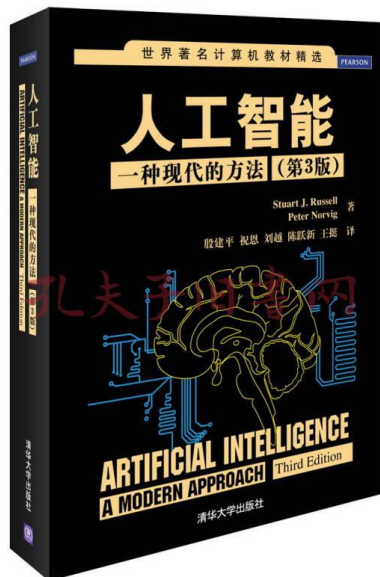# 人工智能技术及应用
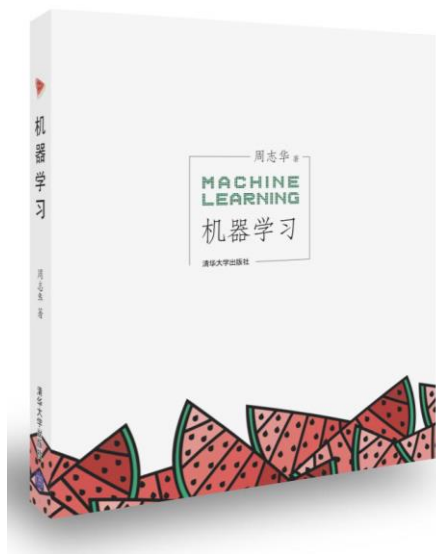## Artificial Intelligence and Application

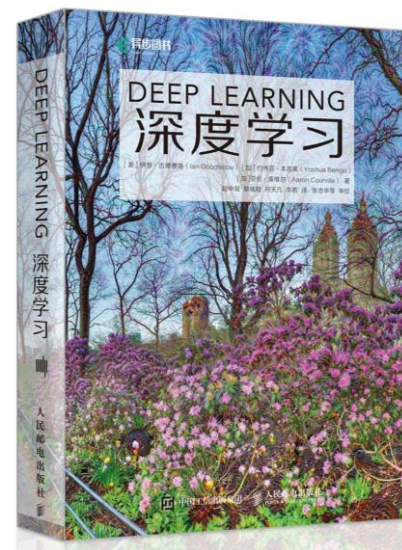# 参考书目

《人工智能：一种
现代的方法》
Stuart J.Russell等
清华大学出版社

《机器学习》
周志华
清华大学出版社
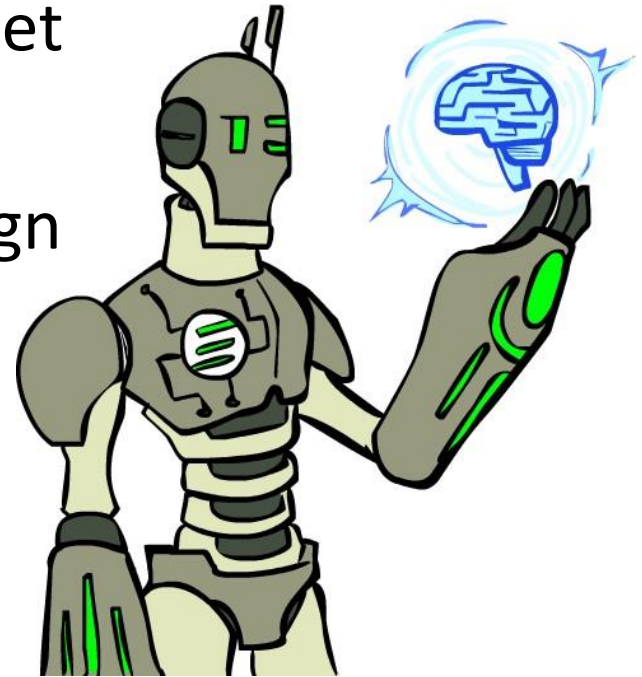
《深度学习》
Ian Goodfellow等
人民邮电出版社

Today

- What is artificial intelligence?
- What can AI do?
  - Where are we and how did we get here?
  - How do we think about the design of AI systems?
- What is this course?

Sci-Fi AI?
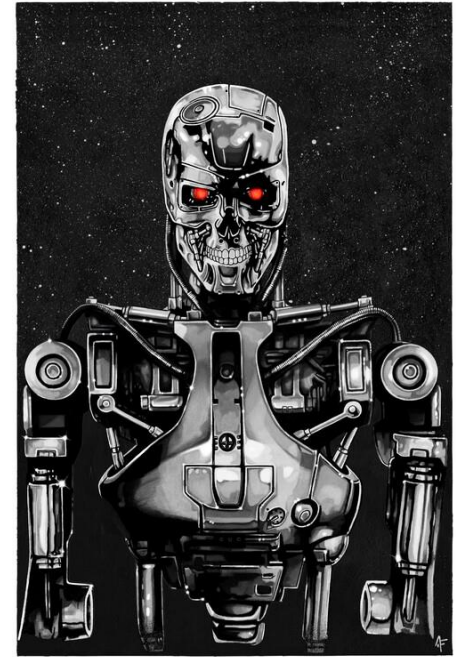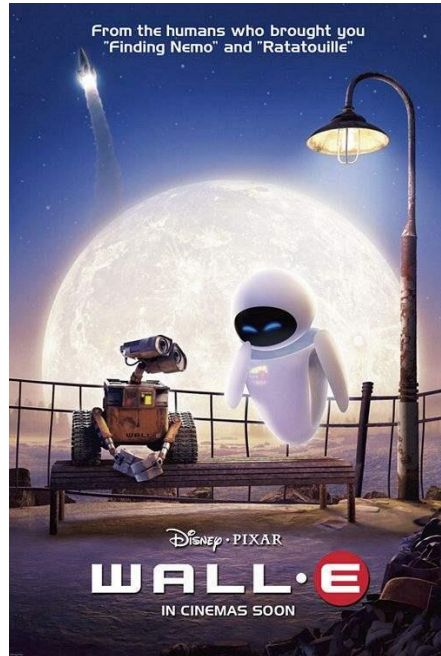
Real-World AI?

AI in Games

Jeopardy (IBM Watson 2011)
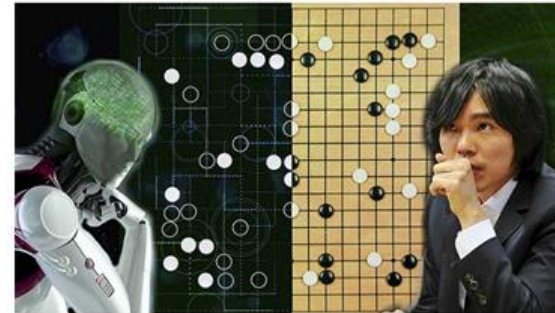
Go (DeepMind AlphaGo 2016)

Dota 2 (OpenAi 2019)

Poker (CMU and Facebook 2019)

Big Dog (Boston Dynamics 2004)

Real-World AI?

Intelligent Drive

Real-World AI?
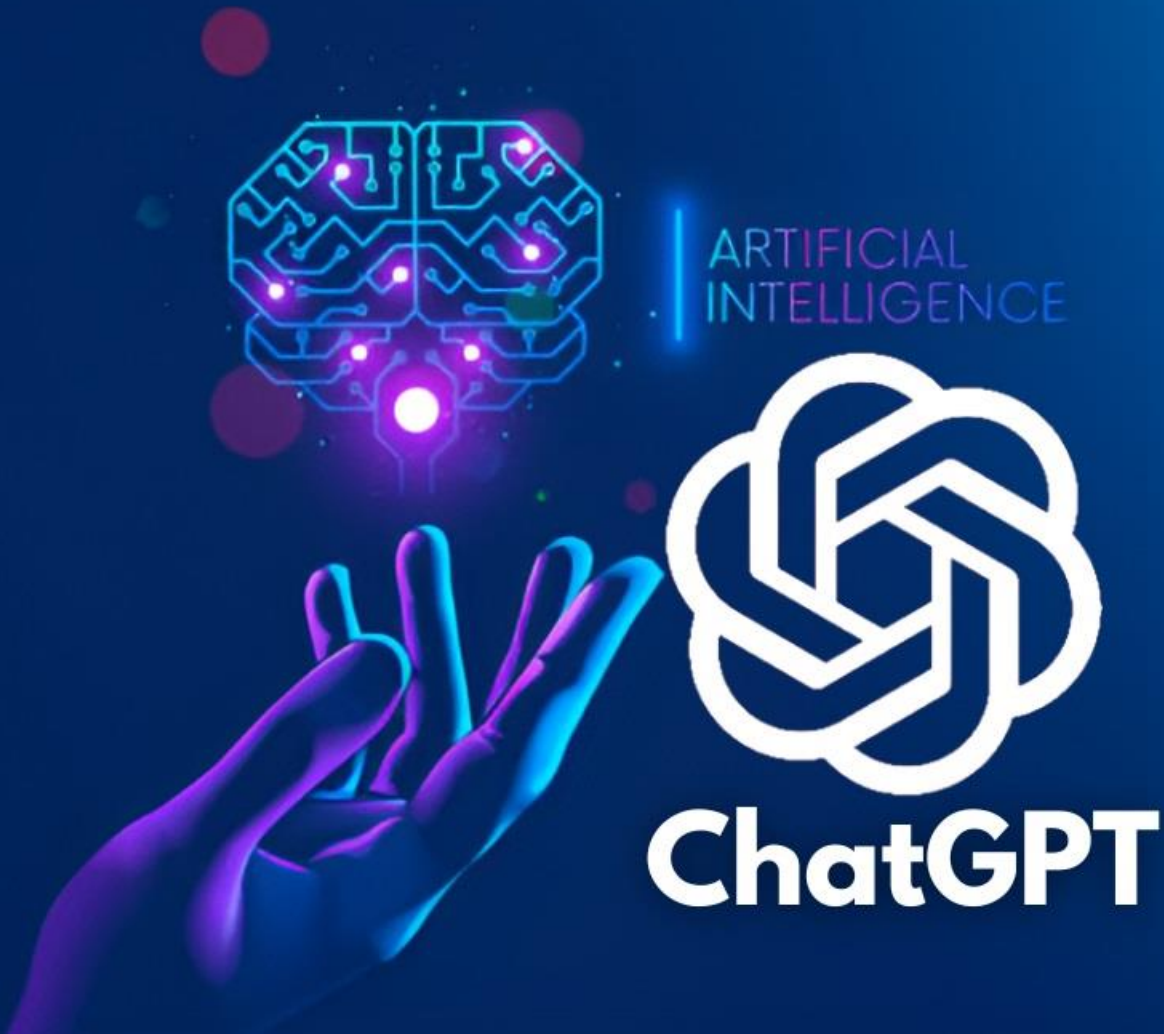
What are GPT for?

What is AI?

Artificial Intelligence

Artificial Intelligence is a field of study that enables machines to mimic human "cognitive" functions, such as "learning' and "problem sovling"

ARTIFICIAL INTELLIGENCE
Any technique that enables computers to mimic human behavior
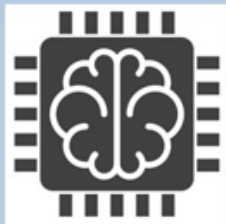
MACHINE LEARNING
Ability to leam without explicity being programmed
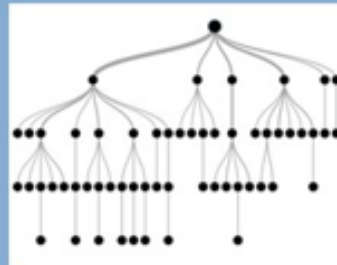
DEEP LEARNING
Leam underlying features in data using neural networks
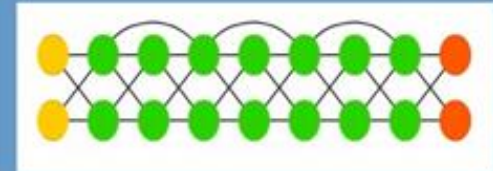
What is AI?

The science of making machines that:
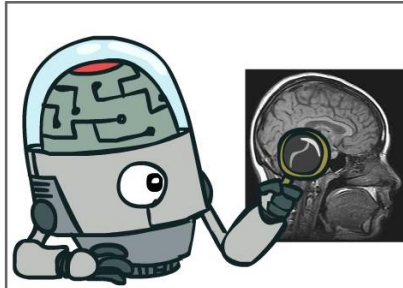
Think like people
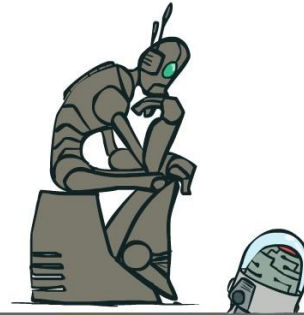
Think rationally

Act like people
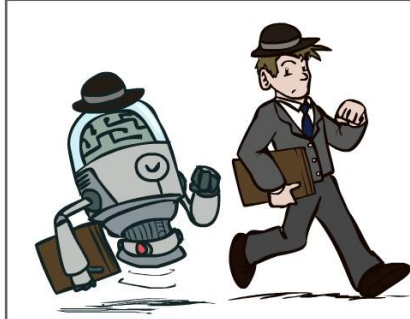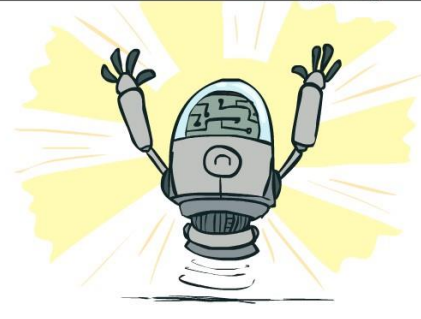
Act rationally

What is AI?

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。

What is AI?

» 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。

What is AI?

» 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。

What is AI?

≫ Weak AI vs. Strong 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。

Brief History of AI

Symbolic AI

Neural AI

1980s-2012
Neural Networks

2012-
Deep learning

1950-1970
AI Excitement

1970- 1980s
Knowledge-based
Systems

1940-1950
Early days

Boolean circuit model of brain
1943

Early AI Programs
1950s

Early Developments
1970s

CNN
1980

Popularization of BP
1986

handwritten digits recognition
1989

AlexNex
2012

AlphaGo
2016

First AI Winter
1966

Second AI Winter
1987

Turing Test
1950

Dartmouth meeting
1956

Expert Systems
1980s

Bayesian Network
1985

SVM
1995

1980s-2000s
Statistical Approach

Statistical AI

Brief 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严冬
1980–1987	The Boom of AI	AI的繁荣期
1987–1993	The Second AI Winter	第二个AI严冬
1993–Present	The Breakthrough	突破

Brief History of AI

>> 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。
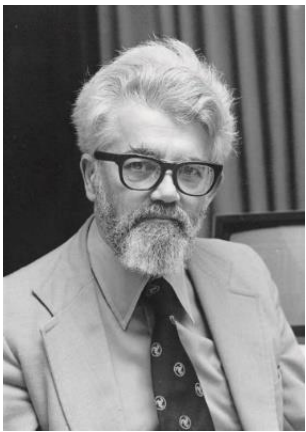
☐ 1956, the field of Artificial Intelligence research was founded at a conference on Dartmouth College.

 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

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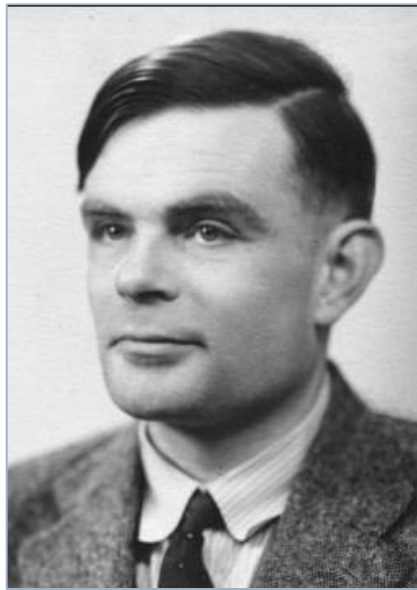
Alan M. Turing
艾伦·图灵
English mathematician, logician, computer scientist
and cryptanalyst.
英国数学家、逻辑学家、
计算机科学家和密码学家

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

Turing Test

Natural language processing   ■ 自然语言处理

Knowledge representation   ■ 知识表示

Automated reasoning   ■ 自动推理

Machine learning   ■ 机器学习

Total Turing Test

Computer vision   ■ 计算机视觉

Robotics   ■ 机器人学

Early AI Programs

- Machine can play games

  - 1952, **Samuel's Checkers Player:** Samuel's program can play at strong amateur level by performing a lookahead search and estimate"score"for every move.

Checkers
Game

Playing checkers
on the IBM 701

- Machine can prove theorems

  - 1956, **Newell & Simon's Logic Theorist:** it can prove theorems in Principia Mathematica using search tree and heuristics search.

    - Root is the hypothesis; Each branch is a corollary; .
    - Proposition can be found in the tree, and proof is the search path.

  hypo   Prop
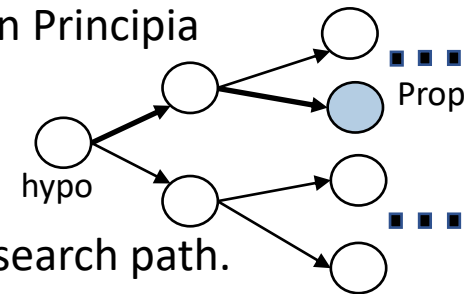
  - Further, Newell and Simon's General Problem Solver promised to solve any problem which could be suitably encoded in logiC.

Birth of AI

• 1956, Workshop at Dartmouth College (达特茅斯会议).

John McCarthy
（1971 Turing Award)

Marvin L ee Minsky
(1969 Turing Award)

Claude Elwood
Shannon

- Name "**Artificial Intelligence**" for the new field.

- Aim for general principles:

Every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it.

Brief History of AI

》 1956–1974, The Golden Years

☐ 1956, Herbert Simon and Allen Newell had a demonstration the first AI program, Logic Theorist (LT).

    1956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。

First AI Winter

Machines will be capable, within 20 years, of doing any work a man can do.

- Herbert Simon (1975 Turing Award)

- Underwhelming results

  - Machine Translation (MT): English→Russian→English.

    The spirit is willing but the flesh is week. (心有余而力不足)

    (Russian)

- The vodka is strong but meat is rotten. (伏特加酒虽然很浓，但肉是腐烂的)

- 1966: ALPAC report cut off government funding for MT, first AI winter.

- Problems:

  - Limited computation: search space grew exponentially, outpacing hardware.

  - Limited information: complexity of AI problems (number of words, objects, concepts in the world).

Brief History of AI

First AI Winter

Machines will be capable, within 20 years, of doing any work a man can do.
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- 1966: ALPAC report cut off government funding for MT, first AI winter.

- Contributions（John McCarthy）：

  - Lisp and Lisp machines.

  - garbage collection.

  - time sharing.

  Lisp Language

  Lisp Machines

Brief History of AI

》 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.
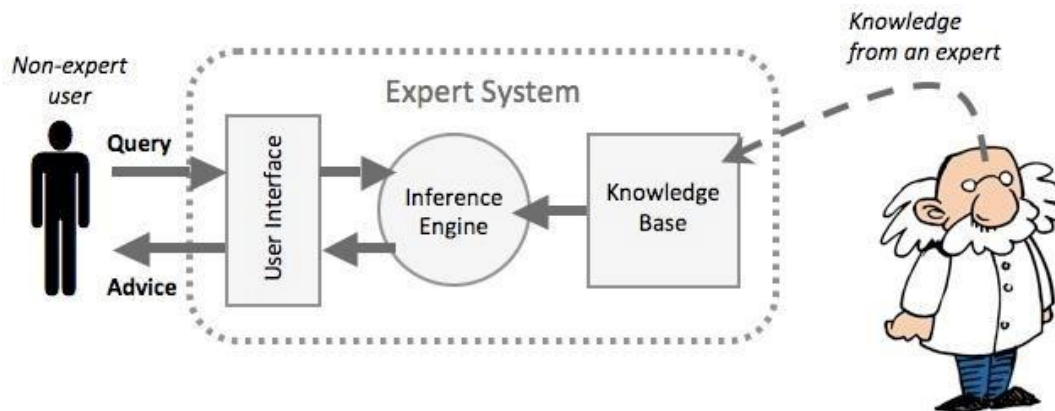
　1973-74，美国DARPA削减了一般性AI学术研究经费。

Brief History of AI

》 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。

Knowledge-based Systems

- DENDRAL (1960s)

  - Identifying unknown organic molecules, by analyzing their mass spectra and using knowledge of chemistry.

  - Meta-Dendral: receives the set of possible chemical structures and corresponding mass spectra as input to propose a set of rules of mass spectrometry as knowledge base.

  - Heuristic-Dendral: use mass spectra or other experimental data together with a knowledge base of chemistry to produce a set of possible chemical structures.

- MYCIN (1970s)

  - Diagnose blood infections and recommend antibiotics.

    - a fairly simple inference engine

    - a knowledge base of ~600 rules
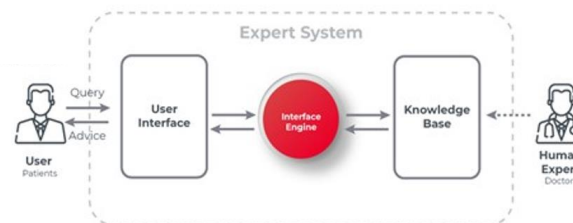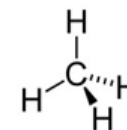
Brief History of AI

Knowledge-based Systems

- Expert systems:
  - Encode prior knowledge to reduce computation.
  - Elicit specific domain knowledge from experts in form of rules:

    If [premises] then [conclusion]

- Contributions:
  - First real application that impacted industry.
  - Knowledge helped both the information and computation gap.

- Problems:
  - Deterministic rules could not handle the uncertainty of the real world.
  - Rules quickly became too complex to create and maintain.

  1987: Collapse of Lisp machines market. Second AI winter occurred.

Brief History of AI

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

Brief History of AI

》 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。
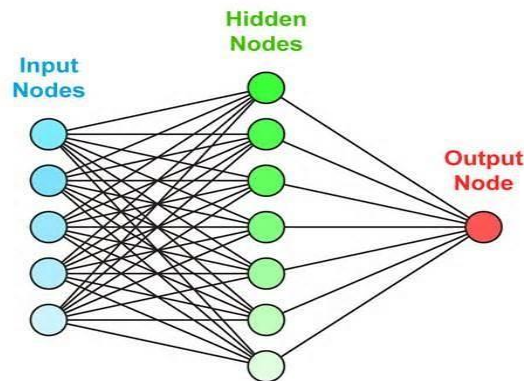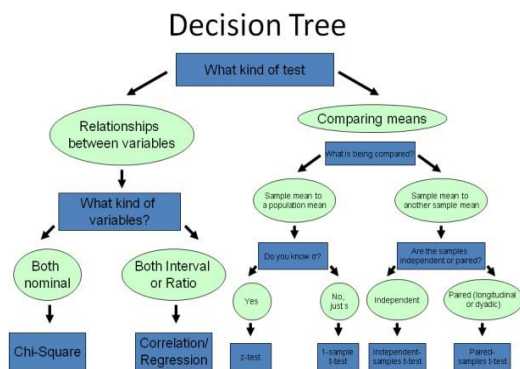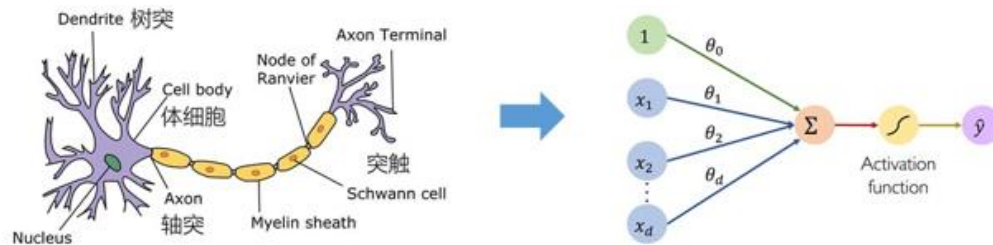
Brief History of AI

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。
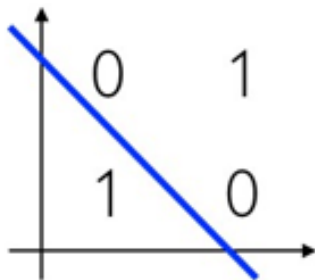
Neural Networks

- 1943, McCulloch and Pitts introduced Artificial Neural Networks, connect neural circuitry and logic by **Threshold logic unit**.

- 1969, Perceptrons book showed that linear models could not solve XOR, killed neural nets research.

Linear classifier
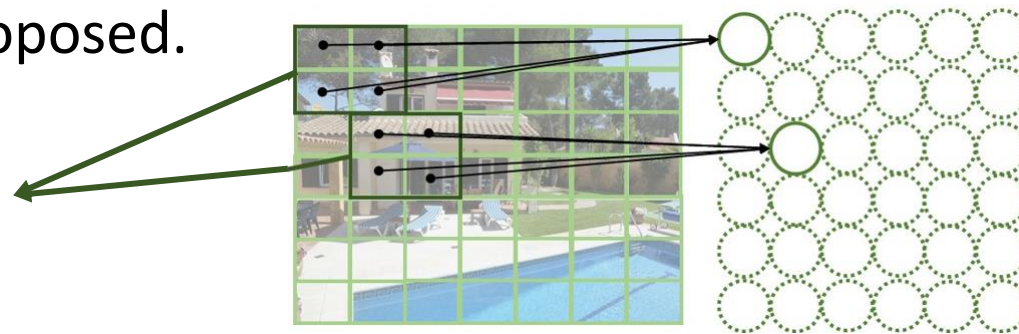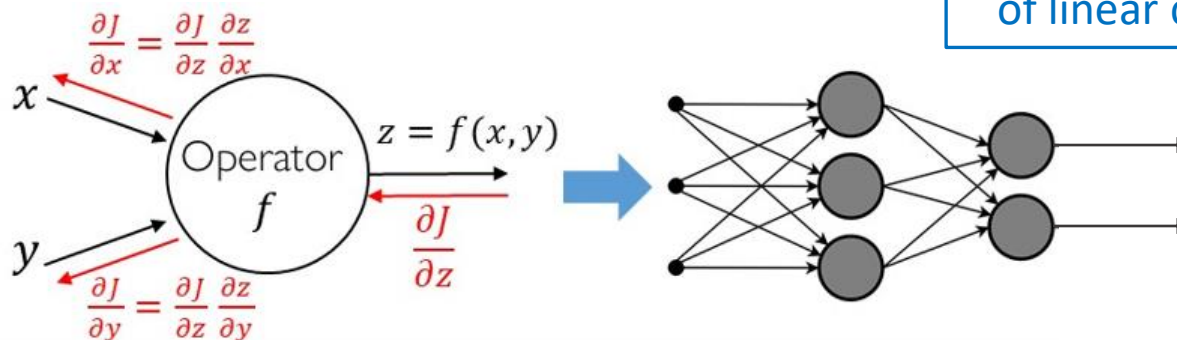can not solve XOR ☹

Marvin Lee Minsky
(1969 Turing Award)

Some Progresses

- 1980, inspired by biological processes, Convolutional Neural Network is proposed.

Receptive field
(感受野)

- 1986, backpropagation is popular for training multi-layer networks.

Break the limitation of linear classifier

$$\frac{\partial J}{\partial x} = \frac{\partial J}{\partial z} \frac{\partial z}{\partial x}$$

x

Operator f

$z = f(x,y)$

$\frac{\partial J}{\partial z}$

y

$$\frac{\partial J}{\partial y} = \frac{\partial J}{\partial z} \frac{\partial z}{\partial y}$$

Brief History of AI

Real Applications

- 1989, LeCun applied Convolutional Neural Networks to recognizing handwritten digits for USPS.
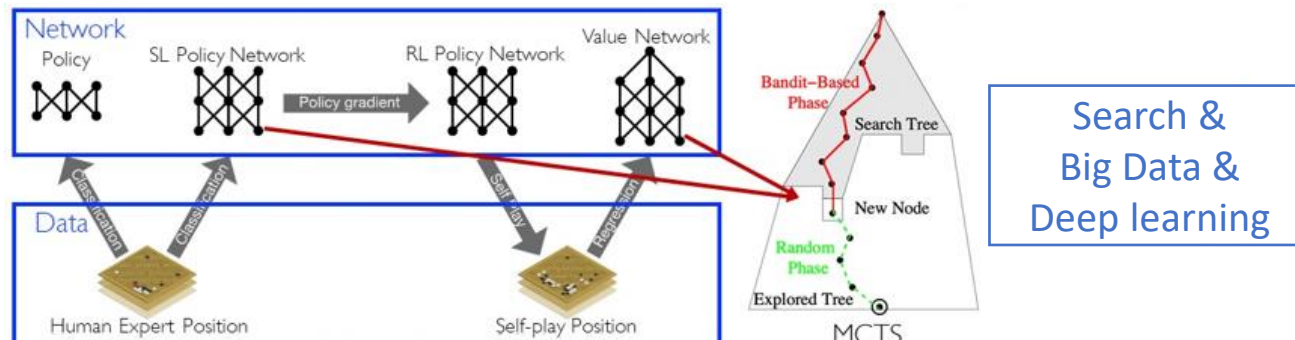

Yann LeCun

(2018 Turing Award)

Deep Learning

- AlexNet (2012): deep convolutional networks on ImageNet powered by GPU.

Big Data &
Big Computation

- AlphaGo (2016): deep reinforcement learning defeated world champion Lee Sedol.

Search &
Big Data &
Deep learning

Brief History of AI

Bayesian Networks

Judea Pearl
(2011 Turing Award)

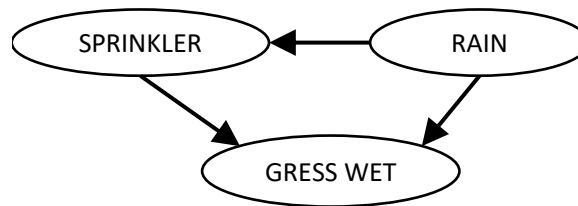"for fundamental contributions to artificial intelligence through the development of a calculus for probabilistic and causal reasoning"

- 1985, Bayesian network: use graphical models for reasoning under uncertainty.

Conditioned on RAIN

RAIN	SPRINKLER T	F
F	0.4	0.6
T	0.01	0.99

RAIN	
T	F
0.2	0.8

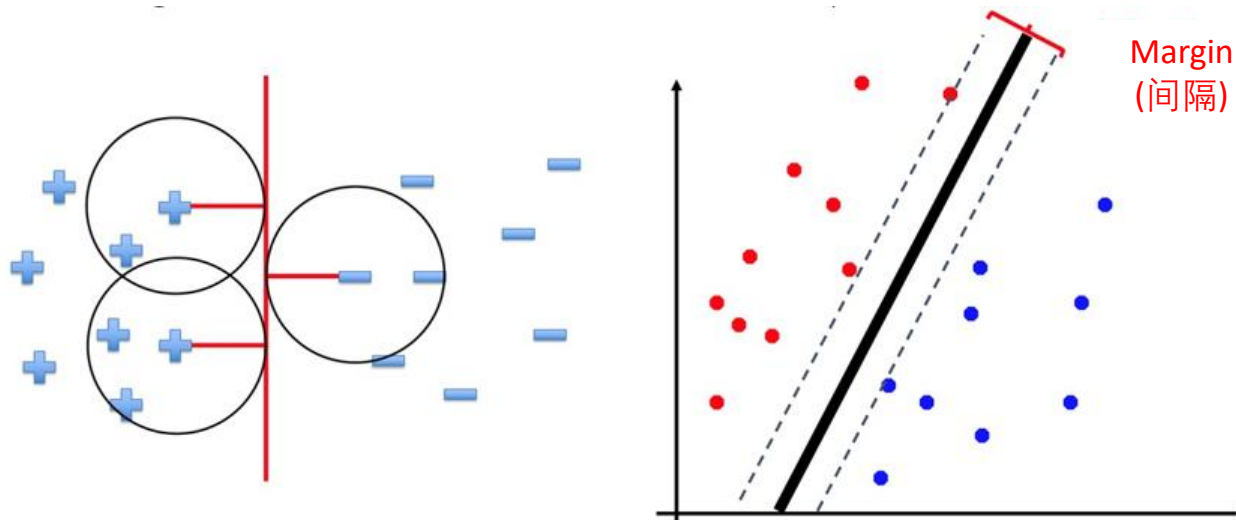| SPRINKLER	RAIN	GRASS WET T	F
F	F	0.0	1.0
F	T	0.8	0.2
T	F	0.9	0.1
T	T	0.99	0.01

Conditioned on Sprinkler & RAIN

Real world processes are probabilistic!

Support Vector Machines

- 1995, SVM: find the linear classifier to maximize the margin.

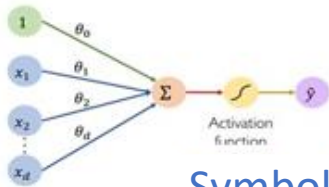 - Margin: Twice of the distance to the closest points of either class.
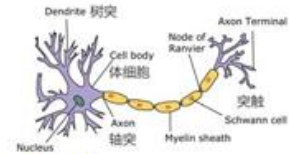

Margin
(间隔)

Find the best by optimization algorithm!

Three Intellectual Traditions

Symbolic AI

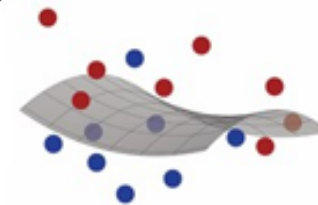A top- down approach by abstracting logic rules, such as knowledge base.

A Melting Pot:
Probability, Astronomy, Logic, Statistic, Neuroscience, Economics, Optimization, Algorithms, Control Theory, …

Neural AI

A bottom-up method, starting with simple perceptual tasks.

Statistical AI

Reach the objective function by optimization algorithms with mathematical rigor and clarity.

Brief History of AI

AI Methods   Applications

Search

| Uniform Cost Search | CSP and Local Search | Adversarial Search |

Early AI programs(1950s)
Games: AlphaGo(2016)

Symbolic AI
Logic

| First-Order Logic | Propositional Logic |

Knowledge based systems(1970-1980s)

Neural AI
Learning

| Statistical Learning | Deep Learning |

Widely used in recent applications(2010-)

Statistical AI
Uncertain Reasoning

| Probabilistic Reasoning | Sequential Reasoning | Causal Reasoning |

Topic Model (2000s)
Weather Prediction

Communicating Perceiving Acting

| NLP | CV | Robotics |

Brief History of AI

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

Brief History of AI

» 1993–Present, Breakthrough

☐ In 2011, Google started Deep Learning project, Google Brain, as one of the Google X projects.
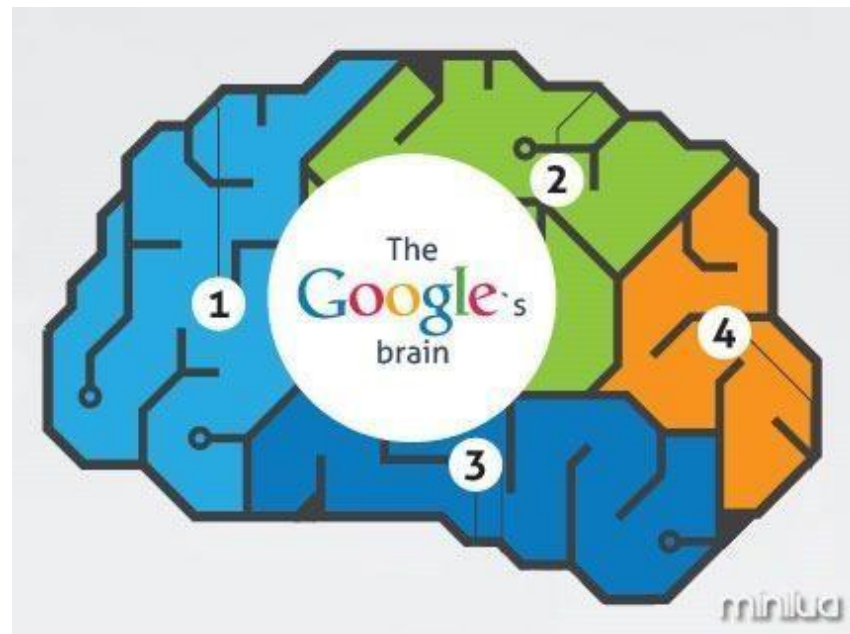
　　2011，谷歌启动了深度学习项目，谷歌大脑，作为Google X项目之一。

- 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。

Brief History of AI

》 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。

Brief History of AI

》 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。
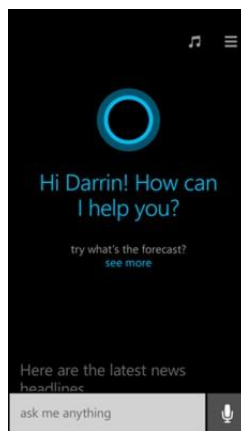
Brief History of AI

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.
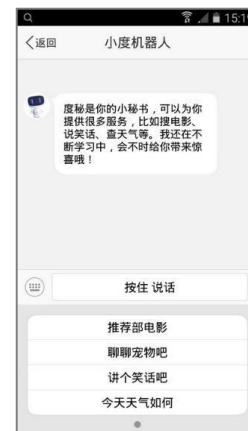
　2014年6月，微软中国推出了聊天机器人小冰，可让微信用户与她交谈。

☐ 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

Brief History of AI

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。

Brief History of AI

☐ 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.
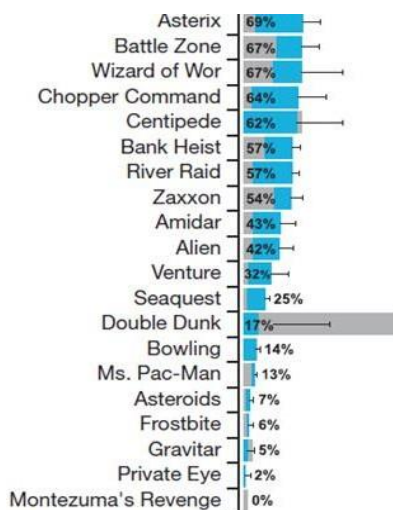TrueNorth是一款神经形态的CMOS芯片，由4096个硬件核组成，每个仿真256个可编程的硅神经元，总计刚好超过百万个神经元。
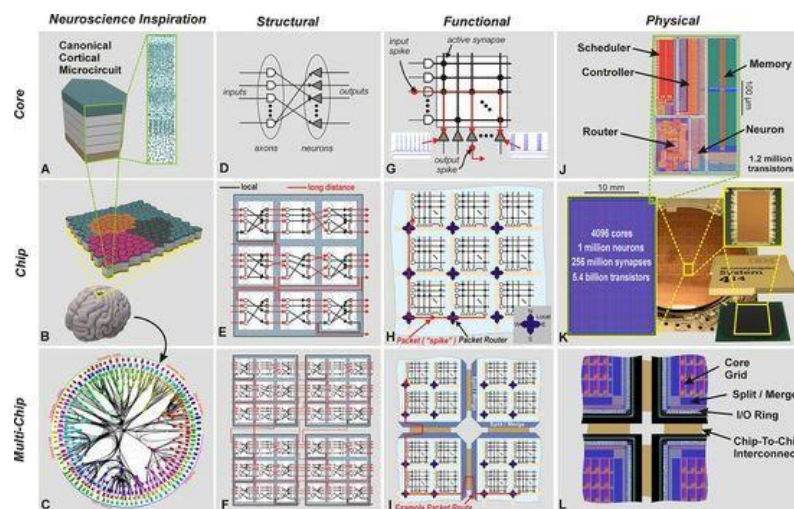
Brief History of AI
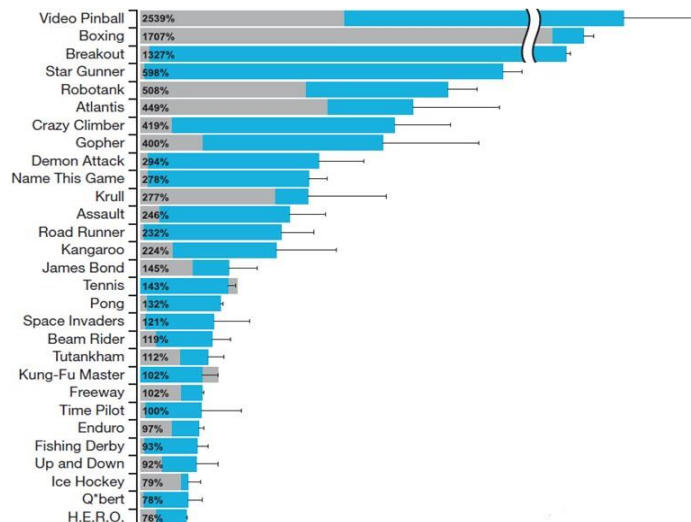
》 1993–Present, Breakthrough

☐ 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

Brief History of AI

≫ 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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International weekly journal of science

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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

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).

Brief History of 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 !

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

What is AI?

The science of making machines that:
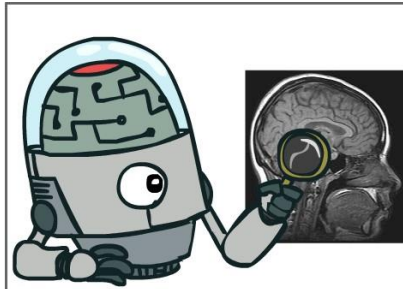
Think like people
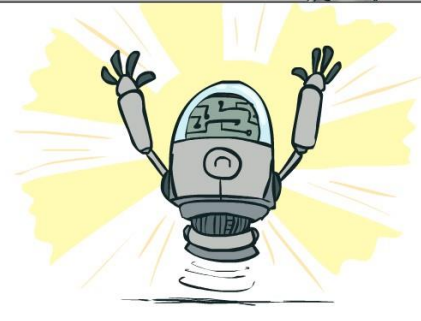
Think rationally
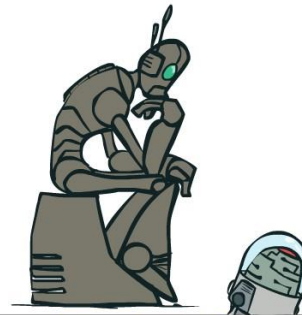
Act like people
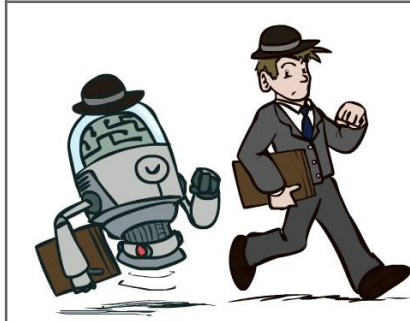
Act rationally

Rational Agent

Rational Decisions

- We'll use the term **rational** in a very specific, technical way:

  - Rational: maximally achieving pre-defined goals
  - Rationality only concerns what decisions are made (not the thought process behind them)
  - Goals are expressed in terms of the **utility** of outcomes
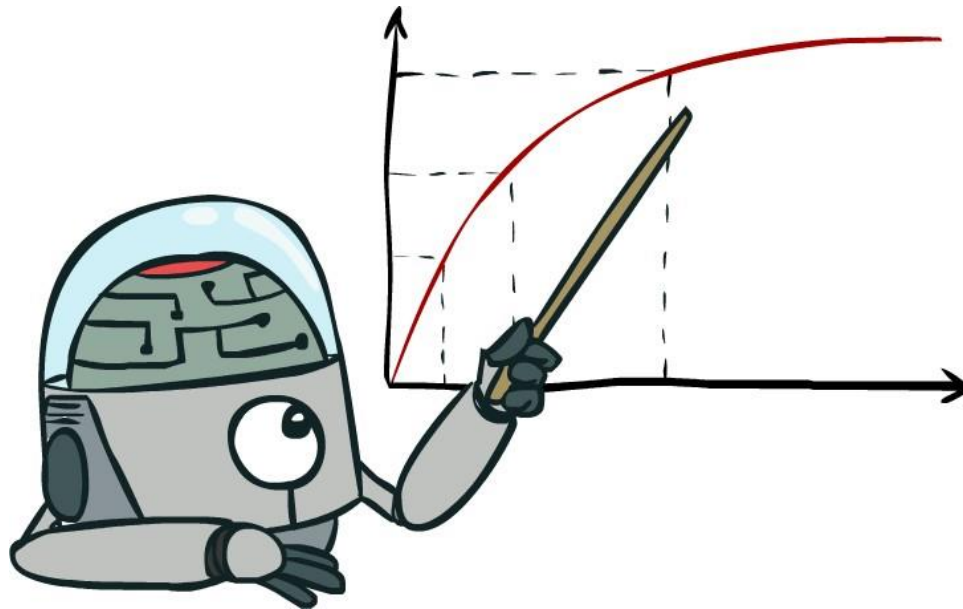 - Being rational means **maximizing your expected utility**

A better title for this course would be:

Computational Rationality

Maximize Your Expected Utility

Rational Agent

Agent and Environment

Intelligent agent refers to an autonomous entity which acts, learns or uses knowledge towards achieving goals, upon an environment using observation through sensors and consequent actuators.
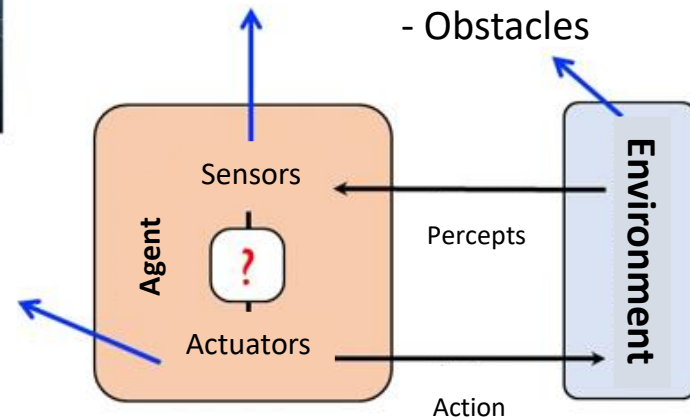
Audio Control

People Tracking

Command: straight

Tracking

nature

DUAL CONTROL

Sensors:
- Camera
- Microphone

Environment:
- Streets
- Pedestrians
- Obstacles
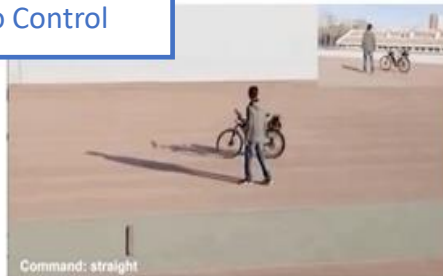
Actuators:
- Steering
- Chain
- Brake

Agent

Sensors

?

Actuators

Percepts

Action

Environment

Towards artificial general intelligence with hybrid Tianjic chip architecture. Nature. 2019.

Designing Rational Agents

o An **agent** is an entity that *perceives* and *acts*.

o A **rational agent** selects actions that maximize its (expected) **utility**.

o Characteristics of the **percepts, environment,** and **action space** dictate techniques for selecting rational actions

o **This course** is about:
  o General AI techniques for a variety of problem types
 o Learning to recognize when and how a new problem can be solved with an existing technique
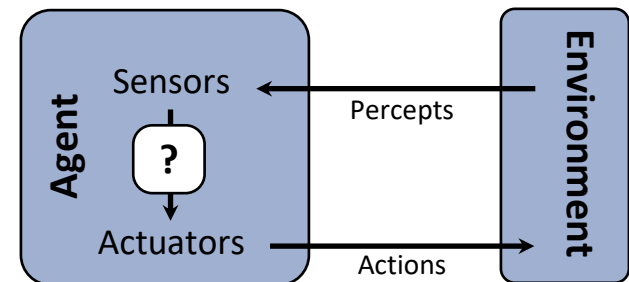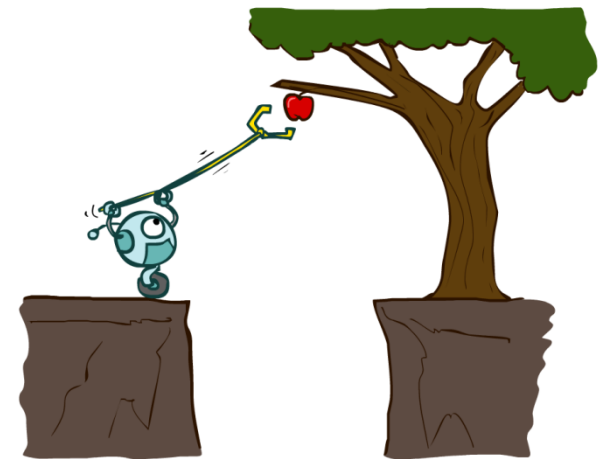
AI as Designing Rational Agents

- An **agent** is an entity that *perceives* and *acts*.

- A **rational agent** selects actions that maximize its expected **utility**.

- Characteristics of the **sensors, actuators, and environment** dictate techniques for selecting rational actions

- **This course** is about:
  - General AI techniques for many problem types
  - Learning to choose and apply the technique appropriate for each problem
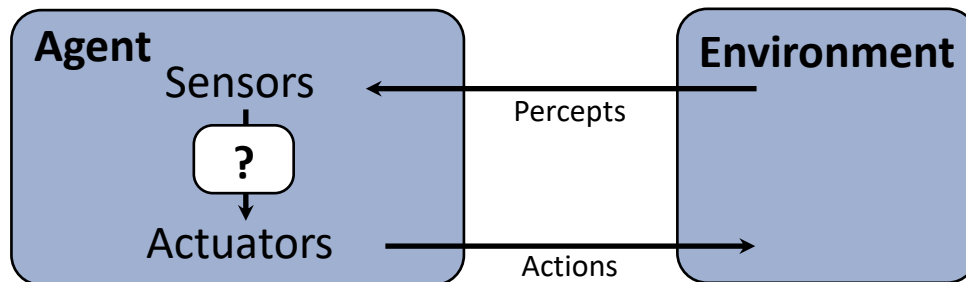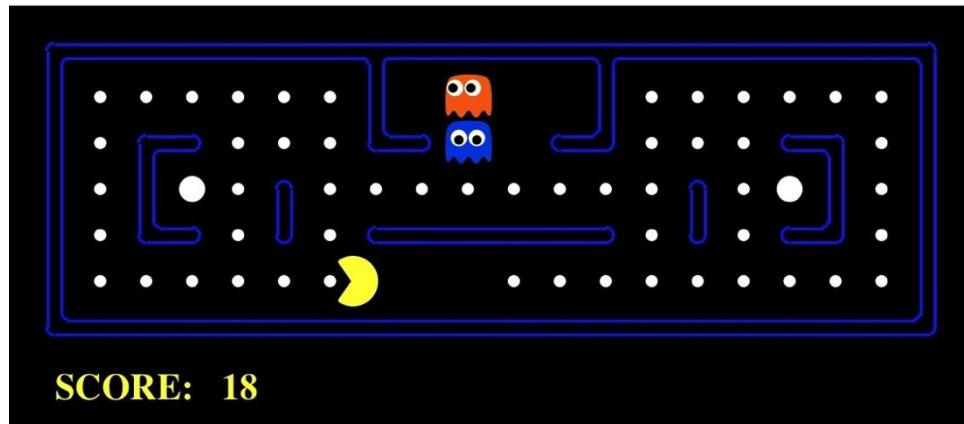
SCORE: 18
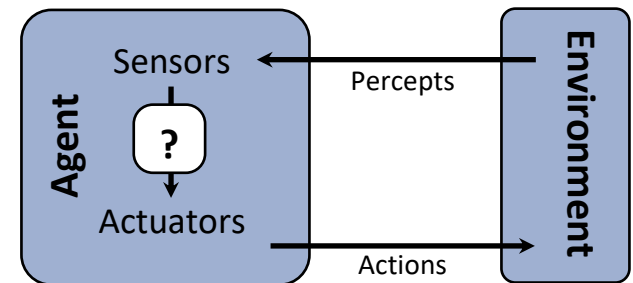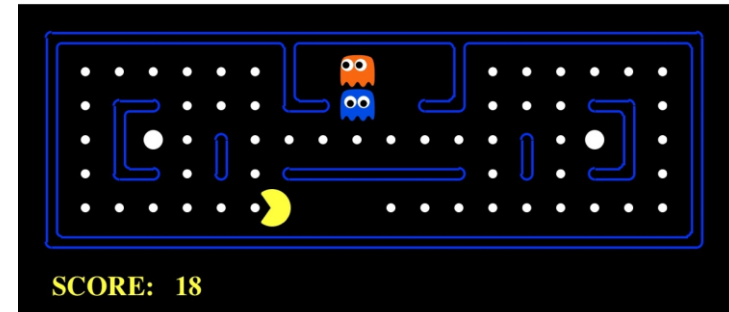
Pac-Man is a registered trademark of Namco-Bandai Games, used here for educational purposes

Rational Agent

Pac-Man as an Agent

Rational Agent

Two Views

- Intelligence Agent

    - Think like human

    - Act like human

  how can we create intelligence?
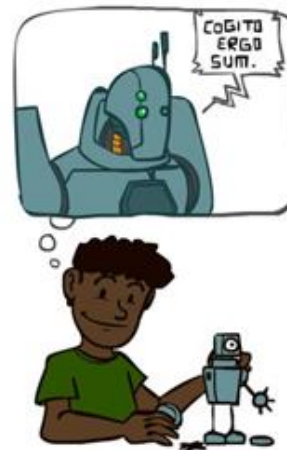
  Perception   Robotics   Language

  Knowledge   Reasoning   Learning

- AI Tools

    - Try to solve problems

    - Human cannot do well

  how can we benefit society?

    - Planning
    - Scheduling
    - Medical
    - Image
    - Topic Model
    - Prediction

Rational Agent

Intelligence Agent

Keep Knowledge
- Procedural: coding, riding bike, ...
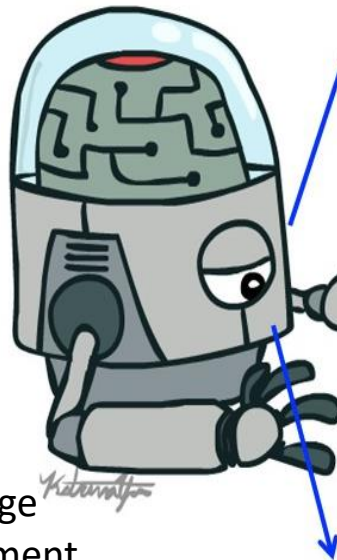- Declarative: where is classroom, ...

classroom, ...

Reasoning
- Inference: exam, ...
- Decision: dining hall for lunch, ...

Learning
- Learn new knowledge
- Adapt new environment

Think Like Human

Perceive the world
Computer vision

Perform actions
Robotics

Communicate with each other
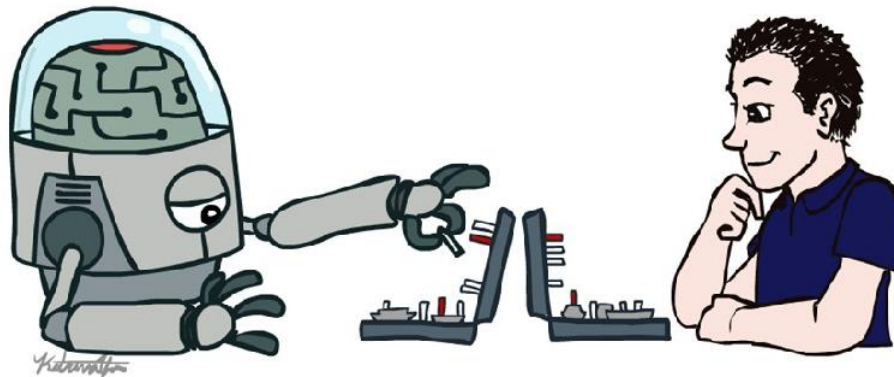Natural language Processing

Act Like Human

Rational Agent

Are We There Yet

| Machines
narrow tasks, millions of examples | Human
diverse tasks, very few examples |

AlphaGo
- Learn from 19.6 million games
- Only play one game Go

Human
- Learn from wide set of experiences
- Do lot of tasks

We are still very far away from Artificial General Intelligence (AGI).