

Lecture 1: Introduction to Artificial Intelligence

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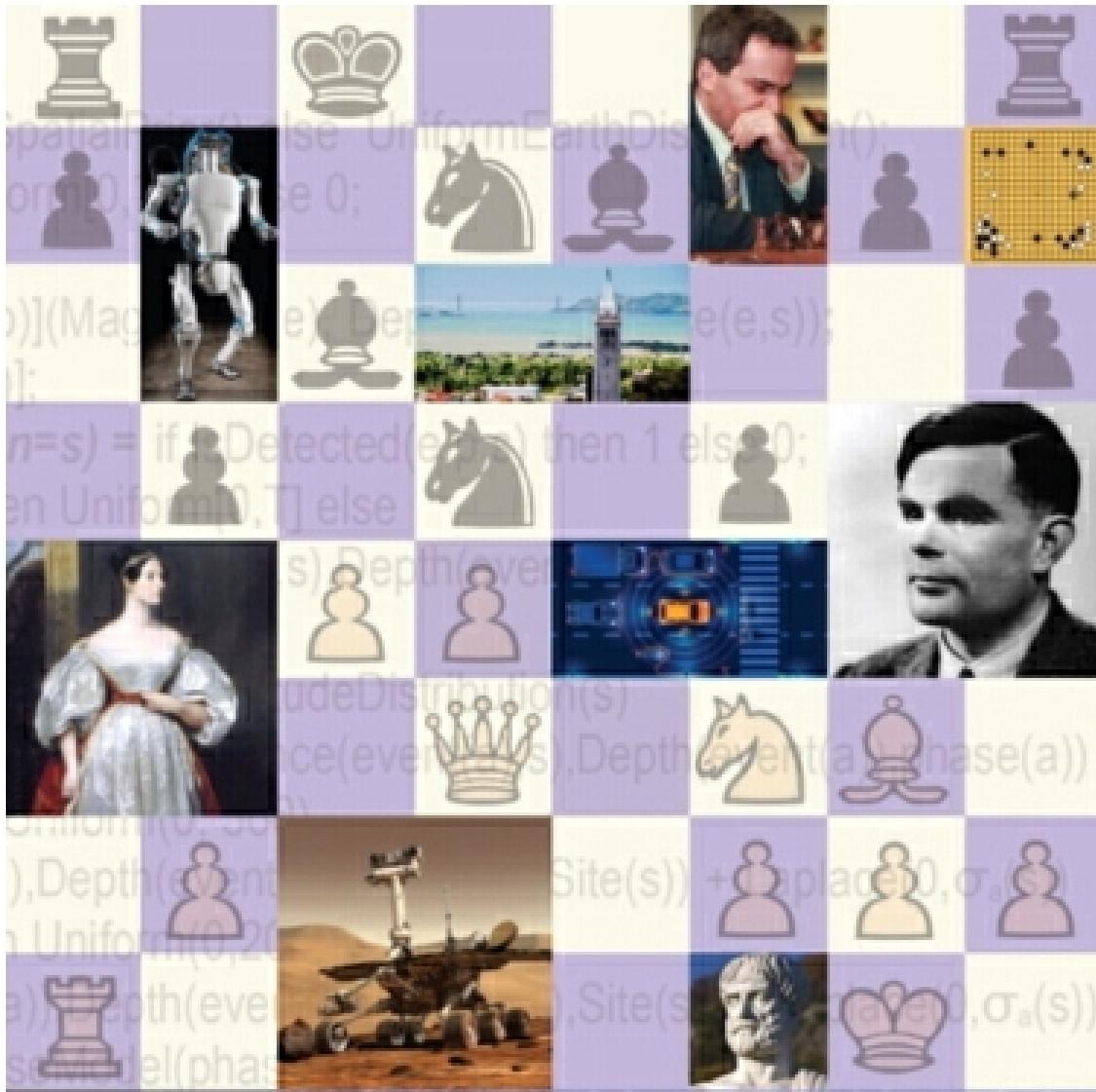
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AI course

- schedule, lecture notes, tutorials, assignment, grading, office hours
- Textbook: S. Russell and P. Norvig ***Artificial Intelligence: A Modern Approach***, 4th edition., Pearson, 2020
- Reference book and home page:
 - Global lecture: <http://shanghailectures.org>
 - Local lecture: <http://axxt.nwpu.edu.cn/2012>- ShanghAI lectures
- Lecturer: LI Xiaoan
- Grading: Class participation (20%), Project assignment (20%), Final exam (60%)
 - **Class participation** includes participation in both lectures and tutorials (attendance, asking and answering questions, presenting solutions to tutorial questions).
 - Note that attendance at every lecture and tutorial will be taken and constitutes part of the class participation grade.
 - **Project assignment**
 - **final exam** (2 hrs) are closed-book
- **Office hours: 10:00am-12:00pm Wednesday (*to be determined*)**



Artificial Intelligence

A Modern Approach

Fourth Edition

Stuart
Russell
Peter
Norvig



- Deep Blue vs Garry Kasparov
 - WATSON
 - AlphaGO vs Lee Sedol
 - Atlas
by Boston Dynamics
 - Self-driving car
 - Alan Turing
-

Syllabus Artificial Intelligence Course 2021 Fall

Date	Topics	Assignment	read before class
10.19	Introduction to Artificial Intelligence (1)	1.1, 1.2	chapter 1 (29p)
10.21	Introduction to Artificial Intelligence (2)	1.7, 1.10, 1.13	chapter 1
10.26	Agents and environments	2.3, 2.5, 2.6	chapter 2 (22p)
10.28	Problem-solving by searching	3.1, 3.6	chapter 3 (45p)
11.02	Informed search algorithms: A*	3.14, 3.21, 3.23	chapter 3 (45p)
11.04	Beyond classical search: introduction	4.1	chapter 4 (34p)
11.09	Beyond classical search: GA	2 Additional exercises	chapter 4 (34p)
11.11	Beyond classical search: NN	18.19, 2 Additional exercises	Chapter 18.7
11.16	Logical agents: Knowledge-based Agents	7.5, 7.10	Chapter 7.1-7.5 (26p)
11.18	Inference-based agents	7.1, 7.4	Chapter 7.1-7.5 (26p)
11.23	Propositional inference	7.13	Chap 7.7, 7.8, 8.1 (13p)
11.25	First-order logic and KE	8.10, 8.1, 8.27	8.2, 8.3, 8.4, 8.5,12
11.30	Inference in first-order logic	9.4, 9.6	9.1-9.4,9.6(p.352) (23p)
12.02	Learning decision trees	18.1, 18.2, 18.6, 18.7*	18.1-18.3 (15p)
12.07	Uncertainty and Bayesian rules	13.8, 13.13, 13.15	Chapter 13
12.09	Bayesian networks	14.1	14.1-14.4 (19p)
12.14	Reinforcement Learning	Reading 21.7	Chap 21
12.16	Embodied Intelligence	2 Additional exercises	Slides of 2017SHAIL
12.21	Summary (Trends in AI)	26.6, 26.10	chap 26, 27 (25p)
12.23	Presentation for course projects		
12.30(tentative)	Final Exam (10:00 am - 12:00 pm)		

Outline

- What is AI?
- A brief history
- The state of the art
- Course overview
- Summary

What is AI?

***The Joy of AI*, made by BBC, 2018**

https://v.youku.com/v_show/id_XMzg2NDE2NjEyMA==.html

***The Imitation Game*, made in 2014**

AI: topics to discuss

- What if one day, scientists manage to create an AI that rivals, or exceeds, the full range of what human intelligence can do?
- Big challenging problem for AI
 - To recognize in practical world, such as *dog*
 - To talk with human naturally, such as *Alana*
 - To drive an UAV/UV in common sense environment, such as *Unman-controlled car*
 - Could AI become emotional/conscious?
 -

Lecture 2: Introduction to Artificial Intelligence (P2)

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What is AI?

Views of AI:

- Human-like AI or nonhuman-like
- Strong AI or Weak AI
- “I think, therefore I am”
- “I act, therefore I am”
-

Definitions:

What is AI?

Views of AI fall into four categories:

Thinking humanly

Thinking rationally

Acting humanly

Acting rationally

Some definitions of artificial intelligence

- **Thinking Humanly**

- “The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense.” (Haugeland, 1985)
- “[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . .” (Bellman, 1978)

- **Acting Humanly**

- “The art of creating machines that perform functions that require intelligence when performed by people.” (Kurzweil, 1990)
- “The study of how to make computers do things at which, at the moment, people are better.” (Rich and Knight, 1991)

- **Thinking Rationally**

- “The study of mental faculties through the use of computational models.” (Charniak and McDermott, 1985)
- “The study of the computations that make it possible to *perceive, reason, and act.*” (Winston, 1992)

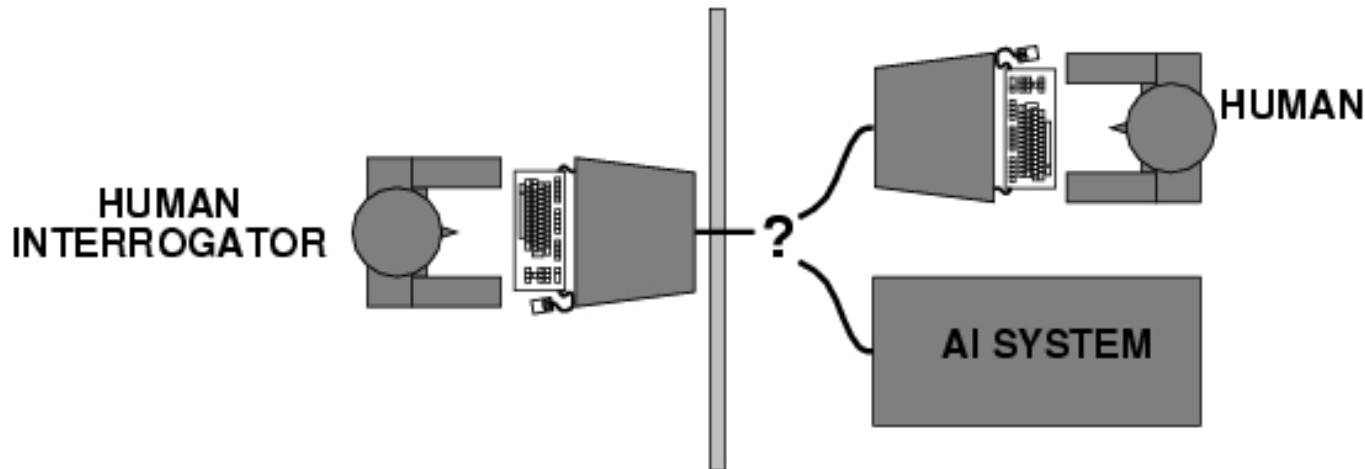
- **Acting Rationally**

- “**Computational Intelligence** is the study of the design of intelligent agents.” (Poole et al., 1998)
- “AI . . . is concerned with intelligent behavior in artifacts.” (Nilsson, 1998)

★ The textbook advocates "acting rationally"

Acting humanly: Turing Test *

- Turing (1950) "Computing machinery and intelligence":
- "***Can machines think?***" → "***Can machines behave intelligently?***"
- Operational test for intelligent behavior: the Imitation Game



- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
- Anticipated all major arguments against AI in following 50 years
- Suggested major components of AI: **knowledge, reasoning, language understanding, learning**

Thinking humanly: cognitive modeling

- 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!

New cognitive revolution: (by Li Deyi, 2020)

New Generation AI in China: focus on Computational Cognition (LXA, 2021)

Thinking rationally: "laws of thought"

- Aristotle: what are correct arguments/thought processes?
- Several Greek schools developed various forms of *logic*: *notation* and *rules of derivation* for thoughts; may or may not have proceeded to the idea of mechanization
- Direct line through mathematics and philosophy to modern AI
- Problems:
 1. Not all intelligent behavior is mediated by logical deliberation
 2. What is the purpose of thinking? What thoughts should I have?

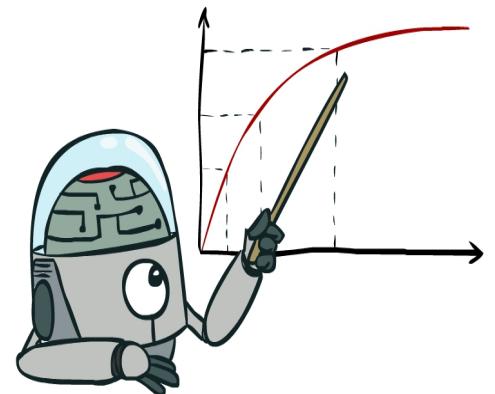
Acting rationally: rational agent*

- Rational behavior: doing *the right thing*
- *The right thing*: that which is expected to maximize goal achievement, given the available information
- Doesn't necessarily involve thinking, but thinking should be in the service of rational action
- Rational Decisions
Rational agent

Rational Decisions*

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

- **Rational**: maximally achieving pre-defined **goals** given available information
- **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

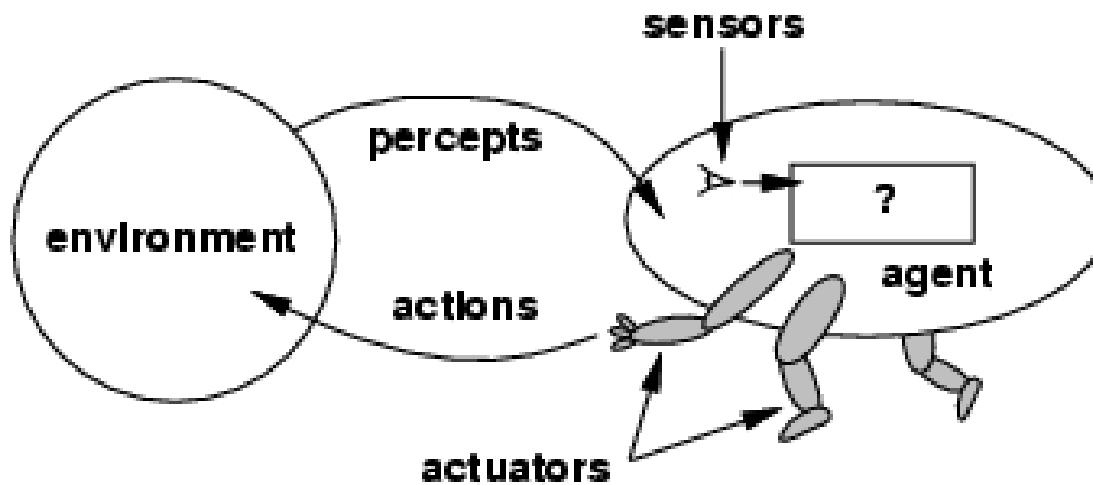


A better title for this course would be:

Computational Rationality

Rational agents*

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



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

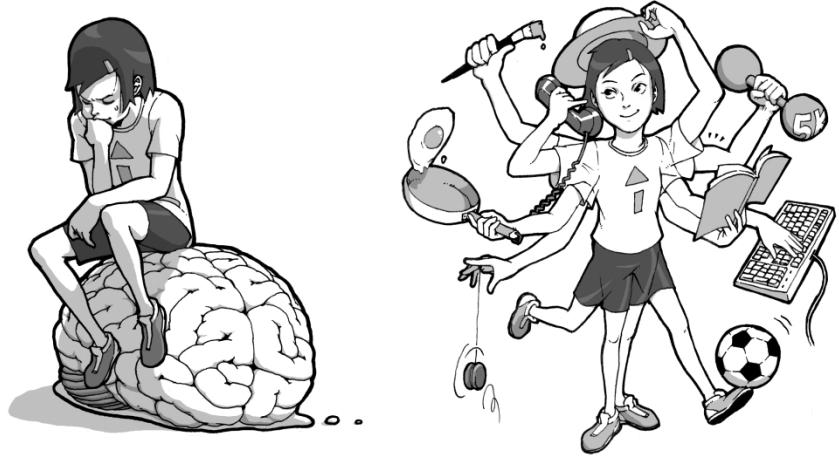
- *Rational* agents vs *Perfect* agents

Caveat!: computational limitations make perfect rationality unachievable

Two views of intelligence

classical:
“cognition as computation”

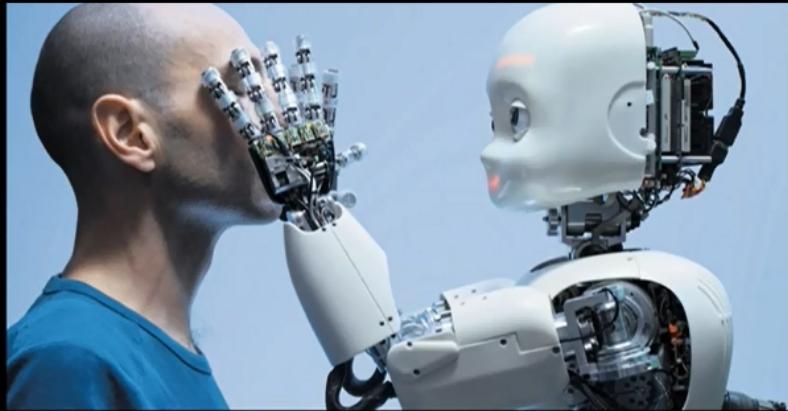
embodiment:
“cognition emergent from sensory-motor and interaction processes”



Illustrations by Shun Iwasawa

“I think, therefore I am!”

Discours de la méthode, René Descartes, 1637



“I act - therefore I am”



What is AI?

Mission of AI:

“Solve intelligence and then use it to solve everything else”

Three goals of AI:

- To build models of (or replicate) human cognition
 - Psychology, neuroscience, cognitive science: *the brain is tricky*
- To build useful intelligent artifacts
 - Engineering
- To create and understand intelligence as a general property of systems
 - Encompasses all of the above
 - Rationality within computational limitations

Outline

- What is AI?
- A brief history of AI
- The state of the art
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A brief history of AI

- Past: how did the ideas in AI come about?
- Present: what is the state of the art?
- Future: will robots take over the world?

A short prehistory of AI

- **Philosophy** from Aristotle onwards
- **Psychology** (learning, cognitive models)
- **Neuroscience** (neurons, adaptation)
- **Biology**
- **Mathematics** (logic, probability)
- **Economics** (rationality, game theory)
- **Control theory** (feedback)
- **Computer Science**
- **Linguistics** (knowledge representation)

*Science and Theoretical basis for intelligence

AI's official birth: Dartmouth, 1956



“An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. ***We think that a significant advance can be made if we work on it together for a summer.***”

John McCarthy and Claude Shannon
Dartmouth Workshop Proposal

A Short History of AI

- 1940-1950: Early days
 - 1943: McCulloch & Pitts: Boolean circuit model of brain
 - 1950: Turing's "Computing Machinery and Intelligence"
- 1950—70: Excitement: Look, Ma, no hands!
 - 1950s: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
 - 1956: Dartmouth meeting: "**Artificial Intelligence**" adopted
 - 1965: Robinson's complete algorithm for logical reasoning
 - 1966-9: Failure of naïve MT and learning methods
- 1970—90: Knowledge-based approaches
 - 1969—79: Early development of knowledge-based systems
 - 1980—88: Expert systems industry booms
 - 1988—93: Expert systems industry busts: "**AI Winter**"
- 1990—: Statistical approaches
 - Resurgence of probability, focus on uncertainty
 - General increase in technical depth
 - Agents and learning systems... "**AI Spring**"?
- 2000—: Where are we now?
 - DBNN+Deep learning
 - AMD+Developmental learning



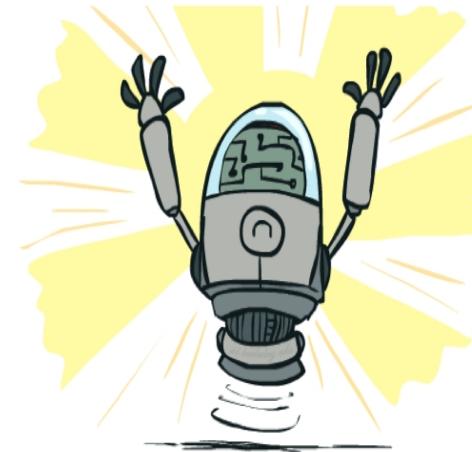
A brief history of AI

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What Can AI Do?

Quiz: Which of the following can be done at present?

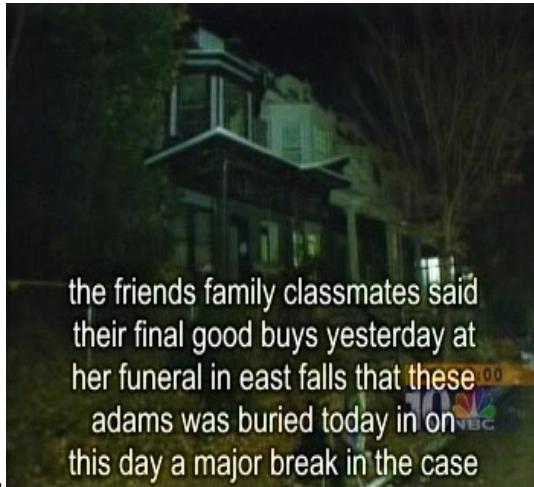
- ✓ Play a decent game of table tennis?
- ✓ Play a decent game of Jeopardy?
- ✓ Drive safely along a curving mountain road?
- ? Drive safely along Telegraph Avenue?
- ✓ Buy a week's worth of groceries on the web?
- X Buy a week's worth of groceries at Berkeley Bowl?
- ? Discover and prove a new mathematical theorem?
- X Converse successfully with another person for an hour?
- ? Perform a surgical operation?
- ✓ Put away the dishes and fold the laundry?
- ✓ Translate spoken Chinese into spoken English in real time?
- X Write an intentionally funny story?
-



Q.: Is there one system that can do all these things in an integrated way?

Natural Language

- Speech technologies (e.g. Siri)
 - Automatic speech recognition (ASR)
 - Text-to-speech synthesis (TTS)
 - Dialog systems
- Language processing technologies
 - Question answering (e.g. Watson)
 - Machine translation
 - Web search
 - Text classification, spam filtering, etc.
 - **LanguageBox by ZhongYuTong**



"Il est impossible aux journalistes de rentrer dans les régions tibétaines"

Bruno Philip, correspondant du "Monde" en Chine, estime que les journalistes de l'AFP qui ont été expulsés de la province tibétaine du Qinghai "n'étaient pas dans l'illégalité".

Les faits Le dalai-lama dénonce l'"enfer" imposé au Tibet depuis sa fuite, en 1959

Vidéo Anniversaire de la rébellion tibétaine: la Chine sur ses gardes



"It is impossible for journalists to enter Tibetan areas"

Philip Bruno, correspondent for "World" in China, said that journalists of the AFP who have been deported from the Tibetan province of Qinghai "were not illegal."

Facts The Dalai Lama denounces the "hell" imposed since he fled Tibet in 1959

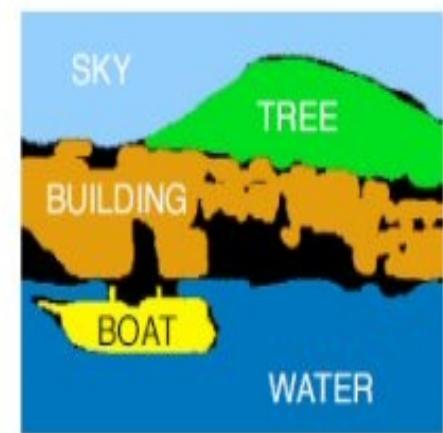
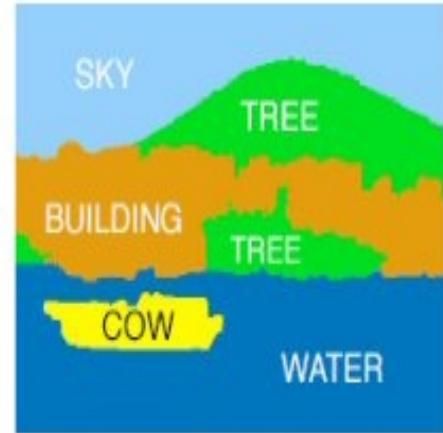
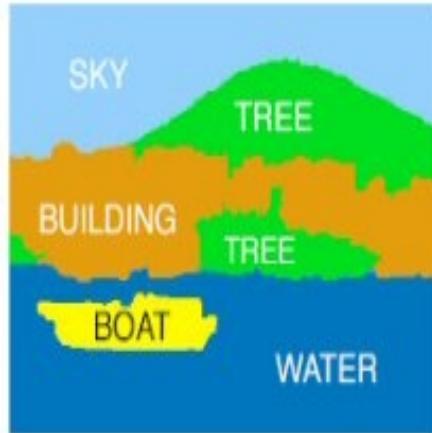
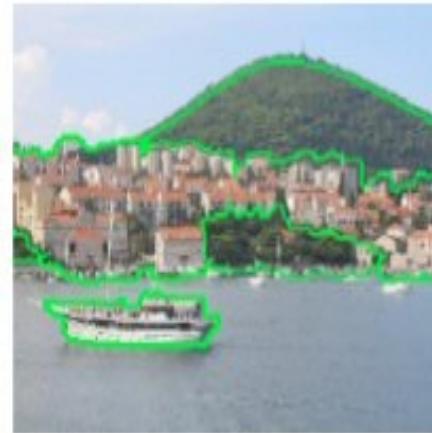
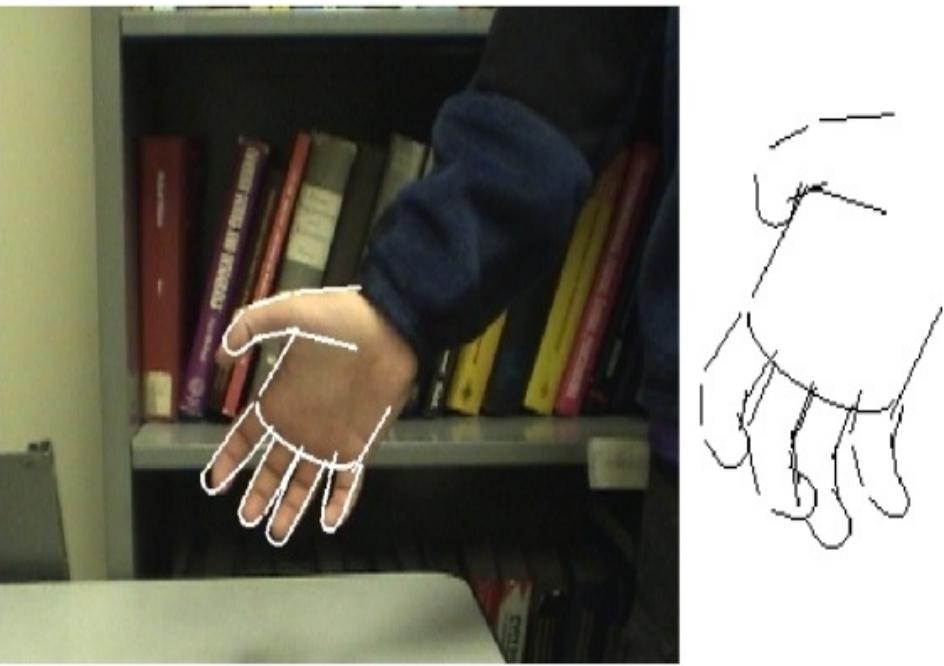
Video Anniversary of the Tibetan rebellion: China on guard



\$77,147

Vision (Perception)

- Object and face recognition
- Scene segmentation
- Image classification
- Object tracking and behavior recognition



Images from Erik Sudderth (left), scienceagogo (right)

Robotics

- Robotics
 - Part mech. eng.
 - Part AI
 - Reality much harder than simulations!
- Technologies
 - Vehicles
 - Rescue
 - Soccer!
 - Lots of automation...
- In this class:
 - We ignore mechanical aspects
 - Methods for **planning**
 - Methods for **reasoning**
 - Methods for **learning**
 - Methods for **decision-making**
 - Methods for **control**



Images from UC Berkeley, Boston Dynamics, RoboCup, Google

Logic

- Logical systems
 - Theorem provers
 - Program and plan synthesis, verification
 - NASA fault diagnosis
 - Question answering
 - Rule-based information systems
 - **Expert Systems**
 - Methods:
 - Deductive inference
 - *Inductive inference*
 - Constraint satisfaction
 - Satisfiability solvers (huge advances!)

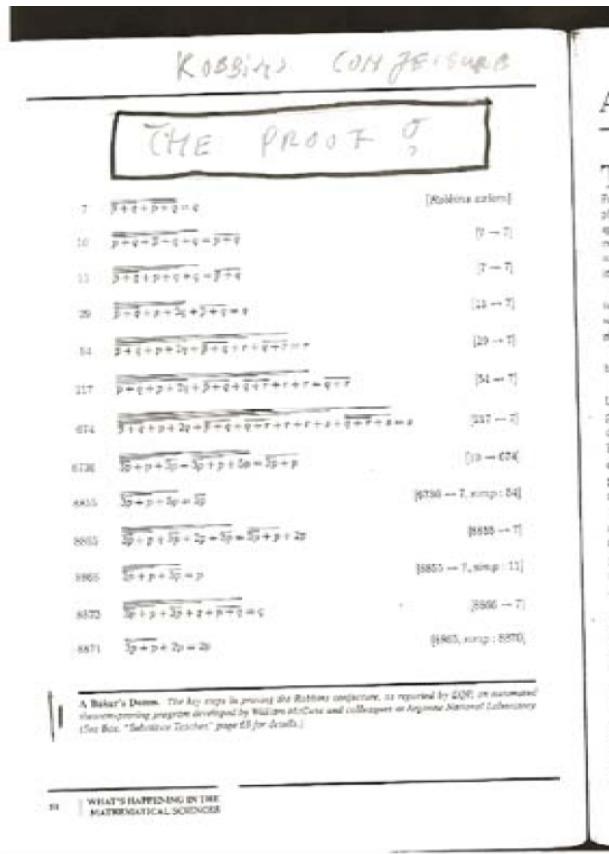


Image from Bart Selman

Game Playing

- Classic Moment: May, '97: **Deep Blue** vs. Kasparov
 - First match won against world champion
 - “Intelligent, creative” play
 - Special-purpose hardware, 200 million board positions per second
 - Current PC programs far ahead of humans
- Open question:
 - How does human cognition deal with the vast search space of chess?
 - Or: how can humans compete with computers at all??
- 1996: Kasparov Beats Deep Blue

“I could feel --- I could smell --- a new kind of intelligence across the table.”
- 1997: Deep Blue Beats Kasparov

“Deep Blue hasn't proven anything.”
- Huge game-playing advances recently, e.g. in Go
- **AlphaGo** vs Lee Sedol (in 2016)
- **AlphaGo** vs Kejie (in 2017)
- **AlphaGo zero** (in 2018-)





What to
move where

Moving



VS.



完全没有悬念
There's no competition at all.

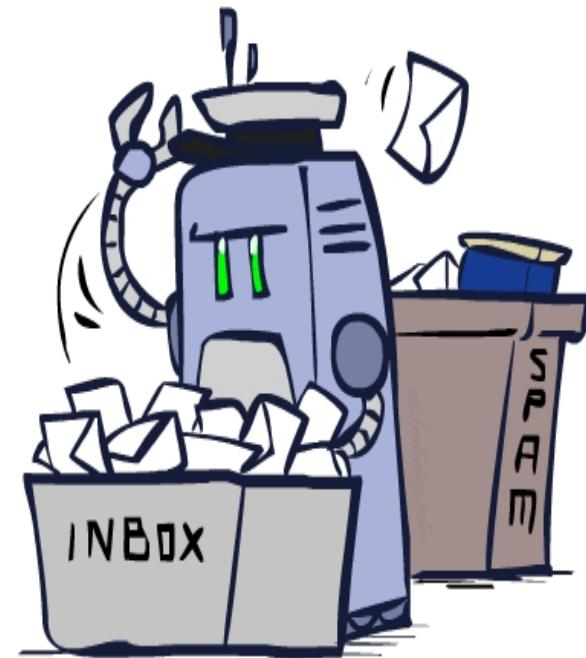
VS.



Embedded applications

– AI lies behind many other useful systems:

- Scheduling, e.g. airline routing, military
- Route planning, e.g. Google maps
- Medical diagnosis, e.g., EKGs
- Automated surveillance
- Web search engines
- Spam classifiers
- Automated help desks
- Fraud detection
- Product recommendations
- **US**, e.g. **Unman Vehicle**
- ... Lots more!



A brief history of AI

- Past: how did the ideas in AI come about?
- Present: what is the state of the art?
- Future: will robots take over the world?

Future

- We are doing AI...
 - To create intelligent systems
 - The more intelligent, the better
 - **Human-centered AI**
 - To gain a better understanding of human intelligence
 - To magnify those benefits that flow from it
 - To get more benefits from AI

Future, contd.

- Progress is accelerating, partly due to an industry arms race
- Once performance reaches a minimum level, every 1% improvement is worth billions
 - Speech
 - Text understanding
 - Object recognition
 - Automated vehicles
 - Domestic robots

What if we do succeed?

- “*The first ultra intelligent machine is the last invention that man need ever make.*” I. J. Good, 1965
- Might help us avoid war and ecological catastrophes, achieve immortality and expand throughout the universe
- Success would be the biggest event in human history ...
 - **and perhaps the last**

Reasons not to worry

- “AI will never reach **human levels of intelligence**”
- “OK, maybe it will, but I’ll be dead before it does”
- “Machines will never be conscious”
 - *Consciousness* isn’t the problem, it’s *competence*!
- “We design these things, right?”
 - Yes, and the genie grants three wishes
 - For ***almost any goal***, a super intelligent system will...
 - Acquire as many resources as possible and improve its own algorithms
 - Protect itself against any attempt to switch it off or change the goal

Precedent: Nuclear Physics

- Rutherford (1933): *anyone who looks for a source of power in the transformation of the atom is talking moonshine.*
- Sept 12, 1933: *The stoplight changed to green. Szilárd stepped off the curb. As he crossed the street time cracked open before him and he saw a way to the future, death into the world and all our woes, the shape of things to come.*
- Szilard (1934): patent on nuclear chain reaction; **kept secret**

So, if that matters.....

- Along what paths will AI evolve?
- What is the (plausibly reachable) best case? Worst case?
- Can we affect the future of AI?
 - Can we reap the benefits of super intelligent machines and avoid the risks?
 - ***The essential task of our age.***

Nick Bostrom, Professor of Philosophy, Oxford University.

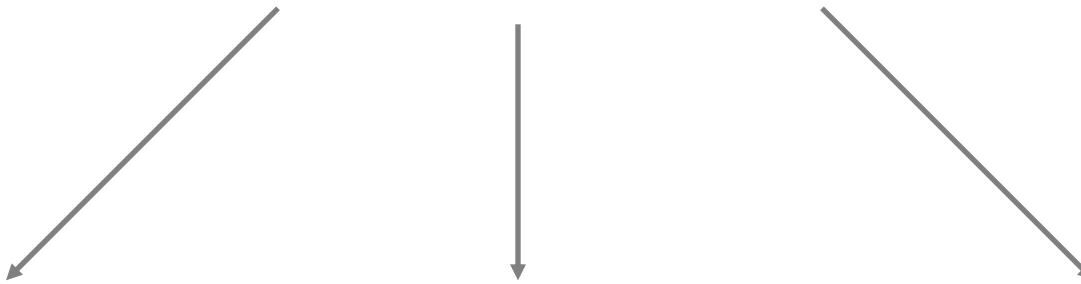
Topics to discuss

- What is AI?
 - What's your understanding to AI?
 - Definition conceptually
- What is an Intelligent Agent?
 - Agent/Intelligent Agent/MAS?
 - Rational Agent/Complete Agent?
- What is Turing Test?
- What is Chinese Room?
- Scientific methodology
- Theoretical basis for intelligence

Artificial Intelligence

goals

higher
level
intelligence



understanding
biological
systems

principles of
intelligent
systems

useful
artifacts
applications



abstract
theory



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
- 2006-- **Deep learning NN! AMD,**

Q.: When and Why AI becomes a science?



AI's Hall of Fame

Edward Albert Feigenbaum/

State of the art

- **AlphaGo** won the reigning world Go champion KeJie in 2017
- **AlphaGo** won the reigning world Go champion Lee Sedol in 2016
- **Deep Blue** defeated the reigning world chess champion Garry Kasparov in 1997
- Proved a mathematical conjecture (Robbins conjecture) unsolved for decades
- No hands across America (*driving autonomously* 98% of the time from Pittsburgh to San Diego)
- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
- NASA's on-board **autonomous planning program** controlled the scheduling of operations for a spacecraft

Q.: Are there any AI systems passed Turing Test?





Waterfall: Natural vs Artificial

Course overview

- Introduction to AI(chapters 1)
- Agents (chapters 2, Embodied Agents)
- Search (chapters 3,4,5,6)
- Logic (chapters 7,8,9)
- Knowledge-based Reasoning(chap 12)
- Uncertainty-oriented Reasoning (chap 13,14)
- Learning (chapters 18,20)
- Robotics (chap 25, How...)
- Conclusions (chap 26, 27)

Summary

- AI
 - Three goals
 - Disciplines
 - Classical AI or OFAI
 - Embodied AI
 - What's your understanding to AI?
 - “Turing test”, “Chinese Room”
- Syllabus AI 2021
- Assignment: *readings & exercises*

Assignment

- **Readings**
 - Chapter 1
 - Additional materials
 - “Turing test”
 - “Chinese Room”
- **Exercises**
 - Chap 1: exercise 1.1, 1.2
 - Chap 1: 1.7, 1.10, 1.13

Handed in your exercise next Tuesday