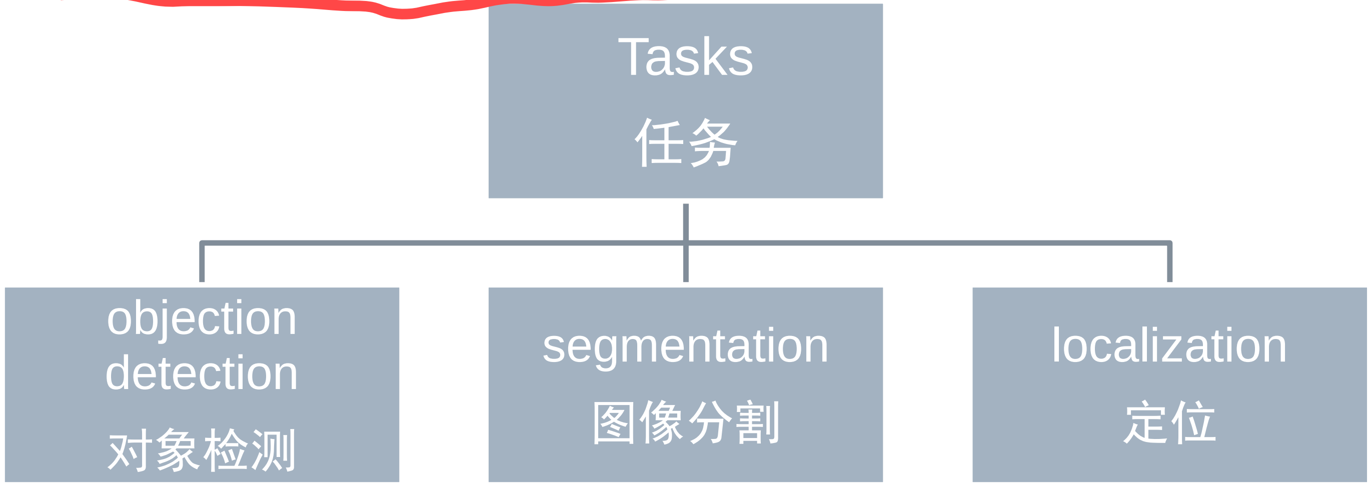
- It was introduced by Donald Geman *et al* in 2014.
  视觉图灵测试是由唐纳德・杰曼等人于2014年提出的。
- An operator-assisted device that produces a stochastic sequence of binary questions from a given test image.
  是采用一个操作员辅助设备、根据给定的图像产生随机的二元问题序列。

Donald Geman
唐纳德・吉曼
Prof. of Applied Mathematics,
Johns Hopkins University
美国约翰-霍普金斯大学
应用数学系教授

Visual Turing Test

- Current computer visual systems were tested by their accuracy for tasks, including objection detection, segmentation and localization. But still not close to the way humans do.
  目前的计算机视觉系统是测试任务的精度。这些任务包括对象检测、图像分割和定位。但仍然与人类的行为方式有差距。

- Visual Turing test was motivated by the ability of human to understand images.
  视觉图灵测试是受人类理解图像能力的启发而提出的。



Visual Turing Test

1. **Q:** Is there a person in the designated region?	**A:** yes
2. **Q:** Is there a unique person in the designated region?	**A:** yes (person1)
3. **Q:** Is person1 carrying something?	**A:** yes
4. **Q:** Is person1 female?	**A:** yes
5. **Q:** Is person1 walking on a sidewalk?	**A:** yes
6. **Q:** Is person1 interacting with any other object?	**A:** no

Chinese Room

- Chinese Room is a thought experiment, also called Sherle’s Chinese Room Argument.
  “中文屋”是一个思想实验，也被称为希而勒的中文屋论证。
- It was first published by American philosopher John Searle in a paper “Minds, Brains and Programs” in the journal *The Behavioral and Brain Sciences*, in 1980.
  它是由美国哲学家约翰·希而勒早在1980年发表在《行为与大脑科学》杂志上的论文“智力、头脑与规划”中提出的。

Chinese Room

- It attempts to show that computer can never be properly described as having a “mind” or “understanding”, regardless of how intelligently it maybe have.
  试图揭示计算机绝不能描述为有“智力”或“知性”，不管它多么智能。

John R. Searle
约翰·希而勒
Slusser Prof. of Philosophy, UC Berkeley.
“斯拉瑟”哲学教授
UC伯克利大学

Chinese Room

- He imagines himself alone in a room following a computer program for responding to Chinese characters slipped under the door.
  他设想他独自在一个房间，操作一套计算机程序来应付从门缝下塞进来的中文字符。

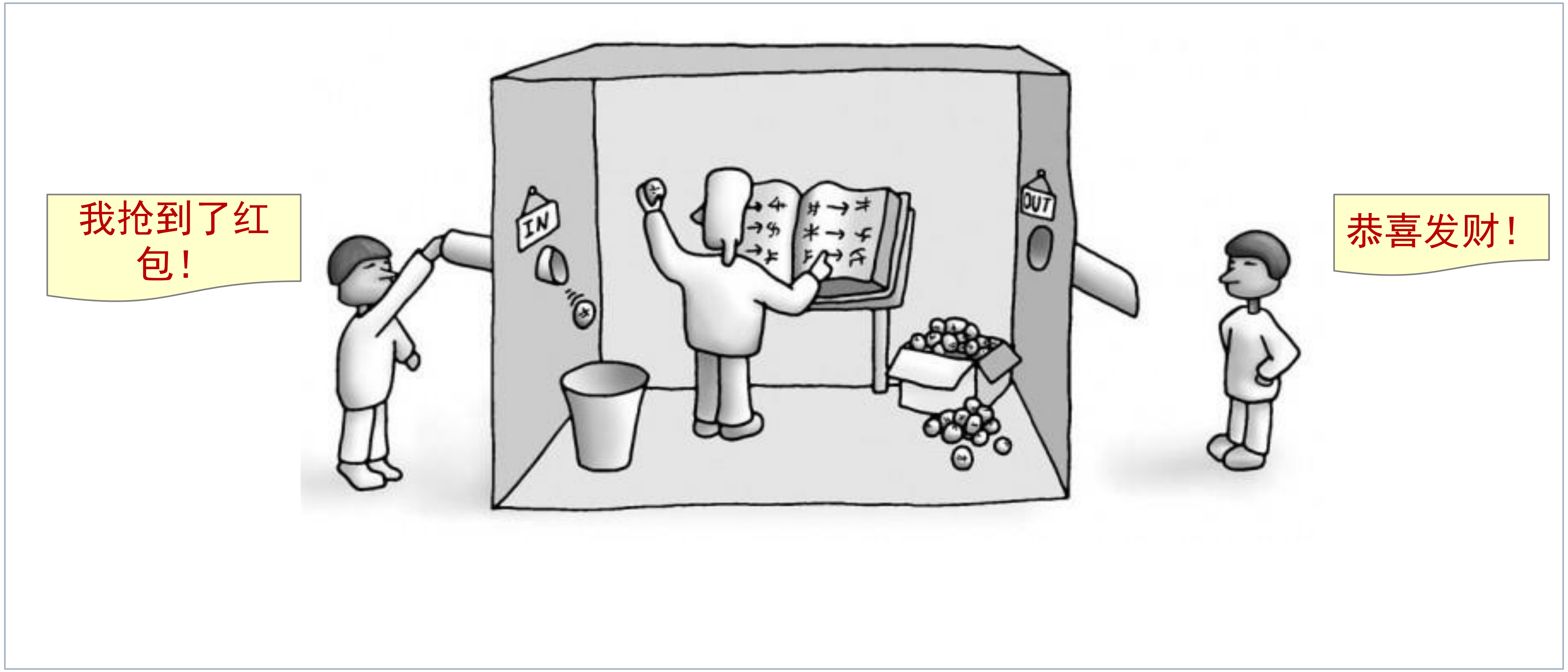
Chinese Room

- He understands nothing of Chinese, and yet, by following the program for manipulating symbols and numerals just as a computer does, he produces appropriate strings of Chinese characters that fool those outside into thinking there is a Chinese speaker in the room.
  他对中文一窍不通，然而，正如同计算机所做的那样，通过操作处理符号和数字，他生成了合适的中文字符串，从而蒙骗了屋外的人，以为屋内有一个精通中文的人。

Chinese Room

- The narrow conclusion is that programming a digital computer may make it appear to understand language but does not produce real understanding.
  唯一的结论是，按程序运行的计算机可以使它看起来理解了语言，但并没有产生真正的理解。
- Hence the “Turing Test” is inadequate.
  由此他断定，图灵测试的结论是不充分的。

Chinese Room



Whoever or whatever is in that room is an intelligent Chinese speaker!

不管是谁、无论如何，在房间里的一定是个聪明的精通中文的人！

Thank you for your attention!

PoAI

Foundations of Artificial Intelligence

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What are the Foundations of AI:

Philosophy	❖ 哲学
Mathematics	❖ 数学
Economics	❖ 经济学
Neuroscience	❖ 神经科学
Psychology	❖ 心理学
Computer engineering	❖ 计算机工程
Control theory and cybernetics	❖ 控制理论和控制论
Linguistics	❖ 语言学

Contents

Mathematics in Three Fundamental Areas:

1) Logic --*What are the formal rules to draw valid conclusions?*

逻辑学 --得出正确结论的形式规则是什么?

- 1847, George Boole:
  propositional logic, also called Boolean logic.
  乔治·布尔：命题逻辑，亦称布尔逻辑。
- 1879, Gottlob Frege:
  first order logic, that extends Boole's logic to include objects and relations.
  戈特洛布·弗雷格：一阶逻辑，它扩展了布尔逻辑，增加了对象和关系。
- Alfred Tarski (1902–1983):
  theory of reference, that shows how to relate the objects in a logic to objects.
  阿尔弗雷德·塔斯基：指称理论，它揭示如何将逻辑中的对象与对象相关联。

Mathematics in Three Fundamental Areas:

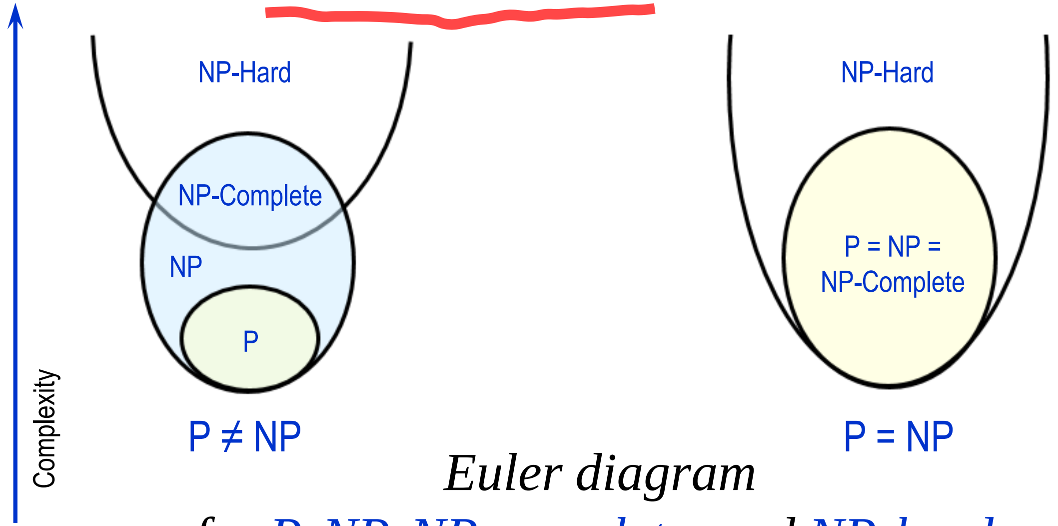
2) Computation -- *What can be computed?*

计算 -- 什么是可计算的?

- Alan Turing (1912–1954):
  try to characterize exactly which functions are computable.
  艾伦・图灵：试图精确地描述哪些函数是可计算的。
- mid-1960s, Cobham and Edmonds:
  proposed the notion of computational tractability.
  科伯姆与埃德蒙兹：提出了计算的易处理性的概念。
- 1972, Steven Cook and Richard Karp:
  proposed the theory of NP-completeness.
  斯蒂文·库克与理查·德卡普：提出了NP完全性的理论。

Terminology: NP-completeness

- In computational complexity theory
  - P: Polynomial time. P：多项式时间
  - NP: Non-deterministic Polynomial time. NP：不确定性多项式时间
  - NP-complete: both in NP and NP-hard. NP完：NP与NP难的交集。



Euler diagram for P, NP, NP-complete, and NP-hard.
尤拉图：P、NP、NP完与NP难

- Nobody has yet been able to determine conclusively whether NP-complete problems are in fact solvable in polynomial time.

- Left side is valid under the assumption P ≠ NP. 当假设P ≠ NP时，左图成立
- Right side is valid under the assumption P = NP. 当假设P = NP时，右图成立

Mathematics in Three Fundamental Areas:

3) Probability -- *How do we reason with uncertain information?*

概率 -- 如何根据不确定信息进行推理?

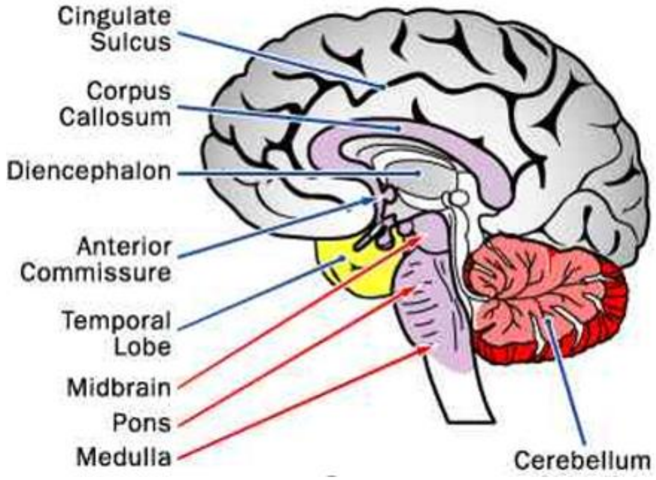
- Gerolamo Cardano (1501–1576)
  framed probability, describing it in terms of possible outcomes of gambling events.
  杰罗拉莫·卡尔达诺：构建了概率的概念，将其描述为博弈事件中可能的结果。
- James Bernoulli (1654–1705), Pierre Laplace (1749–1827), and others
  advanced the theory and introduced new statistical methods.
  詹姆士·伯努力、皮埃尔·拉普拉斯等人：推进了这一理论，并引入了新的统计学方法。
- Thomas Bayes (1702–1761)
  Bayes' rule, it underlies most modern approaches to uncertain reasoning.
  托马斯·贝叶斯：提出了贝叶斯规则，它成为不确定性推理的最现代方法。

Neuroscience

-- *How Do Brains Process Information?*

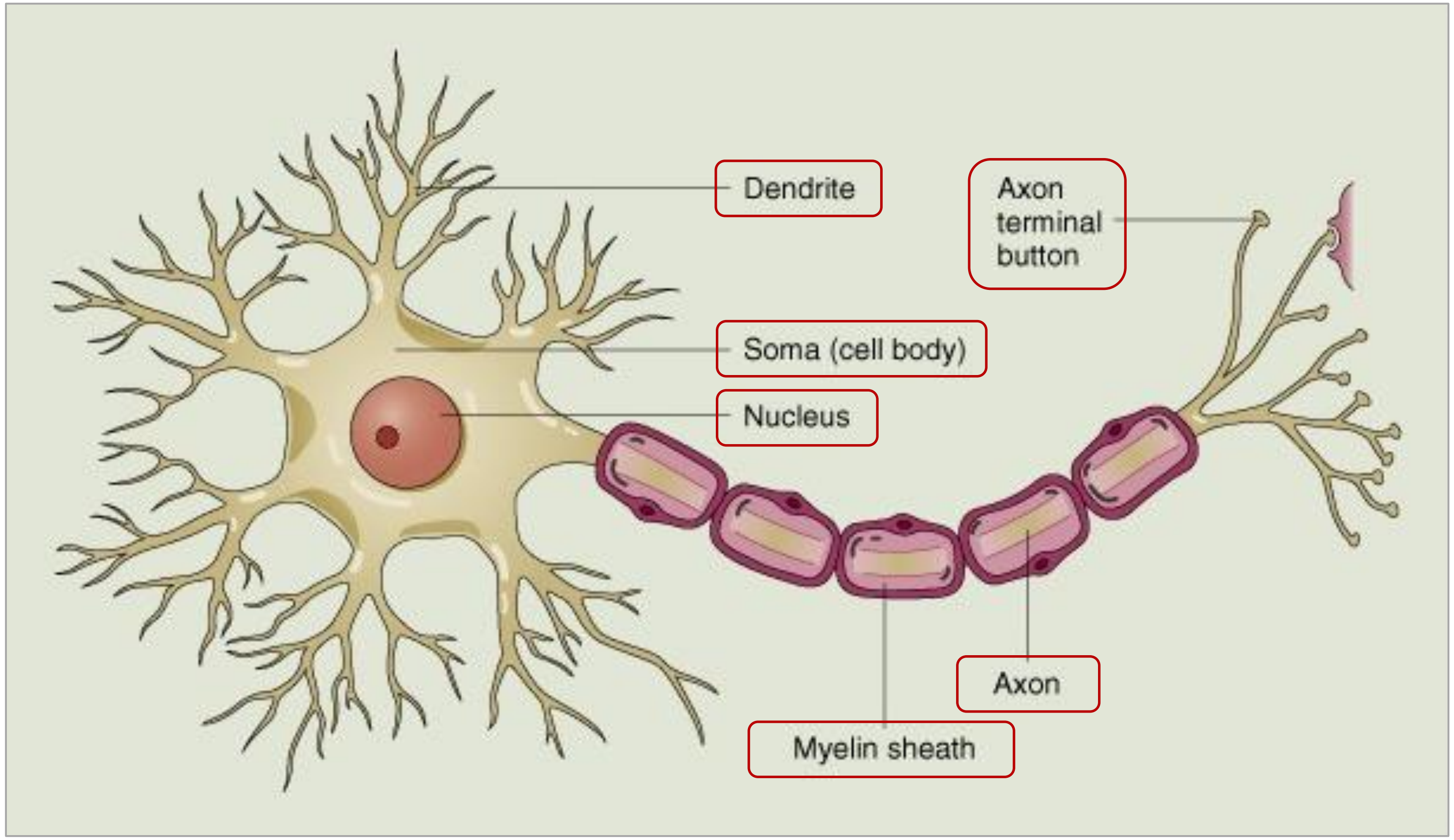
神经科学：--大脑如何处理信息?

- Neuroscience is the study of the nervous system, particularly the brain.
  神经科学研究神经系统，尤其是大脑。
- Brains are very good at making rational decisions (but not perfect).
  大脑在理性决策方面非常优越（但并非完美无缺）。
- Brains aren't as modular as software.
  大脑不像软件那样模块化。
- Prediction and simulation are key to decision making.
  预测和仿真是决策的关键。



Major Internal Parts of the Human Brain
人类大脑的主要内部部件

Parts of a Neuron



Dendrite, Soma, Nucleus, Myelin sheath, Axon, Axon terminal button

树突，细胞体，细胞核，髓鞘，轴突，轴突末端突触

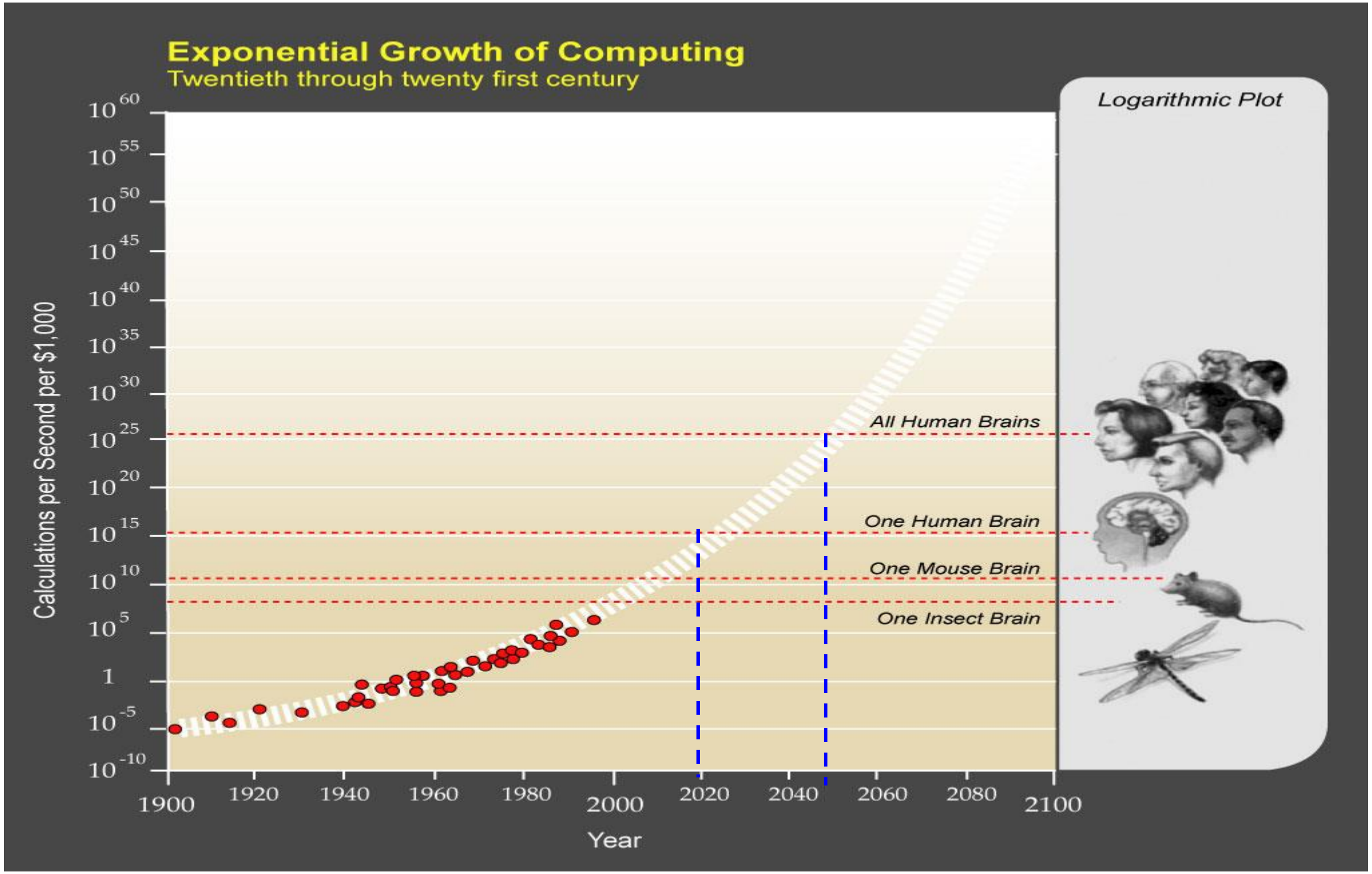
Computer vs. Human brain

- The brain's numbers are essentially fixed.
  大脑中神经元的数量基本是固定的。
- The computer's numbers have been increasing by a factor of 10 every 5 years.
  计算机中处理单元的数量，每5年增加10倍。

	Computer	Human Brain
Computational units	CPU, 64 bits, 10^9 transistors	10^{11} neurons
Storage units	10^{11} bits RAM 10^{13} bits disk	10^{11} neurons 10^{14} synapses
Cycle time	10^{-9} sec	10^{-3} sec
Operations/sec	10^{10}	10^{17}
Memory updates/sec	10^{10}	10^{14}

Computer vs. Human brain

Source: http://waitbutwhy.com/



Cognitive Psychology

-- How do humans think and act?

认知心理学：-- 人类如何思考与行动？

- Views the brain as an information-processing device, studies mental processes:
  把大脑看作是信息处理设备，是研究心智过程的学科：

attention	注意机制
language use	语言运用
memory	记忆
perception	感知
problem solving	问题求解
creativity	创造力
thinking	思考

Mental processes

Attention

- A state of focused awareness on a subset of available perceptual information.
  注意机制：意识集中在某个有用感知信息子集的状态。

Memory

- Three sub-classes:
  procedural memory, semantic memory, episodic memory.
  记忆：三个子集：过程记忆、语义记忆、情景记忆。

Perception

- Physical senses (sight, smell, hearing, taste, touch, and proprioception), as well as their cognitive processes.
  感知：物理感知（视觉、嗅觉、味觉、知觉），及其认知过程。

Mental processes

Language

- Study language acquisition, individual components of language formation, how language use is involved in mood, or numerous other related areas.

  语言：研究语言习得、语言形成的组件、语言使用时的语气、或者许多其它相关领域。

Metacognition

- It is “cognition about cognition”, “thinking about thinking”, or “knowing about knowing”.

  元认知：它是“关于认知的认知”、“关于思考的思考”、或者“关于认识的认识。

- There are generally two components of metacognition: knowledge about cognition, and regulation of cognition.

  元认知通常有两个组成部分：关于认知的知识，以及认知的调节。

Cognitive psychology vs. Cognitive science

Cognitive psychology

be often involved in running psychological experiments involving human participants, with the goal of gathering information related to how the human mind takes in, processes, and acts upon inputs received from the outside world.

认知心理学：通常通过人类参与者的心理实验来收集信息，其目的是研究人脑如何接受外部世界的输入、如何处理以及作用等。

Cognitive science

be concerned with gathering data through research, which has links to philosophy, linguistics, anthropology, neuroscience, and particularly with artificial intelligence.

认知科学：关注于通过研究收集数据，其涉猎心理学、语言学、人类学、神经科学、社会学和教育学，尤其是人工智能。

WIKIPEDIA
The Free Encyclopedia

Control theory and cybernetics

-- How can artifacts operate under their own control?

控制理论与控制论：--机器如何能在其自身的控制下运行？

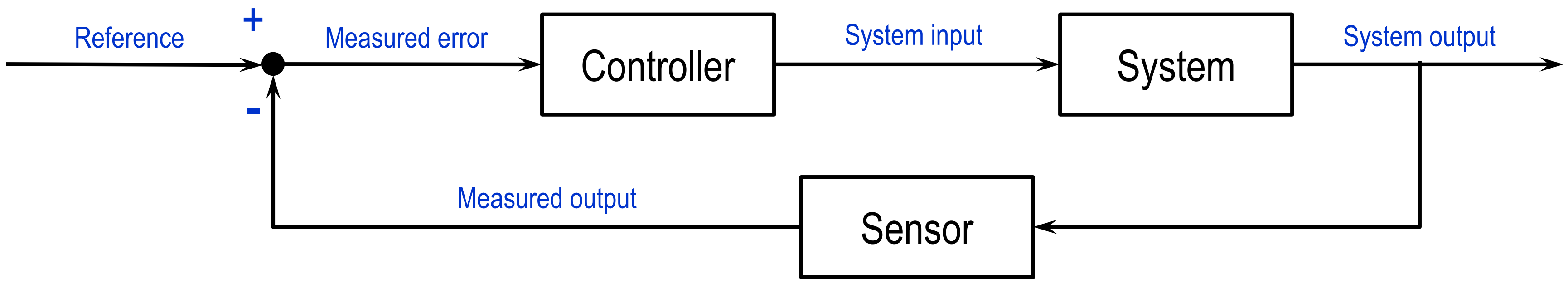
Control theory

- An interdisciplinary branch of engineering and mathematics.

  控制理论:工程与数学的交叉学科分支。

- Deal with the behavior of dynamical systems with inputs, and how their behavior is modified by feedback.

  处理动态系统对输入的行为，以及该行为如何通过反馈进行调整。



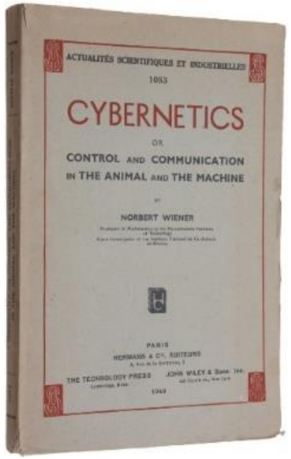
Control theory and cybernetics

□ Cybernetics

- A transdisciplinary approach for exploring regulatory systems, their structures, constraints, and possibilities.
  跨学科的研究途径，探索调控系统、它们的结构、约束、和可能性。

- Defined in 1948 as "the scientific study of control and communication in the animal and the machine."
  控制论：1948被定义为“研究动物与机器的控制与通信的科学”。

- In the 21st century, the term is often used in a rather loose way to imply "control of any system using technology.“
  21世纪，该术语通常被简单通俗地解释为“用技术控制任何系统”。



Thank you for your attention!

History of Artificial Intelligence

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The History of AI

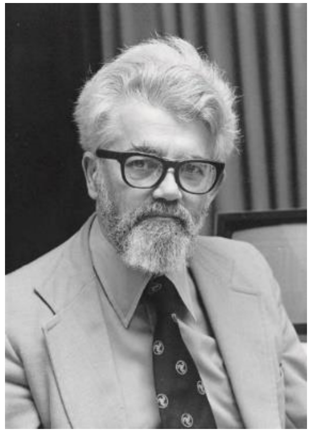
Years	Description	
1950–1956	The Birth of AI	AI的诞生
1956–1974	The Golden Years	黄金之年
1974–1980	The First AI Winter	第一个AI之冬
1980–1987	The Boom of AI	AI的繁荣期
1987–1993	The Second AI Winter	第二个AI之冬
1993–Present	The Breakthrough	突破

1950–1956, The Birth of AI

- 1950, Alan Turing proposes the Turing Test as a measure of machine intelligence.

  1950年，艾伦·图灵提出了图灵测试，将其作为机器智能的度量。
- 1956, the field of Artificial Intelligence research was founded at a conference on Dartmouth College.

  1956年，在美国达特茅斯学院的会议上，人工智能研究领域正式诞生。



John McCarthy
约翰·麦卡锡

Marvin Minsky
马文·明斯基

Allen Newell
艾伦·纽厄尔

Herbert Simon
赫伯特·西蒙

1956–1974, The Golden Years

- 1958, Herbert Simon and Allen Newell had a demonstration the first AI program, Logic Theorist (LT).

  1958年赫伯特·西蒙和艾伦·纽厄尔演示了第一个AI程序，名称为逻辑理论家(LT)。

- 1958, John McCarthy (MIT) invented Lisp programming language.

  1958年约翰·麦卡锡发明了著名的Lisp编程语言。

- 1960s, M. Masterman and colleagues at University of Cambridge design semantic nets for machine translation.

  1960年代，M·马斯特曼与剑桥大学的同事们设计了语义网络，用于机器翻译。

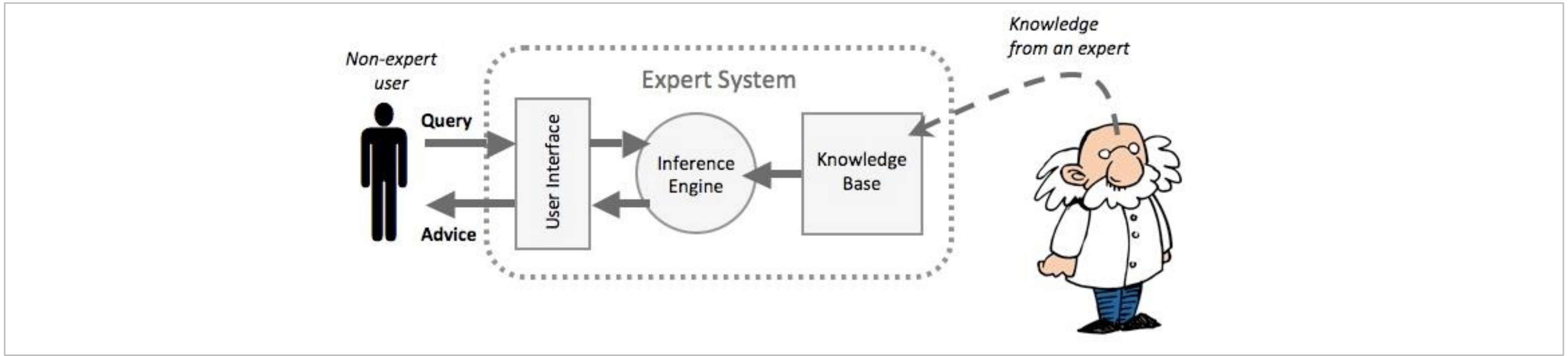
- 1963, Leonard Uhr and Charles Vossler published “A Pattern Recognition Program That Generates, Evaluates, and Adjusts Its Own Operators”, which described one of the first machine learning programs.

  1963年伦纳德·武赫和查尔斯·瓦斯勒发表了关于模式识别的论文，描述了第一个机器学习程序。

1956–1974, The Golden Years

- 1965, E. Feigenbaum initiated Dendral, a software to deduce the molecular structure of organic compounds. It was the first expert systems.

  1965年，E・费根鲍姆开创了Dendral，一个推断有机化合物分子结构的软件。这是首套专家系统。



- 1974, T. Shortliffe demonstrated MYCIN program, a very practical rule-based approach to medical diagnoses.

  1974年，T・肖特列夫演示了MYCIN程序，一个非常实用的基于规则的医学诊断方法。

1974–1980, The First AI Winter

- 1966, the failure of machine translation.
  1966年，机器翻译失败了。
- 1970, the abandonment of connectionism.
  1970年，连接主义遭到遗弃。
- 1971–1975, DARPA‘s frustration with the Speech Understanding Research program at Carnegie Mellon University.
  1971年至75年，美国DARPA对卡内基梅隆大学的语音理解研究项目感到沮丧。
- 1973, the large decrease in AI research in the United Kingdom, in response to the Lighthill report “Artificial Intelligence: A General Survey”.
  1973年，受莱特希尔的“人工智能：综合调查”报告的影响，英国大幅度缩减AI的研究。
- 1973–1974, DARPA‘s cutbacks to academic AI research in general.
  1973-74，美国DARPA削减了一般性AI学术研究经费。

1980–1987, AI Boom

- 1980, First National Conference of the American Association for Artificial Intelligence (AAAI) held at Stanford.

  1980年，美国人工智能学会（AAAI）在斯坦福大学召开了第一届全国大会。

- 1982, Japan started Fifth Generation Computer System (FGCS) project for knowledge processing.

  1982年，日本启动了第五代计算机系统（FGCS）项目，用于知识处理。

The Generations of Computer

Generation	Years	Description
1st	Mid-1940s	Thermionic vacuum tubes 真空管
2nd	1956	Transistors 晶体管
3rd	1964	Integrated circuits 集成电路
4th	1972	Microprocessors 微处理器

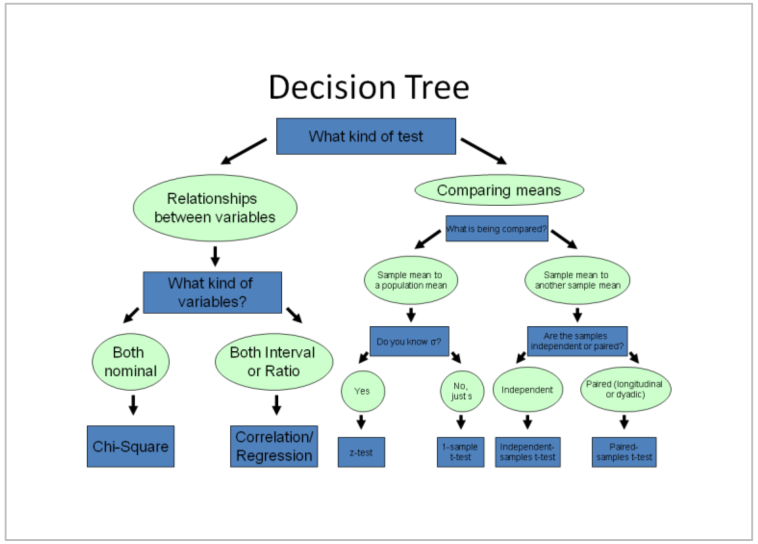
1980–1987, AI Boom

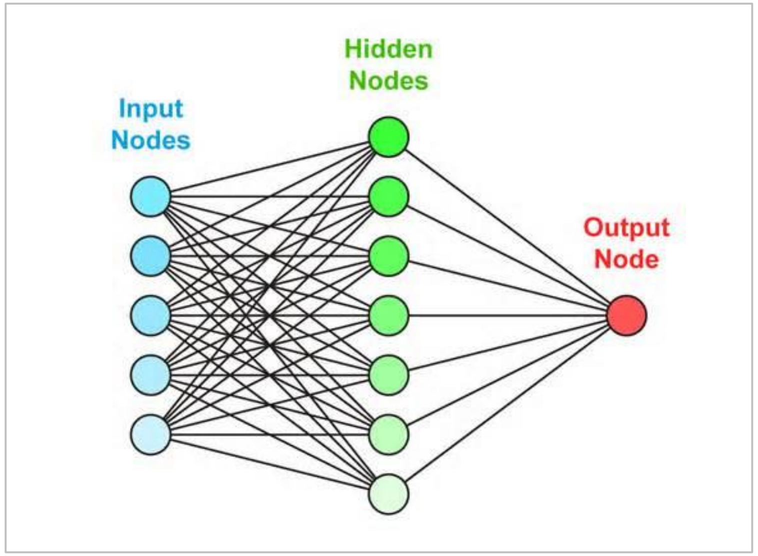
- In mid-1980s, the machine learning came, when the decision tree model was invented and distributed as software. The model can be viewed by a human and is easy to explain.

  1980年代中期，机器学习出现了，当时发明了决策树模型并且以软件形式推出。该模型具有可视化、易说明的特点。

- Also in mid-1980s, multi-layer Artificial Neural Networks (ANN) invented. With enough hidden layers, a ANN can express any function, thus overcoming the limitation of perceptron.

  1980年代中期，还发明了多层人工神经元网络（ANN）。具有足够多的隐藏层，一个ANN可以表达任意的功能，因此突破了感知的局限性。





1987–1993, The Second AI Winter

- 1987, the collapse of the Lisp machine market.

  1987年，Lisp机的市场崩溃。

- 1988, the cancellation of new spending on AI by the United States government's Strategic Computing Initiative.

  1988年，美国政府的战略计算促进会取消了新的AI经费。

- 1993, expert systems slowly reaching the bottom.

  1993年，专家系统缓慢滑向低谷。

- 1990s, the quiet disappearance of the fifth-generation computer project's original goals.

  1990年代，日本第五代计算机项目未能达到其初始目标，悄然退场。

1993–Present, Breakthrough

- In 1997, Deep Blue became the first computer chess-playing system to beat a reigning world chess champion, Garry Kasparov.
  1997年，深蓝战胜了卫冕国际象棋冠军加里・卡斯帕罗夫，成为第一台计算机国际象棋系统。
- In 2005, a Stanford's Stanley, an autonomous robotic vehicle, won the DARPA Grand Challenge.
  2005年，斯坦福的自主机器人车辆Stanley，赢得了DARPA无人驾驶汽车挑战赛。
- In 2006, the term "deep learning" gained traction after a publication by Geoffrey Hinton and Ruslan Salakhutdinov.
  2006年，在杰弗里・辛顿和鲁斯兰・ 萨拉赫丁诺夫在科学杂志上发表了有关"深度学习"的论文之后，该术语成了热门。

Deep Blue

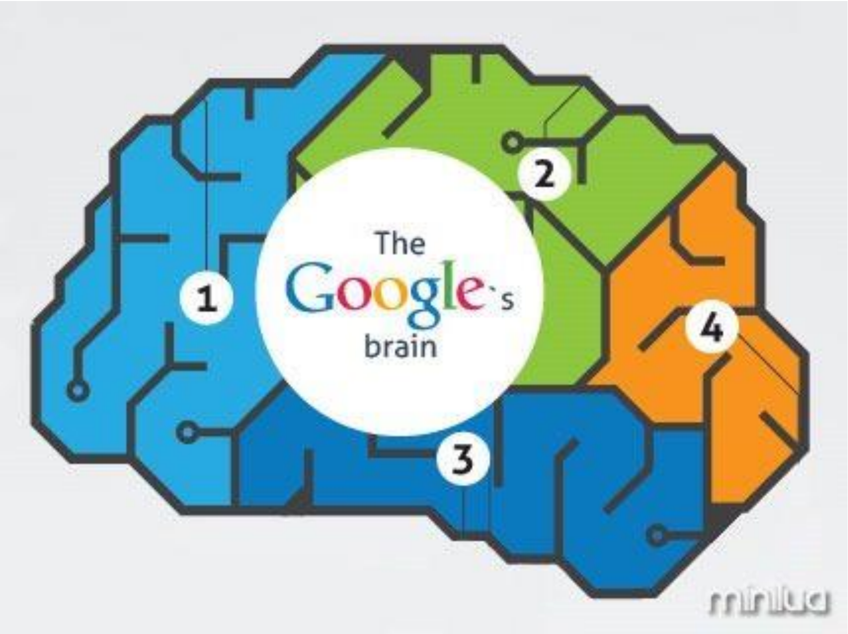
1993–Present, Breakthrough

- Watson, the computer was specifically developed by IBM to answer questions on the quiz show Jeopardy!
  沃森，是IBM专门开发的在智力竞赛Jeopardy!回答问题的计算机。
  - In 2011, Watson competed on Jeopardy! against former winners Brad Rutter and Ken Jennings.
    2011年，沃森在Jeopardy!上战胜了上届冠军布拉德·路特和肯恩·詹宁斯。
  - Watson received the first prize of $1 million.
    沃森获得了1百万美元大奖。

Watson on quiz show Jeopardy!

1993–Present, Breakthrough

- In 2011, Google started Deep Learning project, Google Brain, as one of the Google X projects.
  2011，谷歌启动了深度学习项目，谷歌大脑，作为Google X项目之一。
  - Google brain is a cluster of 16,000 computers dedicated to mimicking some aspects of human brain activity.
    谷歌大脑是由1万6千台计算机连成的一个集群，致力于模仿人类大脑活动的某些方面。
  - It had successfully recognized a cat based on 10 million digital images.
    通过1千万张数字图片的学习，已成功地学会识别一只猫。



1993–Present, Breakthrough

- In 2012, Siri was introduced by Apple as an integral part of iOS since iOS 5, running from iPhone 4S.

  2012年，苹果公司引进了Siri，从iPhone 4S上运行的iOS5开始，已作为iOS的一个组成部分。

  - Siri is an intelligent personal assistant and knowledge navigator.

    Siri是一种智能个人助理和知识导航软件。

  - Use a natural language user interface to answer questions, make recommendations, and perform actions.

    使用自然语言用户接口来回答问题、做出建议和执行动作。

  - Available in: English, French, German, Japanese, Chinese, Korean, Italian, Spanish.

    支持英语、法语、德语、日语、中文、韩文、意大利语、西班牙语。

1993–Present, Breakthrough

- In 2012, Rick Rashid, Microsoft's Chief Research Officer, demonstrated a real-time English-to-Chinese universal translator that keeps your voice and accent.
  2012年, 瑞克・拉希德，微软首席研究官，演示了一款实时的英语–中文通用翻译系统，可以保持你的声音和口音。

  - Not only is the translation very accurate, but the software also preserves the user's accent and intonation.
    该软件不仅翻译非常准确，而且能够保持讲者的口音和语调。

1993–Present, Breakthrough

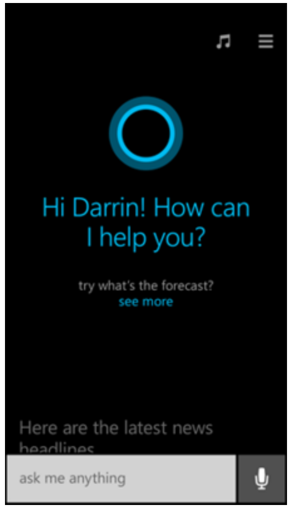
- Apr. 2014, Microsoft demonstrated “Cortana”, an intelligent personal assistant on Windows Phone.

  2014年4月，微软演示了“Cortana”，一款运行在Windows Phone上的智能个人助理。

- Jun. 2014, Microsoft China released chatbot “XiaoIce (小冰)” which allowed WeChat users to have conversations with it.

  2014年6月，微软中国推出了聊天机器人小冰，可让微信用户与她交谈。

- 2015年9月8日，百度在2015百度世界大会上推出了一款机器人助理—度秘，可以为用户提供秘书化搜索服务。



Cortana

小冰

度秘

1993–Present, Breakthrough

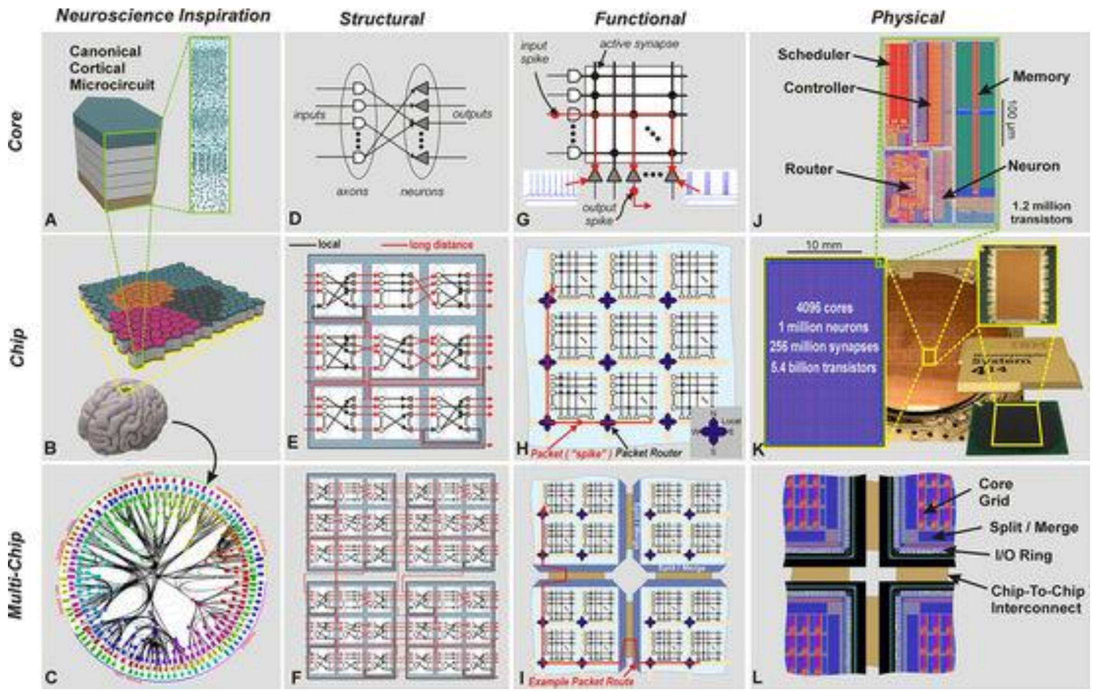
- Jun. 2014, chatbot Eugene Goostman, at a contest marking the 60th anniversary of Turing's death, 33% of the event's judges thought that Goostman was human, so that the event's organizer considered it to have passed Turing's test.
  2014年6月，聊天机器人尤金・古斯特曼，在纪念图灵逝世60周年的一个比赛上，被该活动33%的评委认为古斯特曼是人类，因此组织者认为它已经通过了图灵测试。

  - Eugene Goostman is developed in Saint Petersburg in 2001 by a group of three programmers.
    尤金・古斯特曼是由三个程序员小组于2001年在圣・彼得堡开发的。

1993–Present, Breakthrough

- Aug. 2014, IBM announced “TrueNorth” chip to work like human brain.
  2014年8月，IBM发表了类人脑工作的TrueNorth芯片。

  - TrueNorth is a neuromorphic CMOS chip, consists of 4096 hardware cores, each one simulating 256 programmable silicon "neurons" for a total of just over a million neurons.
    TrueNorth是一款神经形态的CMOS芯片，由4096个硬件核组成，每个仿真256个可编程的硅神经元，总计刚好超过百万个神经元。

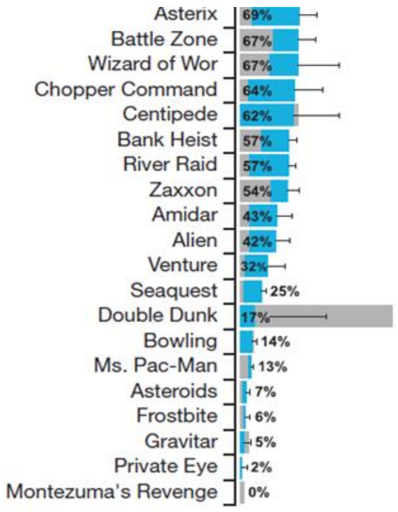


1993–Present, Breakthrough

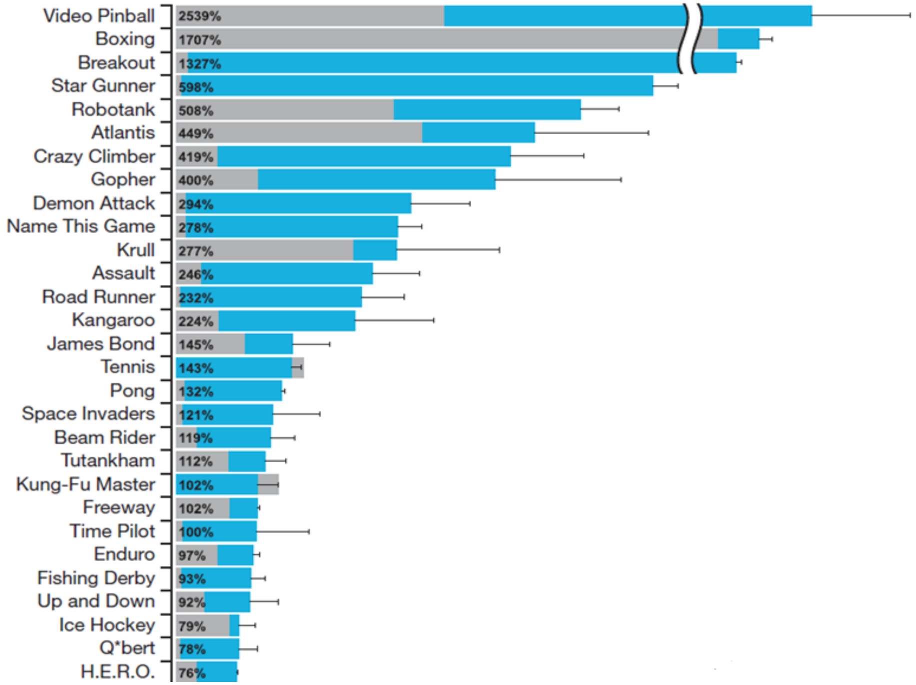
- Feb. 2015, Google DeepMind published Deep Q-Network, the human-level control through deep reinforcement learning.

  2015年2月，谷歌DeepMind公司在Nature杂志上发表了Deep Q-Network，通过深度强化学习达到人类水平的操控。

Below human-level (20/49 ≈ 40.82%)



At human-level or above (29/49 ≈ 59.18%)



Tested on classic Atari video games (late-1970s and early-1980s)

在经典（1970年代后期至1980年代初）的Atari视频游戏机上进行的测试

1993–Present, Breakthrough

- Dec. 2015, Google DeepMind's program AlphaGo beat Fan Hui, the European Go champion, five times out of five in tournament conditions.

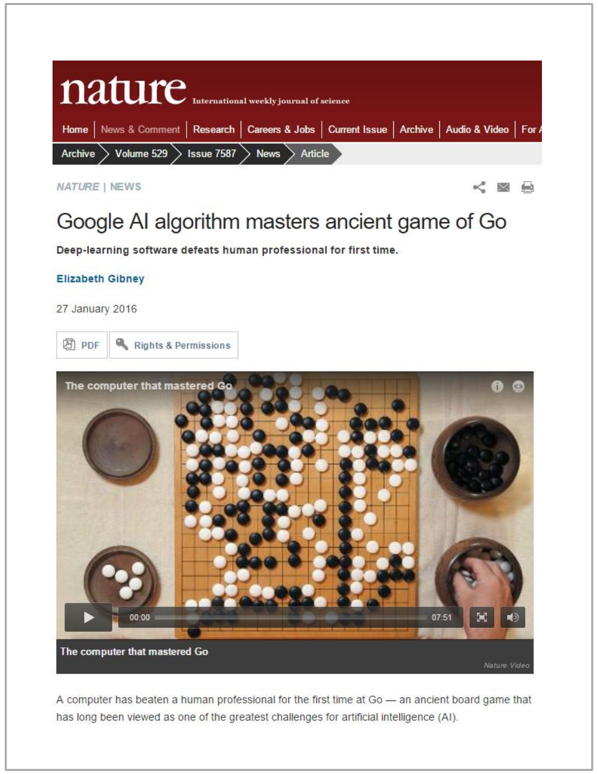
  2015年12月，谷歌DeepMind公司的程序AlphaGo打败了欧洲围棋冠军樊麾，成绩5战5胜。

- Jan. 27 2016, the announcement of the news was delayed until this day, to coincide with the publication of a paper in the journal Nature describing the algorithms used.

  这个消息直到2016年1月27日才宣布，目的是与描述所用算法的论文在《自然》杂志发表的时间同步。

- Deep-learning software defeats human professional for first time.

  深度学习软件第一次击败了人类职业棋手。



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Archive > Volume 529 > Issue 7587 > News > Article

NATURE | NEWS

Google AI algorithm masters ancient game of Go

Deep-learning software defeats human professional for first time.

Elizabeth Gibney

27 January 2016

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The computer that mastered Go

00:00 07:51

The computer that mastered Go

Nature Video

A computer has beaten a human professional for the first time at Go — an ancient board game that has long been viewed as one of the greatest challenges for artificial intelligence (AI).

1993–Present, Breakthrough

- Mar. 9-15 2016, AlphaGo played South Korean professional Go player Lee Sedol, ranked 9-dan, in Seoul, South Korea. AlphaGo won all but the fourth game.

  2016年3月8日至15日，AlphaGo在韩国首尔对垒韩国九段职业棋手李世乭。AlphaGo以5战4胜赢得了比赛。

Source: http://www.goratings.org/history/

Go Ratings

Rating of Go players, using the WHR algorithm, and data kindly provided by go4go.net. Updated daily.

16th May 2016
New version of Crazy Stone for your PC employing Deep Learning technology !

Game of GO Crazy Stone DEEP LEARNING THE FIRST EDITION

Statistics

Games	55905
Players	1747
Most Recent Game	2016-07-25

Rating List

For older ratings, check the History page. There is also a History of top ladies.

Rank	Name	♂♀	Flag	Elo
1	Google DeepMind AlphaGo			3608
2	Ke Jie	♂		3608
3	Park Junghwan	♂		3593
4	Lee Sedol	♂		3550
5	Iyama Yuta	♂		3536
6	Mi Yuting	♂		3528
7	Shi Yue	♂		3509
8	Kim Jiseok	♂		3504
9	Lian Xiao	♂		3504
10	Tuo Jiaxi	♂		3501
11	Chen Yaoye	♂		3496
12	Zhou Ruiyang	♂		3493
13	Park Yeonghun	♂		3492
14	Li Qincheng	♂		3487
15	Huang Yunsong	♂		3475
16	Gu Li	♂		3470
17	Shin Jinseo	♂		3469
18	Tan Xiao	♂		3465
19	Lee Donghoon	♂		3460
20	Gu Zihao	♂		3456

1993–Present, Breakthrough

- 2016年4月9日，《我是歌手》第四季总决赛落下帷幕，李玟夺得总冠军。据报道，在决赛结果宣布之前阿里云小Ai就预测到了李玟夺冠。
- 小Ai是阿里云研发的人工智能程序，主要基于神经网络、社会计算、情绪感知等原理工作，善于洞察本质和实时预测，并能理解人类情感，可以通过强大的计算和机器学习能力不断自我进化。

1993–Present, Breakthrough

- Jan. 19 2016, the Information Technology and Innovation Foundation (ITIF) in Washington DC announced its annual Luddite Award.

  2016年1月19日，位于华盛顿特区的信息技术与创新基金会(ITIF)，公布了年度卢德奖。

- ITIF gave the Luddite Award to “a loose coalition of scientists and luminaries who stirred fear and hysteria in 2015 by raising alarms that artificial intelligence (AI) could spell doom for humanity”.

  ITIF将该卢德奖颁发给“一个科学家和名人组成的松散联盟，他们在2015年警告人工智能(AI)将会导致人类的末日，激起恐惧和歇斯底里”。

- The winners — if that is the correct word — included Elon Musk, and Stephen Hawking.

  获奖者——如果这个词没用错的话——包括埃隆・马斯克、和史蒂芬・霍金。

Source: https://itif.org/publications/2016/01/19/

Thank you for your attention!

PoAI

The State of The Art

School of Electronic and Computer Engineering
Peking University

Wang Wenmin

Contents

Four Categories of AI

	Humanly	Rationally
Acting	Acting humanly	Acting rationally
Thinking	Thinking humanly	Thinking rationally

Humanly

to measure success in terms of fidelity to *human* performance.

类人地：以对人类表现的逼真度来衡量。

Rationally

to measure against an *ideal* performance measure.

理性地：用理想的性能表现来衡量。

- A system is rational if it does the right thing, given what it knows.
  一个系统如果对已知的知识做出正确的动作，则被称为理性。

Eight Definitions for four Categories of AI

Acting humanly

- Kurzweil,1990: To perform functions that require intelligence performed by people.
  完成需要人类智能所能完成的功能。
- Rich and Knight,1991: To make computers do things at which, at the moment, people are better.
  使计算机去做此时此地人类才能做好的事情。

Acting rationally

- Poole et al.,1998: Computational Intelligence is the study to design intelligent agents.
  计算智能是研究如何设计智能体。
- Nilsson,1998: AI is concerned with intelligent behavior in artifacts.
  AI是关注于用人工手段去实现智能行为。

Eight Definitions for four Categories of AI

Thinking humanly

- Bellman,1978: The automation of activities that we associate with human thinking …
  我们与人类思维相关活动的自动化 …
- Haugeland,1985: The new effort to make computers think … machines with minds …
  新的努力使计算机思考 … 机器具有智力 …

Thinking rationally

- Charniak and McDermott,1985: The study of mental faculties through the use of computational models.
  通过使用计算模型进行心智能力的研究。
- Winston,1992: To make computer possible to perceive, reason, and act.
  使计算机能够感知、推理、以及动作。

Weak AI vs. Strong AI vs. Super AI

□ Weak AI

- Also called Artificial Narrow Intelligence (ANI).
  弱人工智能：也被称为人工狭义智能(ANI)。
- It is non-sentient AI that is focused on one narrow task (just a specific problem).
  它是无意识的AI，专注于一个具体的任务（仅针对一个特定的问题）。

□ Strong AI

- Also called Artificial General Intelligence (AGI).
  强人工智能：也被称为人工广义智能（AGI）。
- It means a machine with the ability to apply intelligence to any problem. It is a primary goal of artificial intelligence research.
  意味着机器具有将智能用于处理任何问题的能力。它是人工智能研究的主要目标。

Weak AI vs. Strong AI vs. Super AI

Super AI

- Also called Artificial Super Intelligence (ASI).

  超人工智能：亦称人工超级智能(ASI)。
- It is a hypothetical agent that possesses intelligence far surpassing that of the brightest and most gifted human minds.

  是一个假定的智能体，拥有远远超过聪明和最有天赋的人类大脑的智能。
- Also refer to a property of problem-solving systems, e.g., super intelligent language translators or engineering assistants.

  也指的是问题求解系统的特性，例如，超级智能语言翻译器或工程助理。

Typical Problems to Which AI is Applied

Computer vision	计算机视觉
Image processing	图像处理
VR, AR and MR	VR, AR 和 MR
Pattern recognition	模式识别
Intelligent Diagnosis	智能诊断
Game theory and Strategic planning	博弈论和策略规划
Game AI and Gamebot	AI游戏和游戏机器人
Machine Translation	机器翻译
Natural language processing, and Chatbot	自然语言处理和聊天机器人
Nonlinear control, and Robotics	非线性控制和机器人技术

Other Fields in Which AI is Implemented

Artificial life	智能生活
Automated reasoning	自动推理
Automation	自动化
Biological computing	生物计算
Concept mining	概念计算
Data mining	数据挖掘
Knowledge representation	知识表示
Semantic Web	语义Web
E-mail spam filtering	垃圾邮件过滤
Litigation	诉讼

Other Fields in Which AI is Implemented

- Robotics ■ 机器人学
- Behavior-based robotics
- Cognitive
- Cybernetics
- Development robotics
- Evolutionary robotics
- Hybrid intelligent system ■ 混合人工智能
- Intelligent agent ■ 智能代理
- Intelligent Control ■ 智能控制

Joshua Tenenbaum, Vin Silva, John Langford.

"A Global Geometric Framework for Nonlinear Dimensionality Reduction".
SCIENCE, Vol. 290, Dec. 2000.

"一种用于非线性降维的全局几何框架"

"Here we describe an approach to solving dimensionality reduction problems that uses easily measured local metric information to learn the underlying global geometry of a data set."

"我们在此描述一种解决降维问题的方法，使用易测的局部度量信息来学习数据集潜在的全局几何结构。"

Isomap（等距特征映射）

A Global Geometric Framework for Nonlinear Dimensionality Reduction

Joshua B. Tenenbaum,[1*] Vin de Silva,[2] John C. Langford[3]

Scientists working with large volumes of high-dimensional data, such as global climate patterns, stellar spectra, or human gene distributions, regularly confront the problem of dimensionality reduction: finding meaningful low-dimensional structures hidden in their high-dimensional observations. The human brain confronts the same problem in everyday perception, extracting from its high-dimensional sensory inputs—30,000 auditory nerve fibers or 10^6 optic nerve fibers—a manageably small number of perceptually relevant features. Here we describe an approach to solving dimensionality reduction problems that uses easily measured local metric information to learn the underlying global geometry of a data set. Unlike classical techniques such as principal

The classical techniques for dimensionality reduction, PCA and MDS, are simple to implement, efficiently computable, and guaranteed to discover the true structure of data lying on or near a linear subspace of the high-dimensional input space (*13*). PCA finds a low-dimensional embedding of the data points that best preserves their variance as measured in the high-dimensional input space. Classical MDS finds an embedding that preserves the interpoint distances, equivalent to PCA when those distances are Euclidean. However, many data sets contain essential nonlinear structures that are invisible to PCA and MDS (*4*, *5*, *11*, *14*). For example, both methods fail to detect the true degrees of freedom of the face data set (Fig. 1A), or even its intrinsic three-dimensionality (Fig. 2A).

Isomap (Isometric Feature Mapping)

Sam Roweis and Lawrence Saul.

"Nonlinear Dimensionality Reduction by Locally Linear Embedding".
SCIENCE, Vol. 290, Dec. 2000.

"通过局部线性嵌入进行非线性降维"

"Here, we introduce locally linear embedding (LLE), an unsupervised learning algorithm that computes low-dimensional, neighborhood-preserving embeddings of high-dimensional inputs."

"这里，我们提出局部线性嵌入(LLE)，一种计算高维输入数据中低维、邻域保护嵌入的非监督学习算法。"

Nonlinear Dimensionality Reduction by Locally Linear Embedding

Sam T. Roweis[1] and Lawrence K. Saul[2]

Many areas of science depend on exploratory data analysis and visualization. The need to analyze large amounts of multivariate data raises the fundamental problem of dimensionality reduction: how to discover compact representations of high-dimensional data. Here, we introduce locally linear embedding (LLE), an unsupervised learning algorithm that computes low-dimensional, neighborhood-preserving embeddings of high-dimensional inputs. Unlike clustering methods for local dimensionality reduction, LLE maps its inputs into a single global coordinate system of lower dimensionality, and its optimizations do not involve local minima. By exploiting the local symmetries of linear reconstructions, LLE is able to learn the global structure of nonlinear manifolds, such as those generated by images of faces or documents of text.

along shortest paths confined to the manifold of observed inputs. Here, we take a different approach, called locally linear embedding (LLE), that eliminates the need to estimate pairwise distances between widely separated data points. Unlike previous methods, LLE recovers global nonlinear structure from locally linear fits.

The LLE algorithm, summarized in Fig. 2, is based on simple geometric intuitions. Suppose the data consist of N real-valued vectors $\vec{X}_i$, each of dimensionality D, sampled from some underlying manifold. Provided there is sufficient data (such that the manifold is well-sampled), we expect each data point and its neighbors to lie on or close to a locally linear patch of the manifold. We characterize the local geometry of these patches by linear coefficients that reconstruct each data point from its neighbors. Reconstruction errors are measured

Geoffrey Hinton and Ruslan Salakhutdinov.

"Reducing the Dimensionality of Data with Neural Networks".
SCIENCE, Vol. 313, Jul. 2006.

"利用神经元网络降低数据的维度"

"We describe an effective way of initializing the weights that allows deep autoencoder networks to learn low-dimensional codes that work much better than principal components analysis as a tool to reduce the dimensionality of data."

"我们描述一种初始化权重的有效方法，可让深度自编码网络学习低维代码，作为一种降低数据维度的工具，远远好于主成分分析方法。"

materials are identical for all configurations. The blue bars in Fig. 1 summarize the measured SHG signals. For excitation of the *LC* resonance in Fig. 1A (horizontal incident polarization), we find an SHG signal that is 500 times above the noise level. As expected for SHG, this signal closely scales with the square of the incident power (Fig. 2A). The polarization of the SHG emission is nearly vertical (Fig. 2B). The small angle with respect to the vertical is due to deviations from perfect mirror symmetry of the SRRs (see electron micrographs in Fig. 1). Small detuning of the *LC* resonance toward smaller wavelength (i.e., to 1.3-μm wavelength) reduces the SHG signal strength from 100% to 20%. For excitation of the Mie resonance with vertical incident polarization in Fig. 1D, we find a small signal just above the noise level. For excitation of the Mie resonance with horizontal incident polarization in Fig. 1C, a small but significant SHG emission is found, which is again po-

Reducing the Dimensionality of Data with Neural Networks

G. E. Hinton* and R. R. Salakhutdinov

High-dimensional data can be converted to low-dimensional codes by training a multilayer neural network with a small central layer to reconstruct high-dimensional input vectors. Gradient descent can be used for fine-tuning the weights in such "autoencoder" networks, but this works well only if the initial weights are close to a good solution. We describe an effective way of initializing the weights that allows deep autoencoder networks to learn low-dimensional codes that work much better than principal components analysis as a tool to reduce the dimensionality of data.

Dimensionality reduction facilitates the classification, visualization, communication, and storage of high-dimensional data. A simple and widely used method is principal components analysis (PCA), which finds the directions of greatest variance in the data set and represents each data point by its coordinates along each of these directions. We describe a nonlinear generalization of PCA that uses an adaptive, multilayer "encoder" network

504 28 JULY 2006 VOL 313 SCIENCE www.sciencemag.org

code: http://www.cs.toronto.edu/~hinton/MatlabForSciencePaper.html

Alex Rodriguez and Alessandro Laio.

"Clustering by fast search and find of density peaks".
SCIENCE, Vol. 344, Jun. 2014.

"通过快速查找和发现密度峰值进行聚类"

"We propose an approach based on the idea that cluster centers are characterized by a higher density than their neighbors and by a relatively large distance from points with higher densities."

"我们提出一种基于如下思想的方法：聚类中心点具有密度高于相邻点、距离相对大于次高密度点的特性。"

MACHINE LEARNING

Clustering by fast search and find of density peaks

Alex Rodriguez and Alessandro Laio

Cluster analysis is aimed at classifying elements into categories on the basis of their similarity. Its applications range from astronomy to bioinformatics, bibliometrics, and pattern recognition. We propose an approach based on the idea that cluster centers are characterized by a higher density than their neighbors and by a relatively large distance from points with higher densities. This idea forms the basis of a clustering procedure in which the number of clusters arises intuitively, outliers are automatically spotted and excluded from the analysis, and clusters are recognized regardless of their shape and of the dimensionality of the space in which they are embedded. We demonstrate the power of the algorithm on several test cases.

Brenden Lake, Ruslan Salakhutdinov, Joshua Tenenbaum.

"Human-level concept learning through probabilistic program induction".
SCIENCE, Vol. 350, Dec. 2015.

"凭借概率规划归纳法进行人类层级的概念学习"

"We see the one-shot learning capacities studied here as a challenge for these neural models: one we expect they might rise to by incorporating the principles of compositionality, causality, and learning to learn that BPL instantiates."

"我们看到本文研究的一次性学习能力作为对那些神经模型的一种挑战：通过将组合性、因果性和学会学习BPL实例化的原则相结合，成为一个我们期待它们会崛起的方向。"

RESEARCH ARTICLES

COGNITIVE SCIENCE

Human-level concept learning through probabilistic program induction

Brenden M. Lake,[1*] Ruslan Salakhutdinov,[2] Joshua B. Tenenbaum[3]

People learning new concepts can often generalize successfully from just a single example, yet machine learning algorithms typically require tens or hundreds of examples to perform with similar accuracy. People can also use learned concepts in richer ways than conventional algorithms—for action, imagination, and explanation. We present a

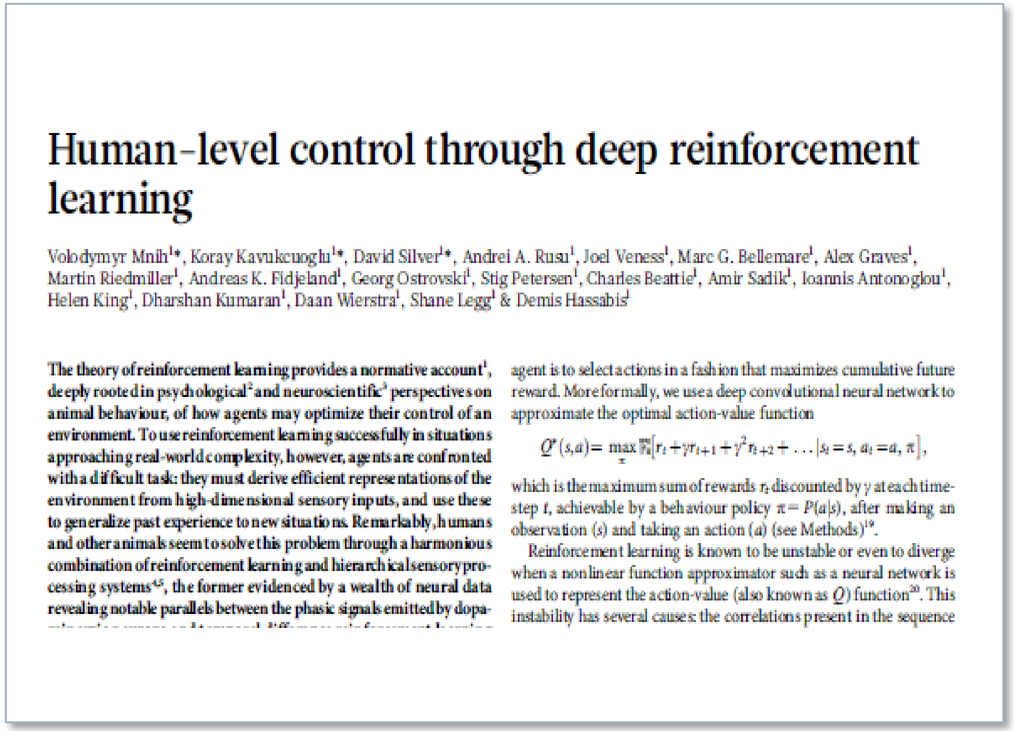
Volodymyr Mnih, Koray Kavukcuoglu, David Silver, *et al.*

"Human-level control through deep reinforcement learning".
NATURE, Vol. 518, Feb. 2015.

"凭借深度强化学习达到人类水平的操控"

"Here we use recent advances in training deep neural networks to develop a novel artificial agent, termed a deep Q-network, that can learn successful policies directly from high-dimensional sensory inputs using end-to-end reinforcement learning."

"这里我们采用训练深度网络的最新进展开发一种新颖的人造智能体，称为深度Q网络，应用端到端的强化学习，能直接从高维感知输入中学习成功的策略。"



Human-level control through deep reinforcement learning

Volodymyr Mnih[1]*, Koray Kavukcuoglu[1]*, David Silver[1]*, Andrei A. Rusu[1], Joel Veness[1], Marc G. Bellemare[1], Alex Graves[1], Martin Riedmiller[1], Andreas K. Fidjeland[1], Georg Ostrovski[1], Stig Petersen[1], Charles Beattie[1], Amir Sadik[1], Ioannis Antonoglou[1], Helen King[1], Dharshan Kumaran[1], Daan Wierstra[1], Shane Legg[1] & Demis Hassabis[1]

The theory of reinforcement learning provides a normative account[1], deeply rooted in psychological[2] and neuroscientific[3] perspectives on animal behaviour, of how agents may optimize their control of an environment. To use reinforcement learning successfully in situations approaching real-world complexity, however, agents are confronted with a difficult task: they must derive efficient representations of the environment from high-dimensional sensory inputs, and use these to generalize past experience to new situations. Remarkably, humans and other animals seem to solve this problem through a harmonious combination of reinforcement learning and hierarchical sensory processing systems[4,5], the former evidenced by a wealth of neural data revealing notable parallels between the phasic signals emitted by dopa-

agent is to select actions in a fashion that maximizes cumulative future reward. More formally, we use a deep convolutional neural network to approximate the optimal action-value function

$$Q^*(s,a) = \max_{\pi} \mathbb{E}\left[r_t + \gamma r_{t+1} + \gamma^2 r_{t+2} + \ldots \mid s_t = s, a_t = a, \pi\right],$$

which is the maximum sum of rewards r_t discounted by γ at each time-step t, achievable by a behaviour policy $\pi = P(a|s)$, after making an observation (s) and taking an action (a) (see Methods)[19].

Reinforcement learning is known to be unstable or even to diverge when a nonlinear function approximator such as a neural network is used to represent the action-value (also known as Q) function[20]. This instability has several causes: the correlations present in the sequence

Y. LeCun, Y. Bengio and G. Hinton.

"Deep learning". *NATURE*, Vol. 521, May. 2015.

"深度学习"

"Deep learning discovers intricate structure in large data sets by using the backpropagation algorithm to indicate how a machine should change its internal parameters that are used to compute the representation in each layer from the representation in the previous layer. "

"深度学习通过利用反向传播算法发现大型数据集中复杂的结构表明，一台机器如何改变其内部参数被用于从前一层表征中计算出每层的表征。"

Deep learning

Yann LeCun[1,2], Yoshua Bengio[3] & Geoffrey Hinton[4,5]

Deep learning allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction. These methods have dramatically improved the state-of-the-art in speech recognition, visual object recognition, object detection and many other domains such as drug discovery and genomics. Deep learning discovers intricate structure in large data sets by using the backpropagation algorithm to indicate how a machine should change its internal parameters that are used to compute the representation in each layer from the representation in the previous layer. Deep convolutional nets have brought about breakthroughs in processing images, video, speech and audio, whereas recurrent nets have shone light on sequential data such as text and speech.

Machine-learning technology powers many aspects of modern society: from web searches to content filtering on social networks to recommendations on e-commerce websites, and it is increasingly present in consumer products such as cameras and smartphones. Machine-learning systems are used to identify objects in images, transcribe speech into text, match news items, posts or intricate structures in high-dimensional data and is therefore applicable to many domains of science, business and government. In addition to beating records in image recognition[1–4] and speech recognition[5–7], it has beaten other machine-learning techniques at predicting the activity of potential drug molecules[8], analysing particle accelerator data[9,10], reconstructing brain circuits[11], and predicting the effects of mutations

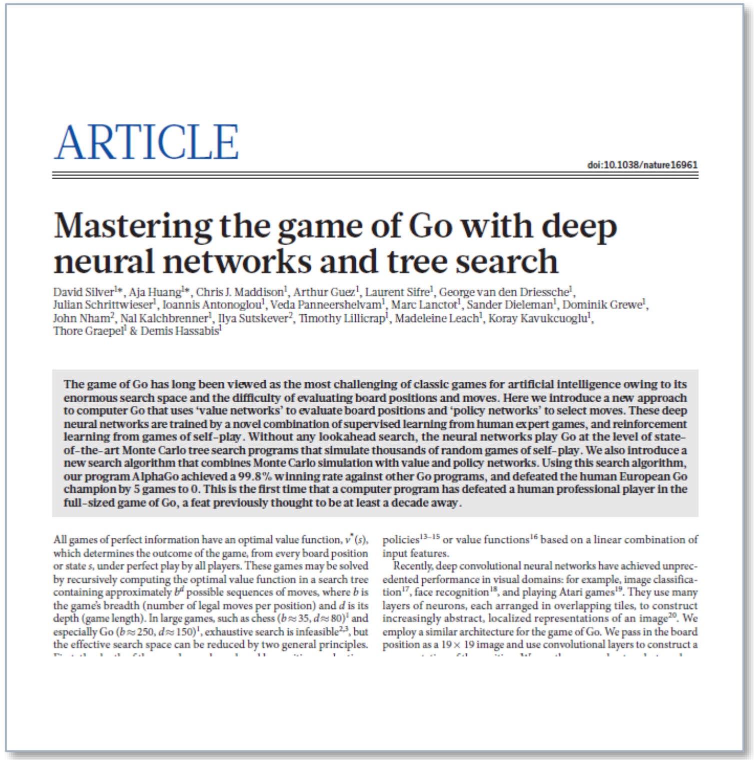
David Silver, Aja Huang, Chris Maddison, *et al.*

"Mastering the game of Go with deep neural networks and tree search".
NATURE, Vol. 529, Jan. 2016.

"利用深度神经网络和树搜索征服围棋游戏"

Here we introduce a new approach to computer Go that uses 'value networks' to evaluate board positions and 'policy networks' to select moves. … Without any look ahead search, the neural networks play Go at the level of state-of-the-art Monte Carlo tree search programs that simulate thousands of random games of self-play.

"我们在此提出一种计算机围棋的新方法，使用'价值网络'评价棋盘位置、使用'策略网络'选择走子。… 没有任何前向搜索，该神经网络以先进水平的蒙特卡洛树搜索程序博弈围棋，模拟成千上万次随机自我对弈。"


ARTICLE

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Mastering the game of Go with deep neural networks and tree search

David Silver[1*], Aja Huang[1*], Chris J. Maddison[1], Arthur Guez[1], Laurent Sifre[1], George van den Driessche[1], Julian Schrittwieser[1], Ioannis Antonoglou[1], Veda Panneershelvam[1], Marc Lanctot[1], Sander Dieleman[1], Dominik Grewe[1], John Nham[2], Nal Kalchbrenner[1], Ilya Sutskever[2], Timothy Lillicrap[1], Madeleine Leach[1], Koray Kavukcuoglu[1], Thore Graepel[1] & Demis Hassabis[1]

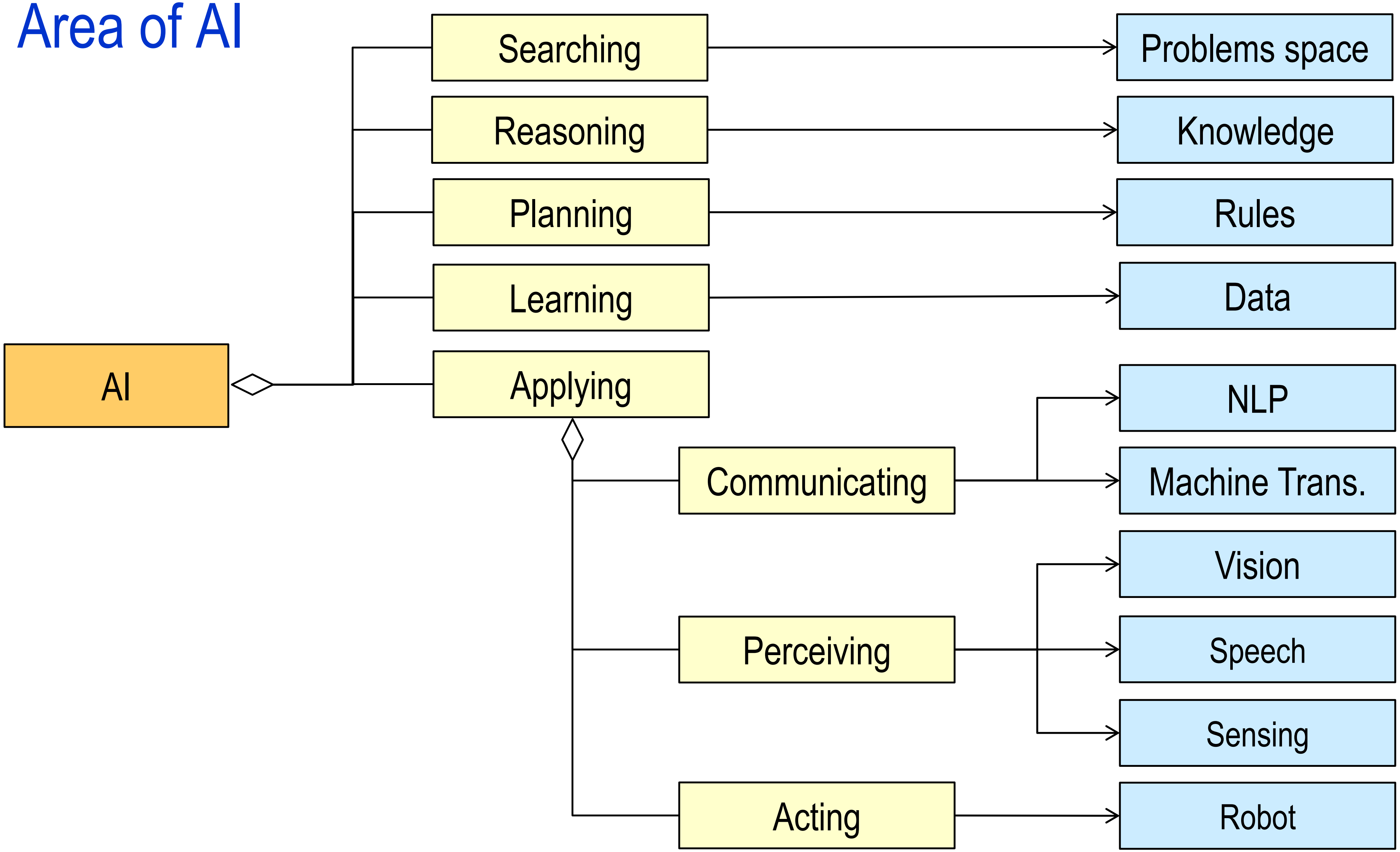
The game of Go has long been viewed as the most challenging of classic games for artificial intelligence owing to its enormous search space and the difficulty of evaluating board positions and moves. Here we introduce a new approach to computer Go that uses 'value networks' to evaluate board positions and 'policy networks' to select moves. These deep neural networks are trained by a novel combination of supervised learning from human expert games, and reinforcement learning from games of self-play. Without any lookahead search, the neural networks play Go at the level of state-of-the-art Monte Carlo tree search programs that simulate thousands of random games of self-play. We also introduce a new search algorithm that combines Monte Carlo simulation with value and policy networks. Using this search algorithm, our program AlphaGo achieved a 99.8% winning rate against other Go programs, and defeated the human European Go champion by 5 games to 0. This is the first time that a computer program has defeated a human professional player in the full-sized game of Go, a feat previously thought to be at least a decade away.

All games of perfect information have an optimal value function, $v^*(s)$, which determines the outcome of the game, from every board position or state s, under perfect play by all players. These games may be solved by recursively computing the optimal value function in a search tree containing approximately b^d possible sequences of moves, where b is the game's breadth (number of legal moves per position) and d is its depth (game length). In large games, such as chess ($b \approx 35$, $d \approx 80$)[1] and especially Go ($b \approx 250$, $d \approx 150$)[1], exhaustive search is infeasible[2,3], but the effective search space can be reduced by two general principles.

policies[13–15] or value functions[16] based on a linear combination of input features.

Recently, deep convolutional neural networks have achieved unprecedented performance in visual domains: for example, image classification[17], face recognition[18], and playing Atari games[19]. They use many layers of neurons, each arranged in overlapping tiles, to construct increasingly abstract, localized representations of an image[20]. We employ a similar architecture for the game of Go. We pass in the board position as a 19 × 19 image and use convolutional layers to construct a

Research Area of AI



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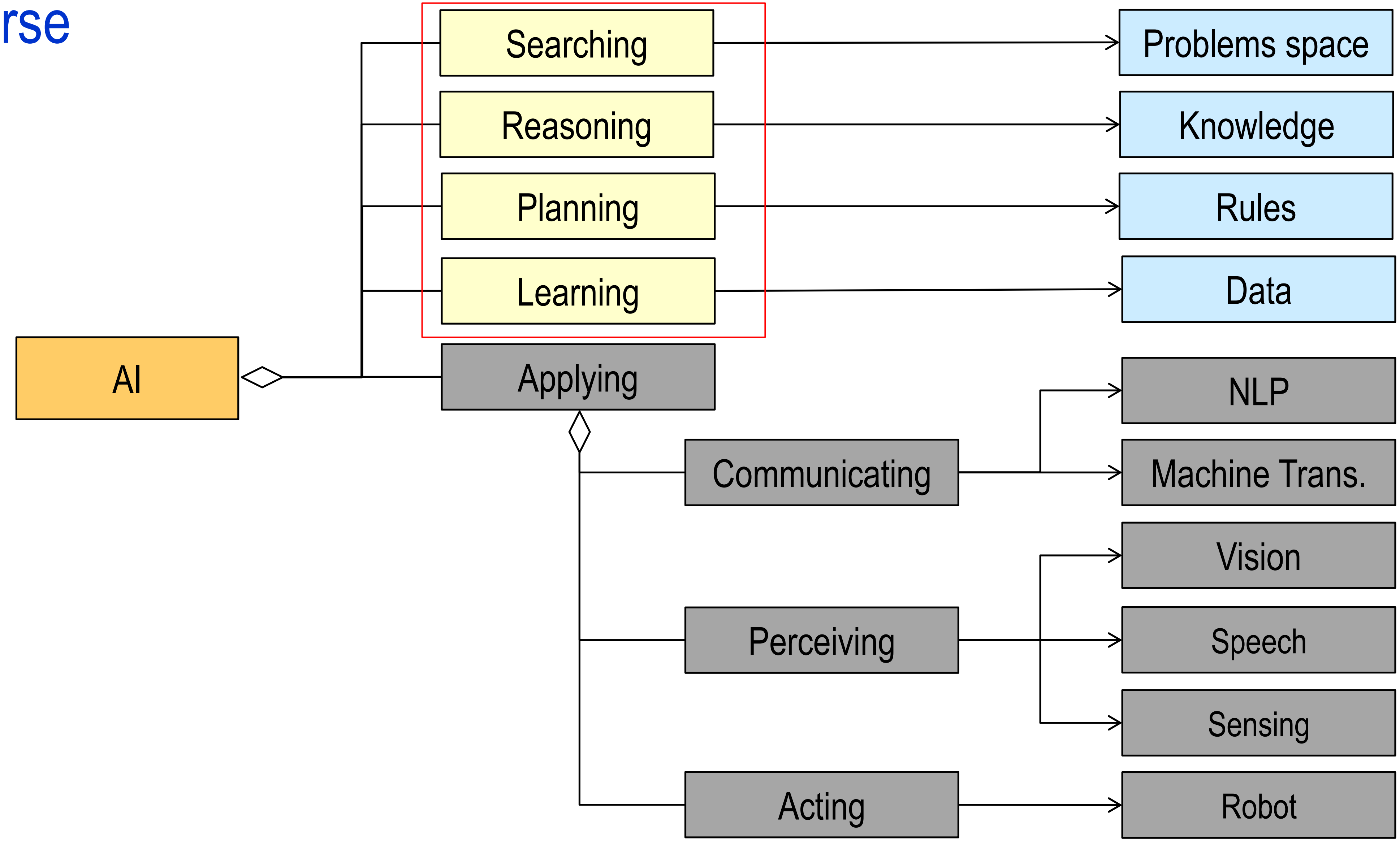

Searching
Reasoning
Planning
Learning
Problems space
Knowledge
Rules
Data
AI
Applying
Communicating
Perceiving
Acting
NLP
Machine Trans.
Vision
Speech
Sensing
Robot

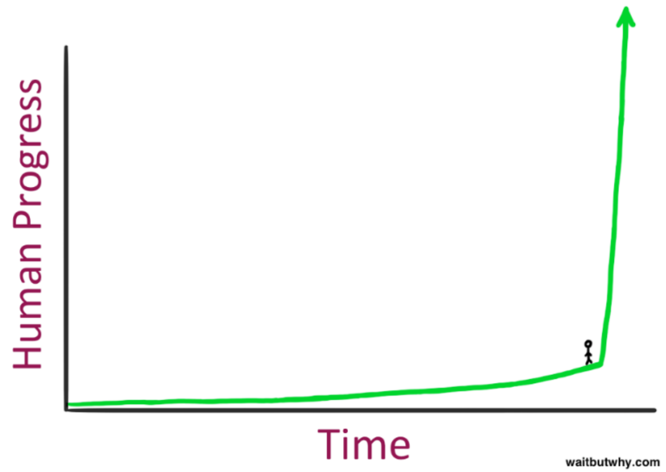
What does it feel like to stand here?

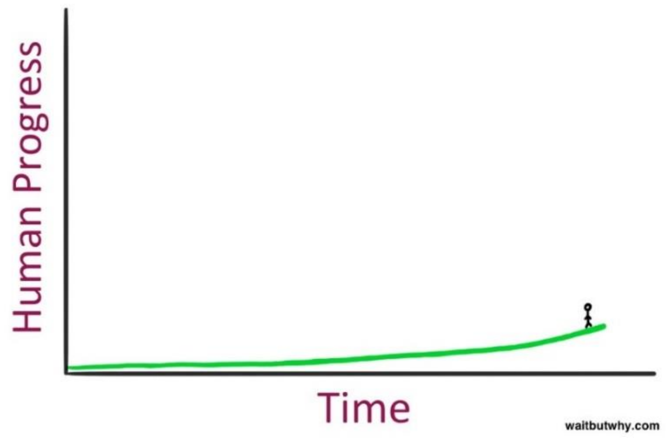
- It seems like a pretty intense place to be standing — but then you have to remember something about what it's like to stand on a time graph: you can't see what's to your right.

  站在看起来好像是令人非常紧张的地方——然后你要记住站在时间曲线上是什么感觉：你看不到你的右侧是什么。

- So here's how it actually feels to stand there: which probably feels pretty normal…

  而这里是要站立的实际感觉如何的地方：大概感觉相当平常…





Source: http://waitbutwhy.com/

Thank you for your attention!

PoAI