人工智能基础

徐林莉 linlixu@ustc.edu.cn

课程简介

- 教材
  - Artificial Intelligence – A modern approach
        S. Russell and P. Norvig
    人工智能——一种现代方法（第三版）

- 参考书
  - 机器学习 周志华 (2016)

- 课程考核
  - 学期总评=期末考试(60%)+书面作业(15%)+实验部分(25%)

- 课件：
  http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

课程大纲

- 第一部分：人工智能概述/Introduction and Agents (chapters 1,2)
- 第二部分：问题求解/Search (chapters 3,4,5,6)
- 第三部分：知识与推理/Logic (chapters 7,8,9,10)
- 第四部分：不确定知识与推理/Uncertainty (chapters 13 -17)
- 第五部分：学习/Learning (chapters 18,19,20,21)

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

助教

梁钰康　　[liangyukang@mail.ustc.edu.cn]
张放　　　[fangzhang@mail.ustc.edu.cn]
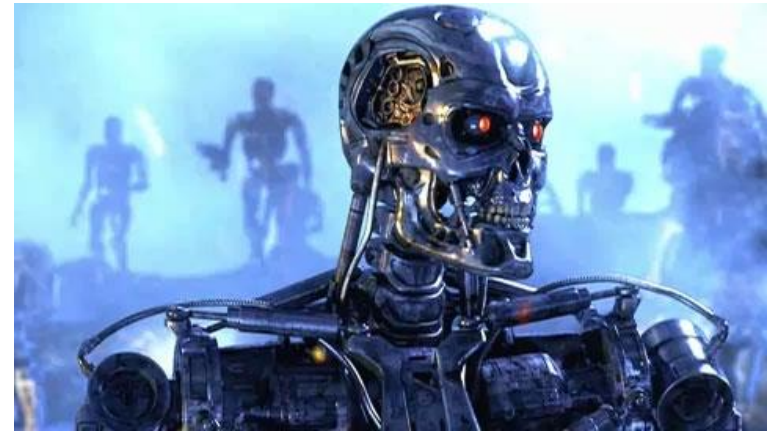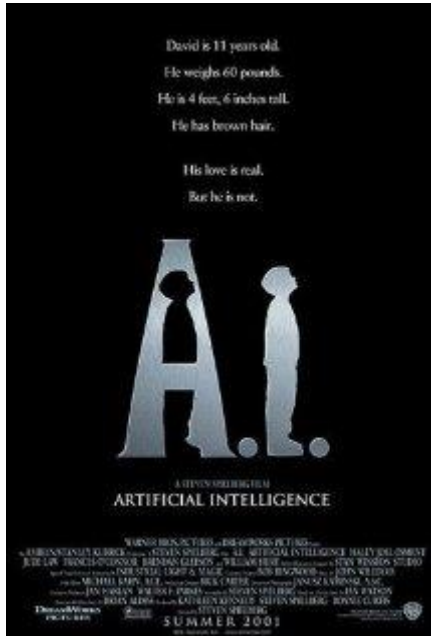高竹锦　　[gaozhujin@mail.ustc.edu.cn]
张文韬　　[wz128595@mail.ustc.edu.cn]

Chapter 1. Introduction

Introduction

- What is AI?
- The history of AI（历史）
- Recent progress in AI（现状）

Sci-Fi AI?

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

Threats of AI?

2 December 2014 Last updated at 13:02

Stephen Hawking warns artificial intelligence could end mankind

COMMENTS (1027)

By Rory Cellan-Jones
Technology correspondent

Stephen Hawking: "Humans, who are limited by slow biological evolution, couldn't compete and would be superseded"

Prof Stephen Hawking, one of Britain's pre-eminent scientists, has said that efforts to create thinking machines pose a threat to our very existence.

New Achievements of AI

Silver, D. et al. Nature (2016)

Go, a complex game popular in Asia, has frustrated the efforts of artificial-intelligence researchers for decades.

ARTIFICIAL INTELLIGENCE

Google masters Go

Deep-learning software excels at complex ancient board game.

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

New Achievements of AI

Li, Y. et al. (2022)

DeepMind   2022-2-19

Competition-Level Code Generation with AlphaCode

Yujia Li[*], David Choi[*], Junyoung Chung[*], Nate Kushman[*], Julian Schrittwieser[*], Rémi Leblond[*], Tom Eccles[*], James Keeling[*], Felix Gimeno[*], Agustin Dal Lago[*], Thomas Hubert[*], Peter Choy[*], Cyprien de Masson d'Autume[*], Igor Babuschkin, Xinyun Chen, Po-Sen Huang, Johannes Welbl, Sven Gowal, Alexey Cherepanov, James Molloy, Daniel J. Mankowitz, Esme Sutherland Robson, Pushmeet Kohli, Nando de Freitas, Koray Kavukcuoglu and Oriol Vinyals

[*]Joint first authors
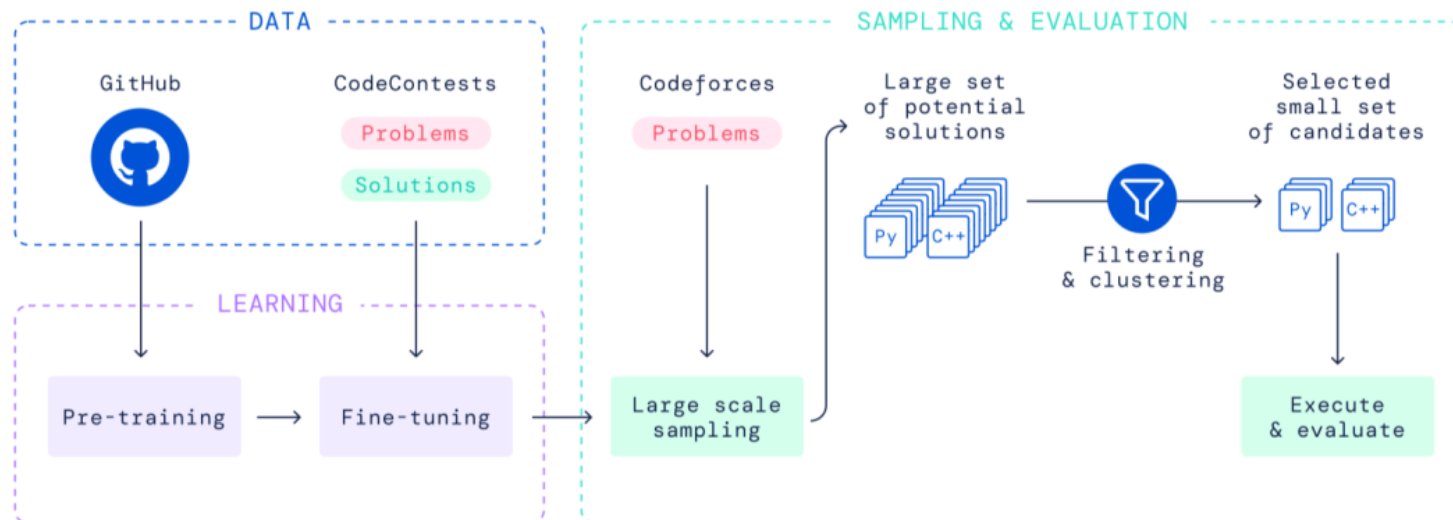
What is AI?

Different people think of AI differently

Views of AI fall into four categories:

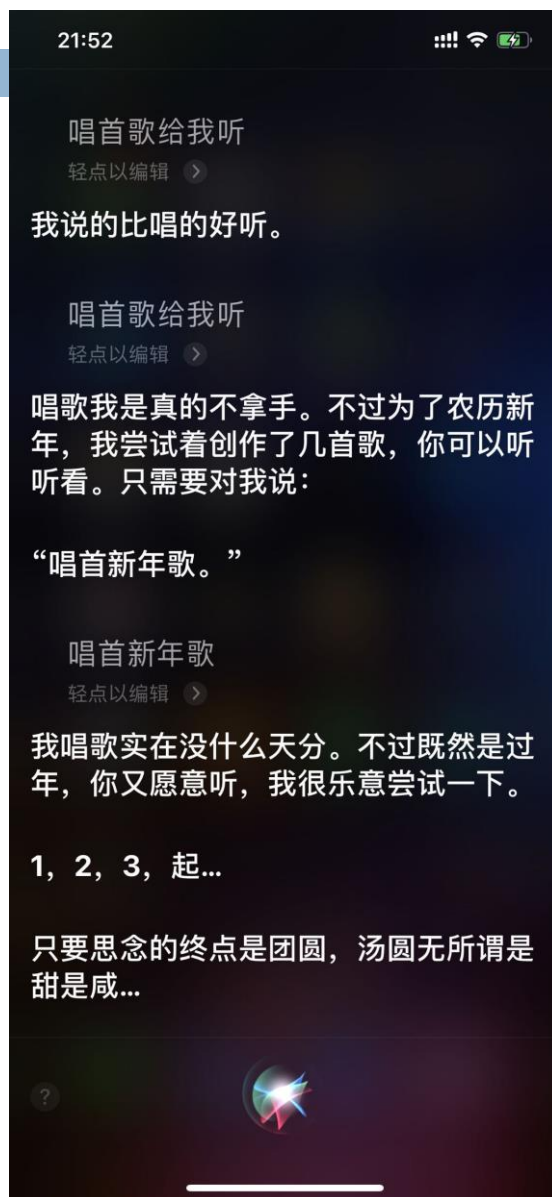| Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

The textbook advocates "acting rationally（理性的）"

Acting humanly: Turing Test图灵测试

- Turing (1950) "Computing machinery and intelligence":
  - "Can machines think?" → "Can machines behave intelligently?"
  - Operational test for intelligent behavior: the Imitation Game
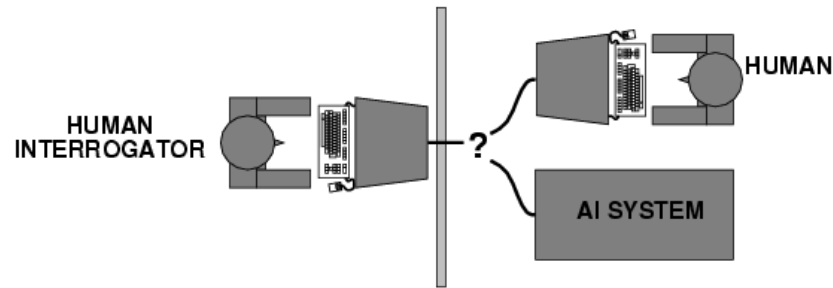
  - Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
  - Anticipated all major arguments against AI in following 50 years
  - Suggested major components of AI: knowledge（知识）, reasoning（推理）, language understanding（语言理解）, learning（学习）
- Problem: Turing test is not reproducible or amenable to mathematical analysis

Acting humanly: Turing Test图灵测试

Thinking humanly: cognitive modeling 认知模型

- 1960s "cognitive revolution": information-processing psychology

- Requires scientific theories of internal activities of the brain

- -- How to validate? Requires
    1) Predicting and testing behavior of human subjects (top-down)
    or 2) Direct identification from neurological data (bottom-up)

    - Both approaches (roughly, Cognitive Science and Cognitive Neuroscience) are now distinct from AI

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

Thinking rationally: "laws of thought"

- Aristotle: what are correct arguments/thought processes?

- Several Greek schools developed various forms of *logic*: *notation* （符号） and *rules* （规则） *of derivation* （推导） for thoughts; may or may not have proceeded to the idea of mechanization

- Direct line through mathematics and philosophy to modern AI

- Problems:
  - Not all intelligent behavior is mediated by logical deliberation
  - What is the purpose of thinking? What thoughts should I have?
  - Logical systems tend to do the wrong thing in the presence of **uncertainty**

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

Acting rationally: rational agent

- Rational behavior: doing the right thing
  - The right thing: 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
  - Entirely dependent on goals!
  - Irrational ≠ insane, irrationality is sub-optimal action
  - Rational ≠ successful

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

# Acting rationally: rational agent

- Our focus here:
  - Systems which make the best possible decisions given goals, evidence, and constraints
  - In the real world, usually lots of uncertainty
    - … and lots of complexity
  - Usually, we're just approximating rationality

Maximize Your Expected Utility

Rational agents

- An agent is an entity that perceives and acts

- This course is about designing rational agents

- Abstractly, an agent is a function from percept histories to actions:
$$[f: \mathcal{P}^\star \rightarrow \mathcal{A}]$$

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

- Caveat: computational limitations make perfect rationality unachievable
  - → design best program for given machine resources
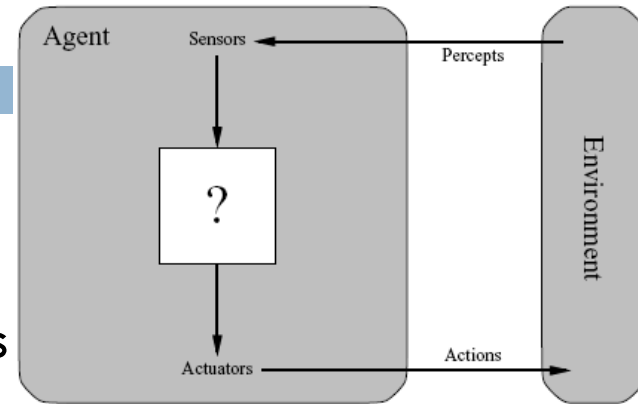
AI prehistory

- Philosophy   Logic, methods of reasoning, mind as physical system foundations of learning, language, rationality

- Mathematics   Formal representation and proof algorithms, computation, (un)decidability, (in)tractability, probability

- Economics   utility, decision theory

- Neuroscience   physical substrate for mental activity

- Psychology   phenomena of perception and motor control, experimental techniques

- Computer engineering   building fast computers

- Control theory   design systems that maximize an objective function over time

- Linguistics   knowledge representation, grammar

AI history

- ☐ The gestation of AI 孕育期 （—1956）
- ☐ Reasoning methods 注重推理时期 （1956-1975）
- ☐ Knowledge-based system 知识运用时期 （1976-1988）
- ☐ Integration 集成运用（1989- present）

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

The Gestation of AI

- 古希腊Aristotle（亚里士多德BC 384-322），给出形式逻辑的基本规律 Syllogism(三段论)。

- 英国Bacon（培根1561-1626），系统地给出Induction(归纳法)。

- 德国Leibnitz（莱布尼茨1646-1716）提出Symbolic Logic(数理逻辑)。

- 英国Boole（布尔1815-1864）提出 Boolean Algebra(布尔代数)系统，实现了思维符号化和数学化

The Gestation of AI (Cont.)

- 1936 英国Turing（图灵,1912-1954）:理想计算机模型Turing Machine（图灵机）

- 1946 美国Mauchly（莫克利）, Eckert（埃克特）: ENIAC

- 1948 美国Shannon（香农）: Information Theory(信息论)

- 1950 Turing Test图灵测试

The Birth of AI (1956)

John McCarthy organized a two-month workshop at Dartmouth in the summer of 1956, ten young men were there：

McCarthy, Minsky, Rochester, Shannon, Moore, Samuel, Selfridge, Solomonff, Simon, Newell.

They introduced all the major figures to each other and agreed to adopt the name of Artificial Intelligence for the field.

Abridged history of AI

- 1943   McCulloch & Pitts: Boolean circuit model of brain
- 1950   Turing's "Computing Machinery and Intelligence"
- 1956   Dartmouth meeting: "Artificial Intelligence" adopted
- 1952—69   Look, Ma, no hands!
- 1950s   Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
- 1965   Robinson's complete algorithm for logical reasoning
- 1966—73   AI discovers computational complexity Neural network research almost disappears
- 1969—79   Early development of knowledge-based systems
- 1980--   AI becomes an industry
- 1986--   Neural networks return to popularity
- 1987--   AI becomes a science
- 1995--   The emergence of intelligent agents

AI Today

- Mostly about engineering domain-specific solutions rather than creating general theories

- We don't know how to do most of intelligent things, but the rest can be solved pretty well

- A set of "tools" for representing information and using them to solve specific tasks
  - Neural networks, hidden Markov models, Bayesian networks, heuristic search, logic, …

- There's no magic in AI. It's all about representation, optimization, probability, and algorithms

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

Well-known AI applications

- Expert systems (organic chemistry, medicine, geology, configuring computers)
- Speech recognition
- Handwriting recognition
- Game playing (chess, checkers, now Go)
- Robots (automated cars, ping pong player, Honda robot)
- Automated theorem proving
- Web search engines
- Natural language understanding (machine translation, Google)
- Logistics scheduling (military --- people, cargo, vehicles)
- Cruise missiles
- Microsoft Answer Wizard

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

State of the art

- Google language translation services
- Google automatic news aggregation and summarization
- Nuance voice recognition (behind Apple's Siri)
- Face detection and face recognition systems
- Apple Siri question-answering system
- IBM Watson question-answering system
- IBM Deep Blue chess playing program
- Deepmind Alpha Series
- Driverless cars

Machine Translation

The spirit is willing but the flesh is weak. [*Bible, Matthew 26:41*]

Дух охотно готов но плоть слаба

Spirit is willingly ready but flesh it is weak

精神是愿意的但骨肉是微弱的

The spirit is wants but the flesh and blood is weak

精神は喜んでであるが、肉は弱い

Mind is rejoicing,, but the meat is weak

El alcohol está dispuesto pero la carne es débil

The alcohol is arranged but the meat is weak

الكحول مستعدّة غير أنّ اللحمة ضعيفة.

The alcohol is ready nevertheless the meat is weak.

Statistical machine translation models

Face Detection

□ Now in most digital cameras for auto focusing

Also blink and smile
detection!

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

Microsoft Kinect for XBOX

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

Question Answering

□ Feb 2011, Watson（沃森）beat human on the quiz show Jeopardy!. And received the first prize of $1 million.

Self-driving cars

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html

Summary

- Applications of AI:
  - high-impact (affect billions of people)
  - diverse (language, vision, robotics)
- Challenges: really hard…
  - computation complexity
  - information complexity
- Paradigm: modeling + algorithms

http://staff.ustc.edu.cn/~linlixu/ai2022spring/ai2022spring.html