CS3317: Artificial Intelligence

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https://shuaili8.github.io

https://shuaili8.github.io/Teaching/CS3317/index.html

Part of slide credits: CMU AI & http://ai.berkeley.edu

Self Introduction

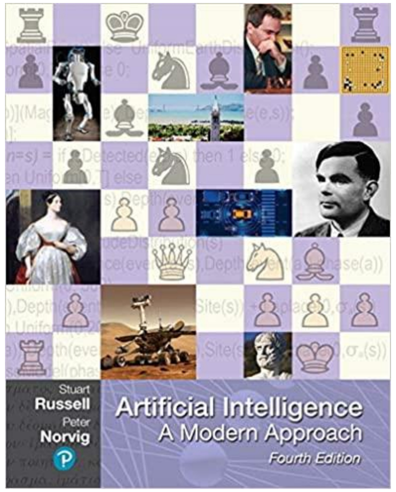
- Position
  - Tenure-track associate professor 2023-now
  - Assistant professor at John Hopcroft Center Aug 2019 - 2022
- Education
  - PhD in Computer Science from the Chinese University of Hong Kong
  - Master in Math from the Chinese Academy of Sciences
  - Bachelor in Math from Chu Kochen Honors College, Zhejiang University
- Research interests
  - Bandit algorithms
  - Reinforcement learning algorithms
  - Machine learning theory
  - Machine learning applications

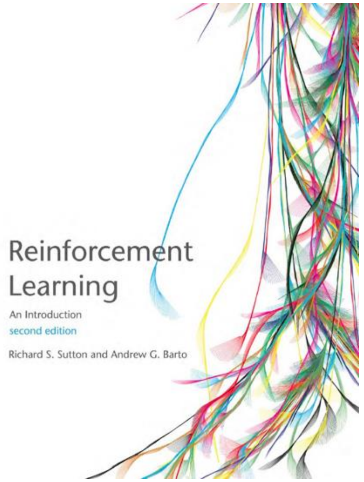
Teaching assistant

- Canzhe Zhao (赵灿哲)
  - Email: canzhezhao@sjtu.edu.cn
  - 4th year Ph.D. student
  - Research on bandits and reinforcement learning theory
  - Office hour: Mon. 7-9 PM
- Zhijie Wang (王至捷)
  - Email: violetevergarden@sjtu.edu.cn
  - 1st year PhD student
  - Research on Large Language Model theory
  - Office hour: Thur 2-4 PM
- Yutian Cheng (程喻天)
  - Email: cyt2021@sjtu.edu.cn
  - 4th year undergraduate student
  - Research on bandit and reinforcement learning algorithms
  - Office hour: Wed 7-9pm

References (will add more during course)

- Artificial Intelligence: A Modern Approach
  by Stuart Russell and Peter Norvig (4th edition)
- Reinforcement Learning: An Introduction
  by Richard S. Sutton and Andrew G. Barto
- 周志华《机器学习》清华大学出版社，2016.





Goal

- Know what is AI and what it usually covers
- Be familiar and understand popular AI problems and algorithms
- Be able to build AI models in applications
  - Know which algorithms to adopt and when to adopt
- Get a touch of latest research

Prerequisites

- Basic computer science principles
  - Big-O notation
  - Comfortably write non-trivial code in Python/numpy
- Probability
  - Random Variables
  - Expectations
  - Distributions
- Linear Algebra & Multivariate/Matrix Calculus
  - Gradients and Hessians
  - Eigenvalue/vector

Slide credit: Anand Avati

Grading

- No exam 没有笔试
- Attendance and participance: 10%
- Homework (written & programming): 40%
- Project: 40%
- Presentations: 10%

Course outline

- Search
- Constraint satisfaction problems
- Game trees
- Markov decision processes (MDPs)
- Reinforcement learning
- Bandit algorithms
- Hidden Markov models (HMMs)
- Bayes nets
- LLM related?

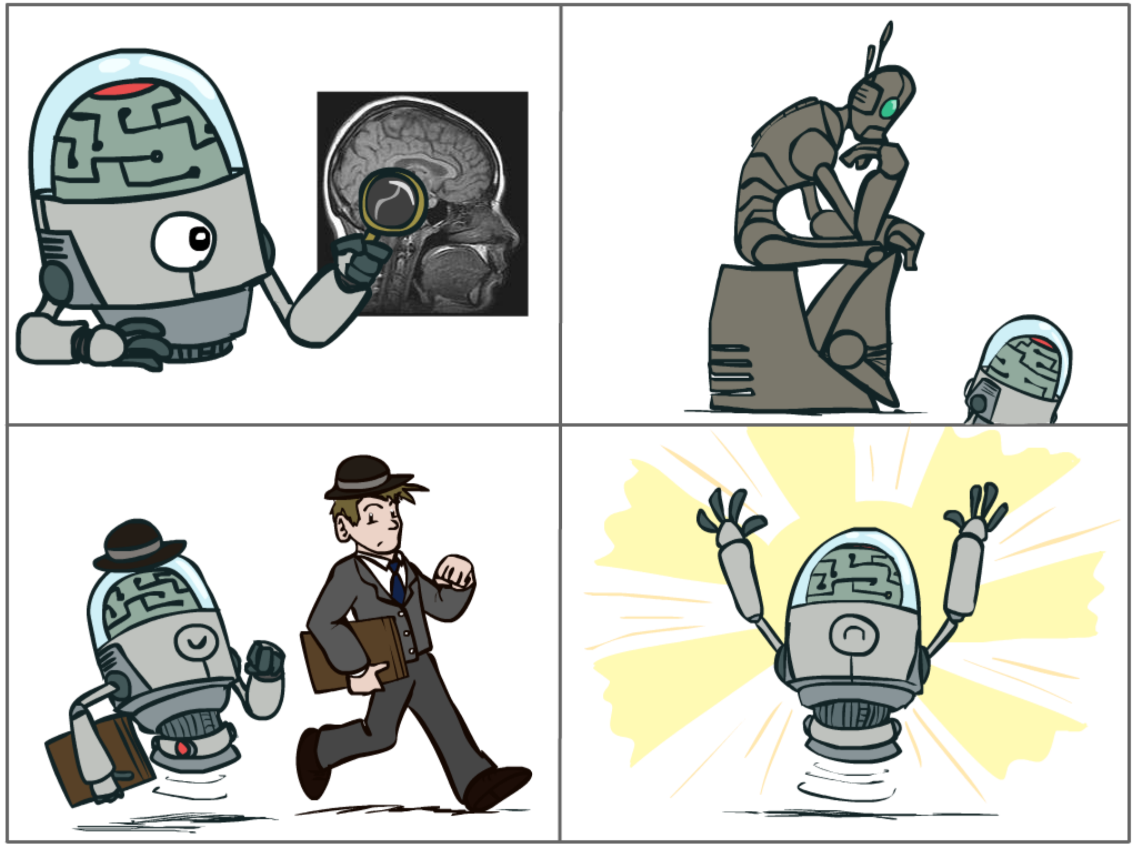
What is AI?

What is AI?

The science of making machines that:

Think like people

Think rationally

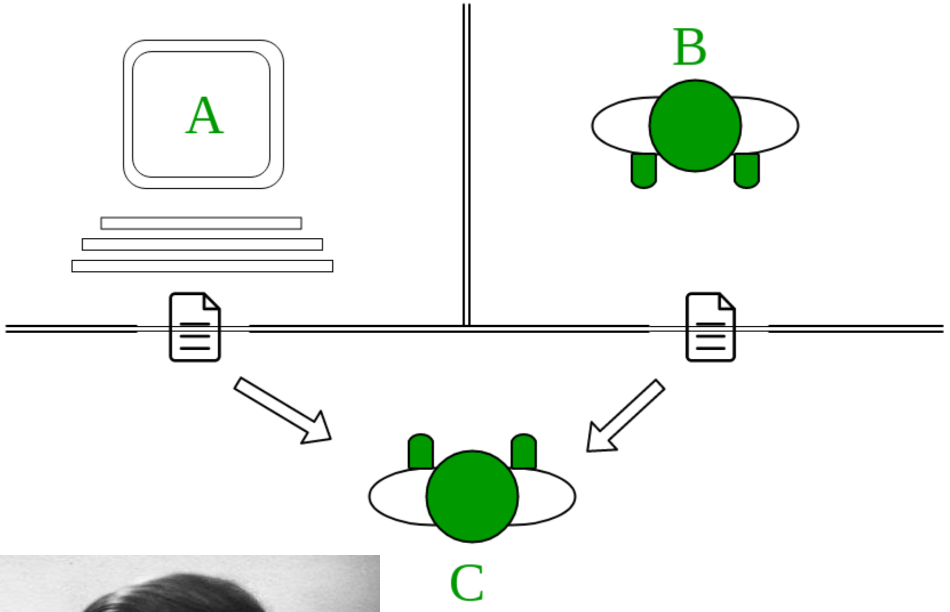


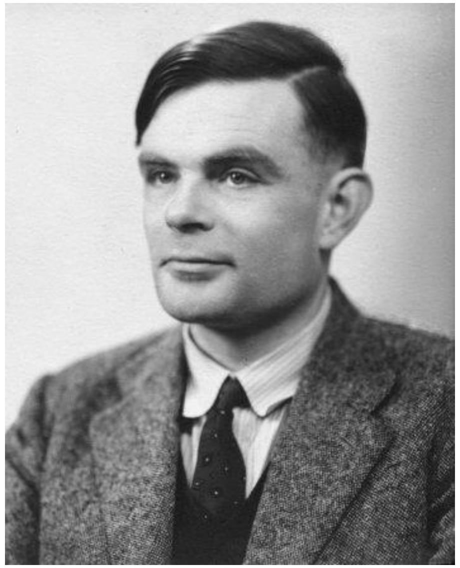
Act like people

Act rationally

Acting humanly: The Turing test approach

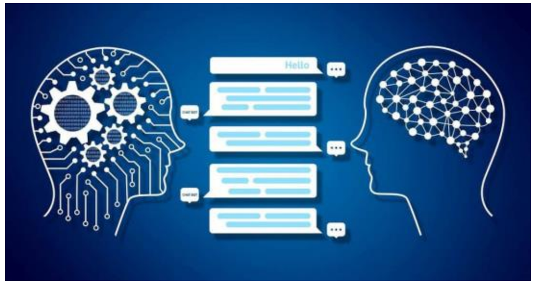
- In 1950, Turing defined a test of whether a machine could perform
- Practically though, it is a test of whether a machine can ‘act’ like a person
- “A human judge engages in a natural language conversation with one human and one machine, each of which tries to appear human. If judge can’t tell, machine passes the Turing test”

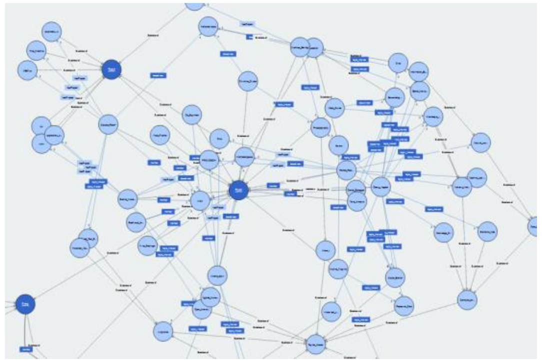




https://en.wikipedia.org/wiki/Turing_test

Acting humanly: The Turing test approach 2





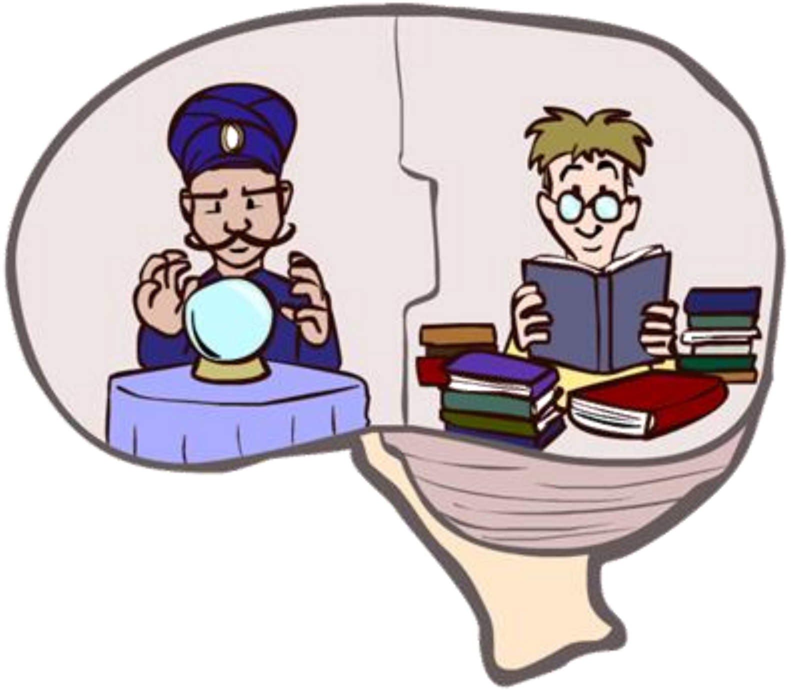
- The computer would need to possess the following capabilities
  - Natural language processing to enable it to communicate successfully in languages
  - Knowledge representation to store what it knows or hears
  - Automated reasoning to use the stored information to answer questions and to draw
  - Machine learning to adapt to new circumstances and to detect and extrapolate patterns
- Total Turing test includes a video signal, so the computer will need
  - Computer vision to perceive objects
  - Robotics to manipulate objects and move about

Thinking humanly: The cognitive modeling approach

- The interdisciplinary field of cognitive science hopes to construct precise and testable theories of the human mind
- Real cognitive science is necessarily based on experimental investigation of actual humans or animals
- In the early days of AI, people think that an algorithm performs well on a task ⇔ it is a good model of human performance

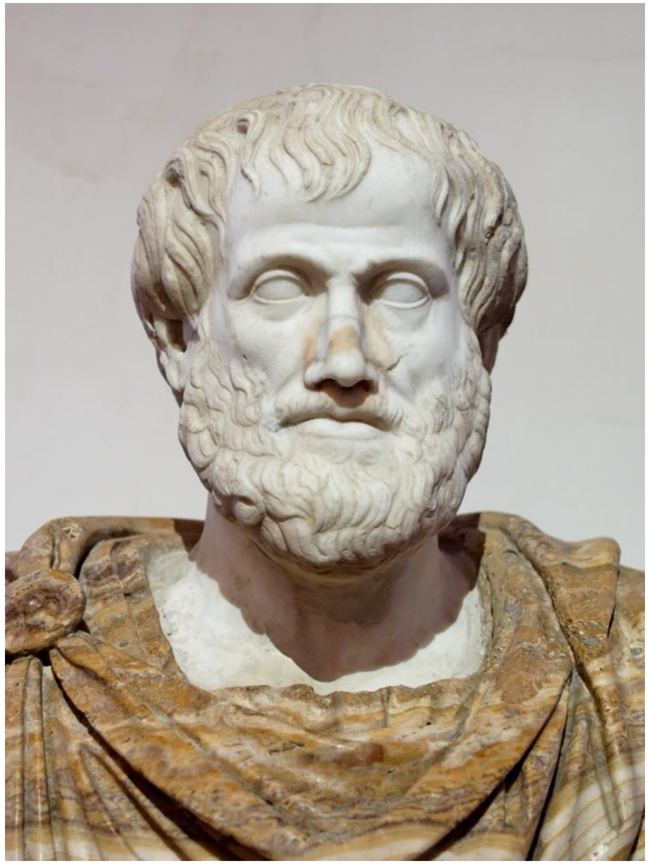
What about the Brain?

- Brains (human minds) are very good at making rational decisions, but not perfect
- Brains aren’t as modular as software, so hard to reverse engineer!
- “Brains are to intelligence as wings are to flight”
- Lessons learned from the brain: memory and simulation are key to decision making



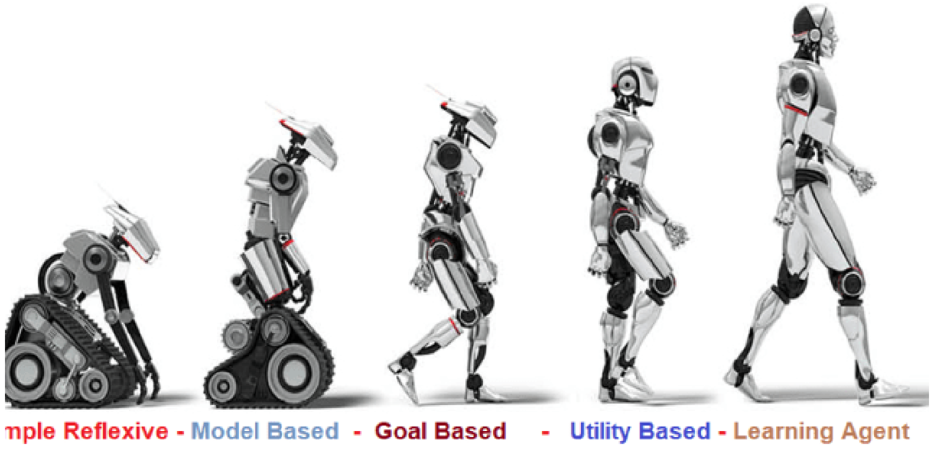
Thinking rationally: The "laws of thought" approach

- The Greek philosopher Aristotle, syllogisms (三段论)
- The logicists hope to build on logic systems to create intelligent systems
- The emphasis was on correct inferences



Acting rationally: The rational agent approach

- Making correct inferences is sometimes *part* of being a rational agent, but not *all*
- A rational agent is one that acts so as to achieve the best expected outcome
- Advantages
  - It is more general than "thinking rationally"
  - It is more amenable than "thinking/acting humanly"

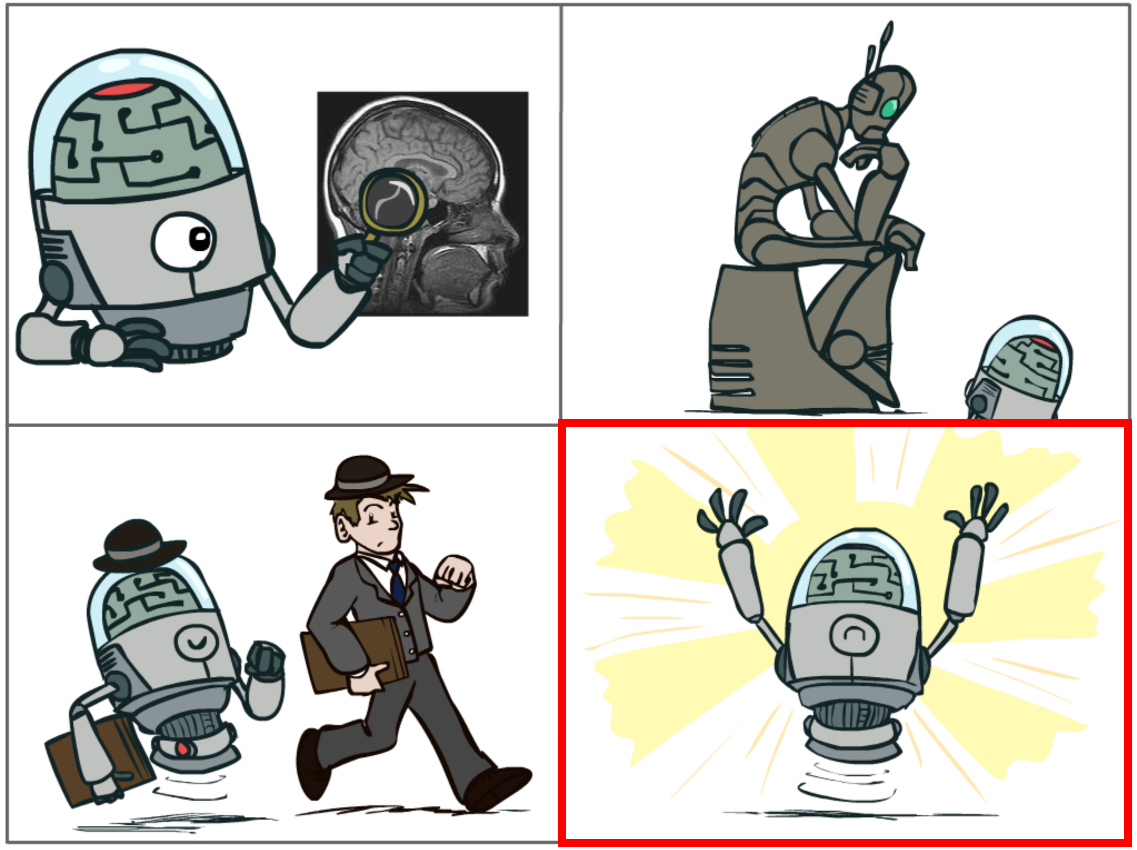


What is AI?

The science of making machines that:

A: Think like people

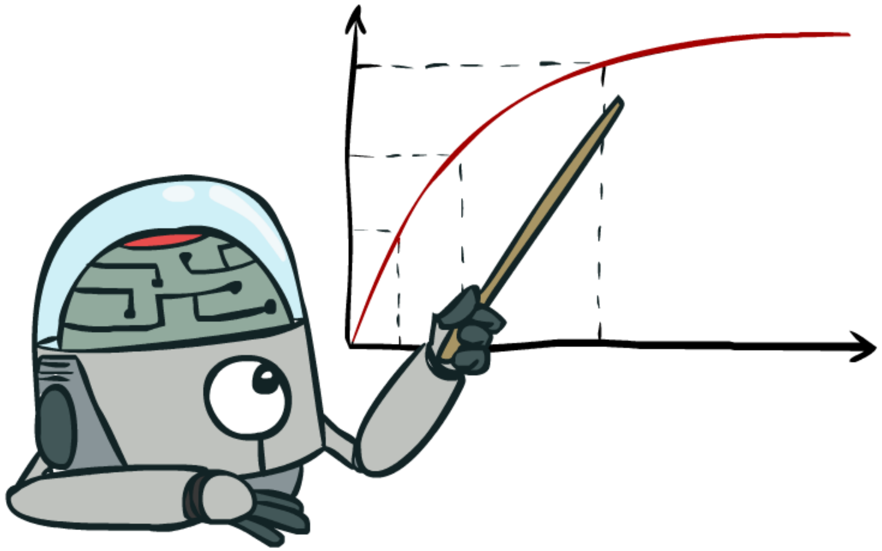
C: Think rationally



B: Act like people

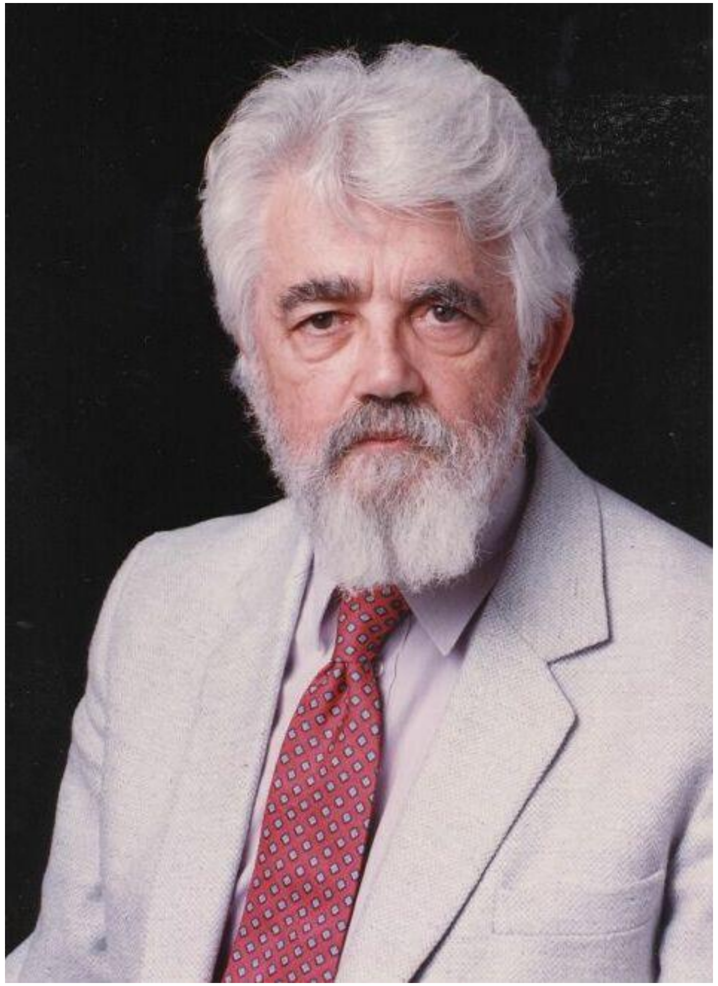
D: Act rationally

Maximize Your Expected Utility



AI definition by John McCarthy

- Artificial intelligence
  - the science and engineering of making intelligent machines, especially intelligent computer programs
- Intelligence
  - the computational part of the ability to achieve goals in the world
- John McCarthy (1927-2011)
  - co-authored the document that coined the term "artificial intelligence" (AI), developed the Lisp programming language family



http://www-formal.stanford.edu/jmc/whatisai/whatisai.html

AI and this course

- Describe machines (or computers) that mimic "cognitive" functions that humans associate with the human mind, such as “learning” and “problem solving”.

    --Russell, S. J., & Norvig, P. (2016). *Artificial intelligence: a modern approach*. Malaysia; Pearson Education Limited.

- This course is about:
    - General AI techniques for a variety of problem types
    - Learning to recognize when and how a new problem can be solved with an existing technique
    - Computational rationality

What is Machine Learning?

- Term “Machine Learning” coined by Arthur Samuel in 1959
    - Samuel Checkers-playing Program

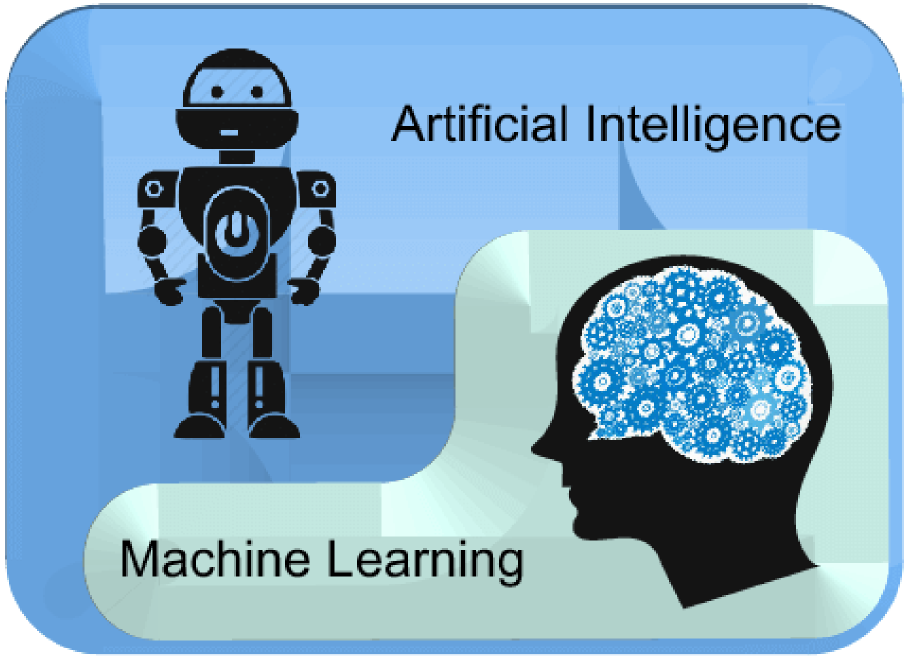
- Common definition (by Tom Mitchell):
    - ***Machine Learning is the study of computer algorithms that improve automatically through experience***

- Subfield of Artificial Intelligence (AI)
    - The hottest subfield - reinvigorated interest in AI due to deep learning!

Slide credit: Anand Avati

Difference between AI and ML

- AI is a bigger concept to create intelligent machines that can simulate human thinking capability and behavior
- Machine learning is an application or subset of AI that allows machines to learn from data without being programmed explicitly



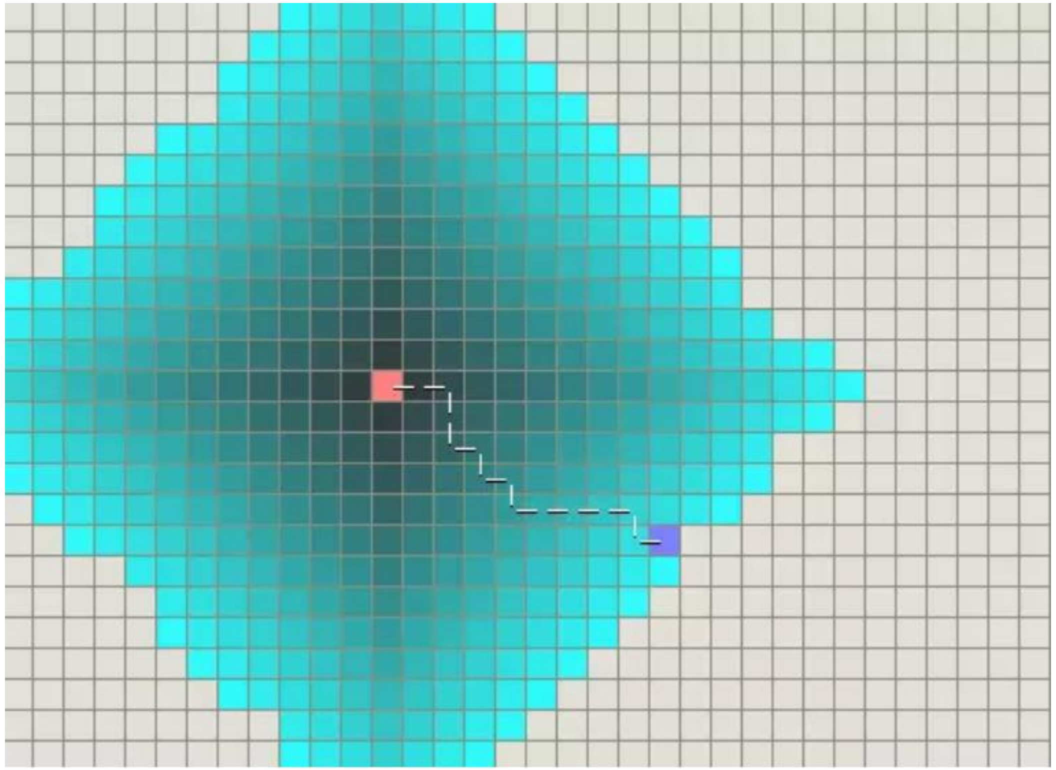
An example of AI but is not machine learning

- A* search algorithm
  - Objective: Find the shortest path between two nodes of a weighted graph
  - Use heuristic information

- Compare with Breadth First Searching and Greedy Searching

Breadth-first searching

- Pink: start point, Purple: end point
- Blue: visited points, the darker the earlier



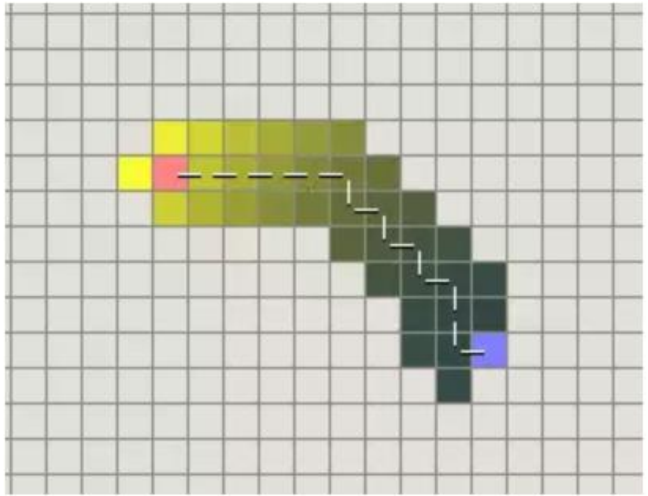
Each time it visits, or expand the point with least $g(n)$ value

- $g(n)$ is the distance from start point to point n

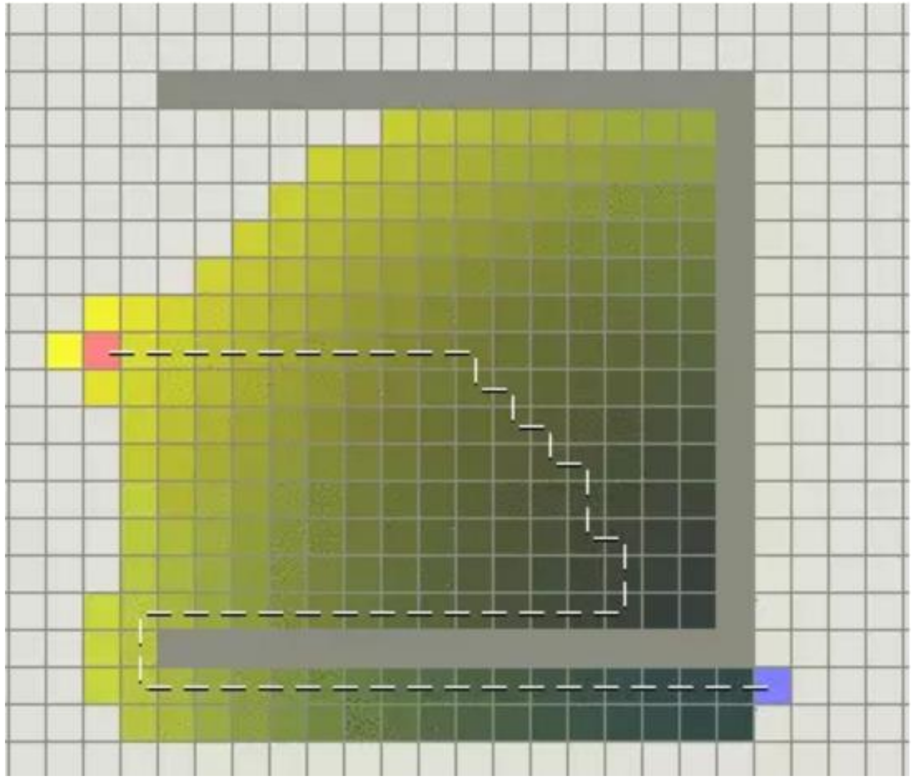
Short comings: computing burden is too high, it visited too many points before getting the end point

Greedy searching

- Each time it visit or expand the point with least $h(n)$ value
  - $h(n)$ is the distance from point n to end point. It works fine when there is no obstacles

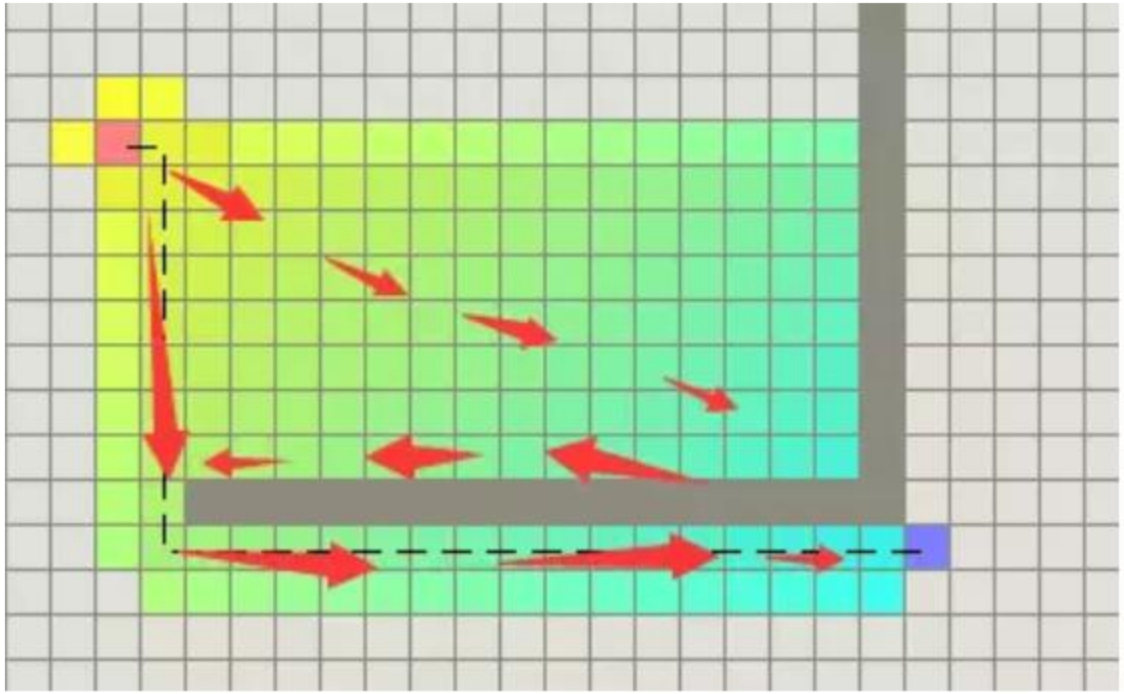


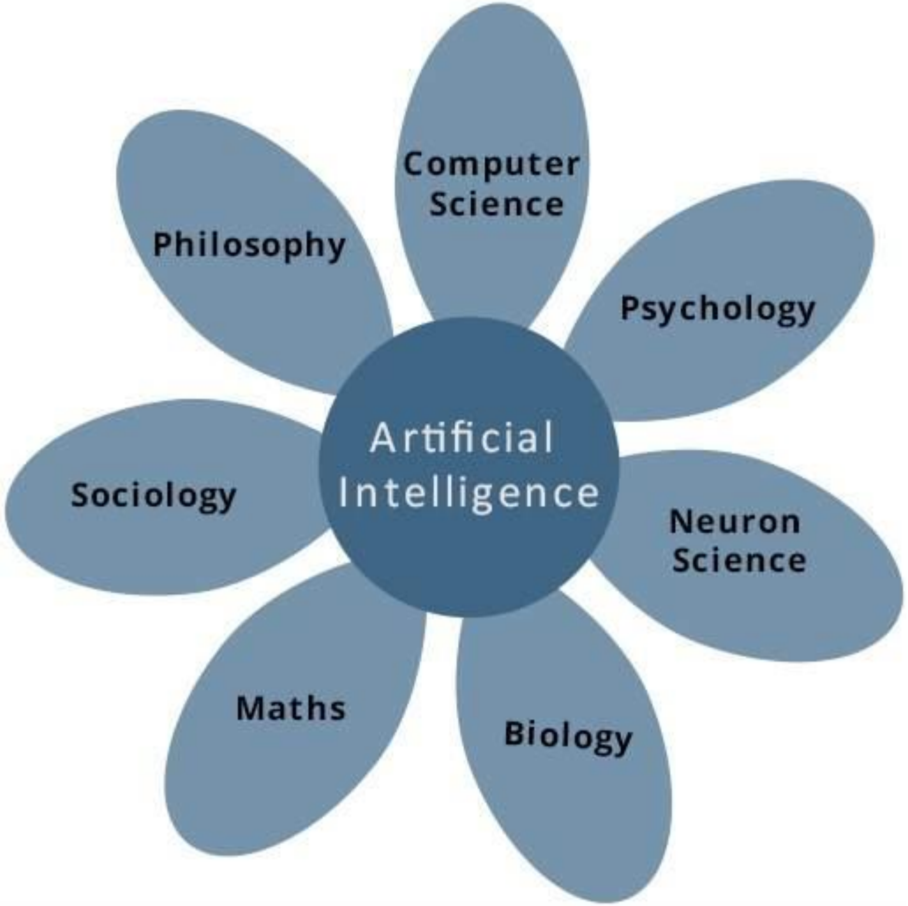
- The cost doubles when there is obstacles



A* algorithm

- It combines the stability of BFS and the heuristics in greedy searching
- Each time it visits point with the least $f(n) = g(n) + h(n)$ value





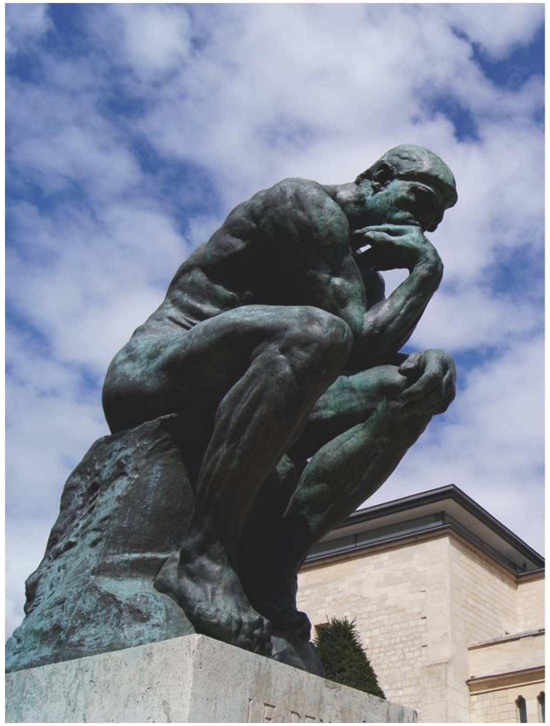
The Foundations of AI

The disciplines that contributed ideas, viewpoints, and techniques to AI

Philosophy

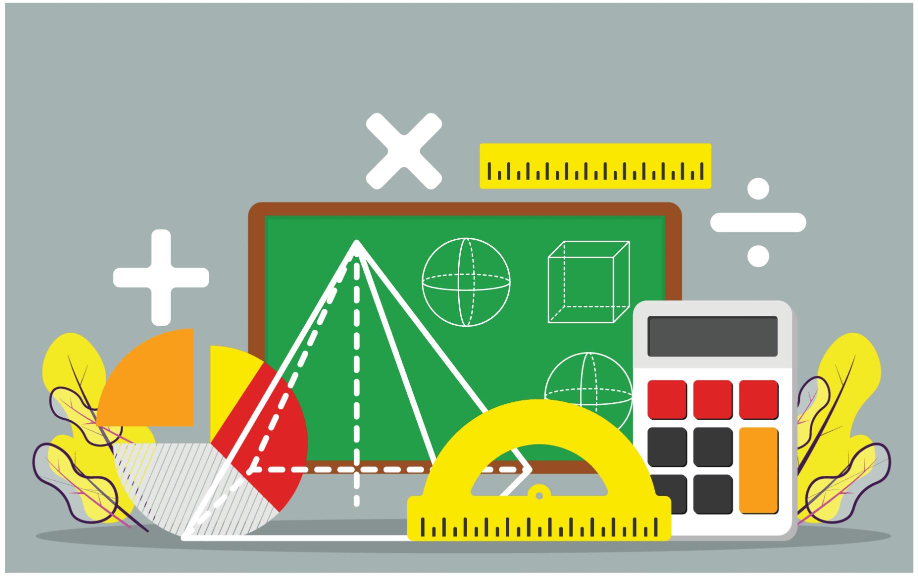
- Can formal rules be used to draw valid conclusions?
- How does the mind arise from a physical brain?
- Where does knowledge come from?
- How does knowledge lead to action?

- Rationalism (理性主义)/materialism (唯物主义)/empiricism (经验主义)



"The only thing I know is that I know nothing"
– Socrates

Mathematics



- What are the formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?

- The first nontrivial algorithm is thought to be Euclid's algorithm for computing greatest common divisors (最大公约数)
- The word algorithm (and the idea of studying them) comes from al-Khowarazmi, a Persian mathematician of the 9th century
- NP-completeness/probability/entropy

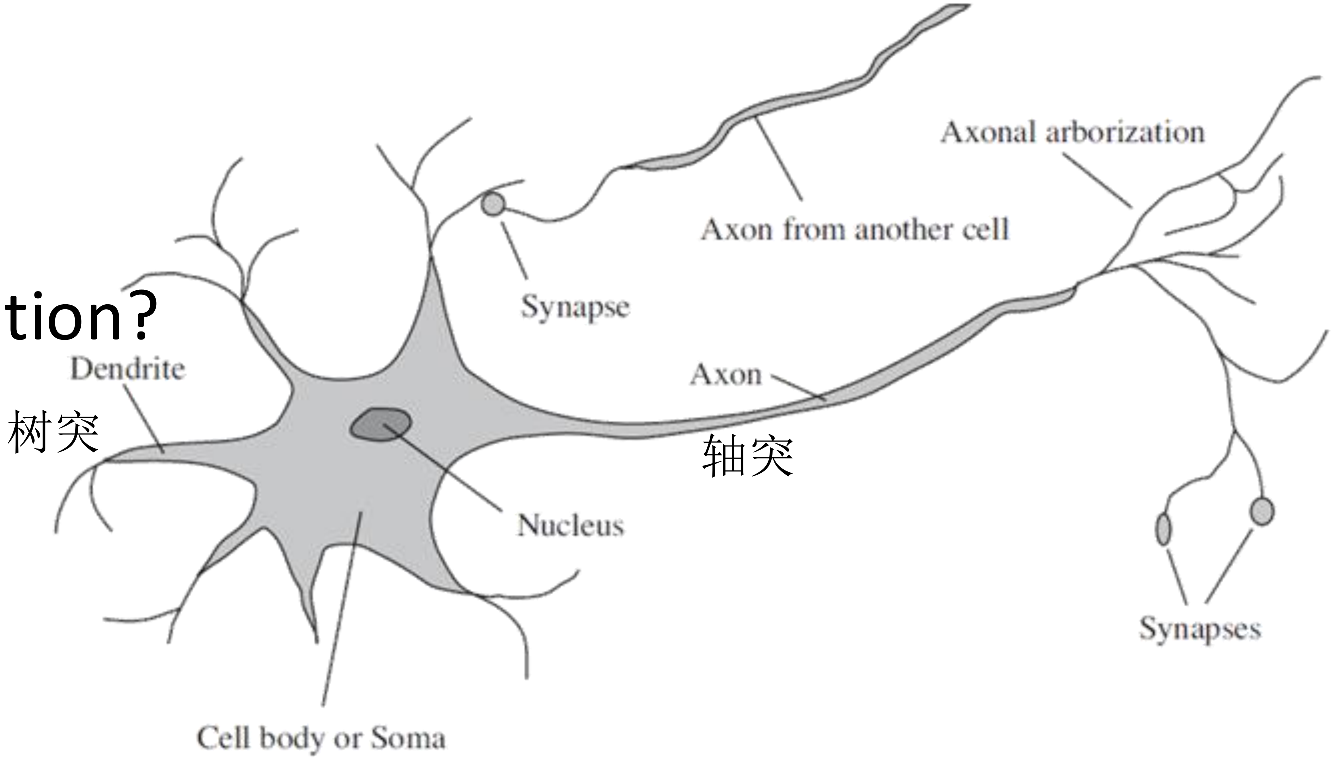
Economics

- How should we make decisions so as to maximize payoff?
- How should we do this when others may not go along?
- How should we do this when the payoff may be far in the future?

- The pioneering AI researcher Herbert Simon (1916–2001) won the Nobel Prize in economics in 1978 for his early work showing that models based on satisficing—making decisions that are “good enough,” rather than laboriously calculating an optimal decision—gave a better description of actual human behavior (Simon, 1947)

Neuroscience

- How do brains process information?

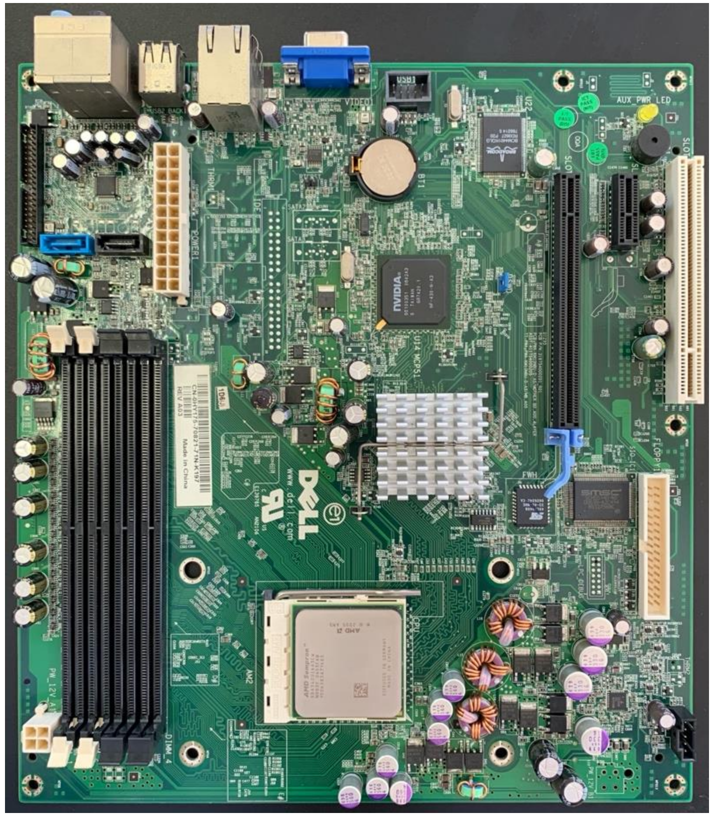


	Supercomputer	Personal Computer	Human Brain
Computational units	10^4 CPUs, 10^{12} transistors	4 CPUs, 10^9 transistors	10^{11} neurons
Storage units	10^{14} bits RAM	10^{11} bits RAM	10^{11} neurons
	10^{15} bits disk	10^{13} bits disk	10^{14} synapses
Cycle time	10^{-9} sec	10^{-9} sec	10^{-3} sec
Operations/sec	10^{15}	10^{10}	10^{17}
Memory updates/sec	10^{14}	10^{10}	10^{14}

Psychology

- How do humans and animals think and act?
- Cognitive psychology views the brain as an information-processing device
- Developmental psychology is the scientific study of how and why human beings change over the course of their life, especially concerned with infants and children

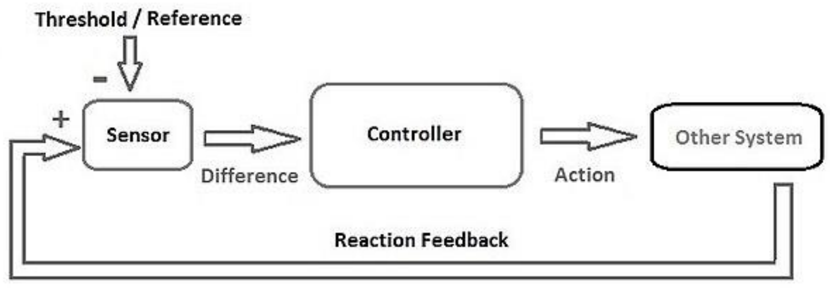
Computer engineering



- How can we build an efficient computer?

- Designing algorithms is not enough
- Hardware
  - modern digital electronic computer
- Software
  - operating systems, programming languages, and tools needed to write modern programs (and papers about them)
- Work in AI has also pioneered many ideas to mainstream computer science
  - time sharing, interactive interpreters, personal computers with windows and mice

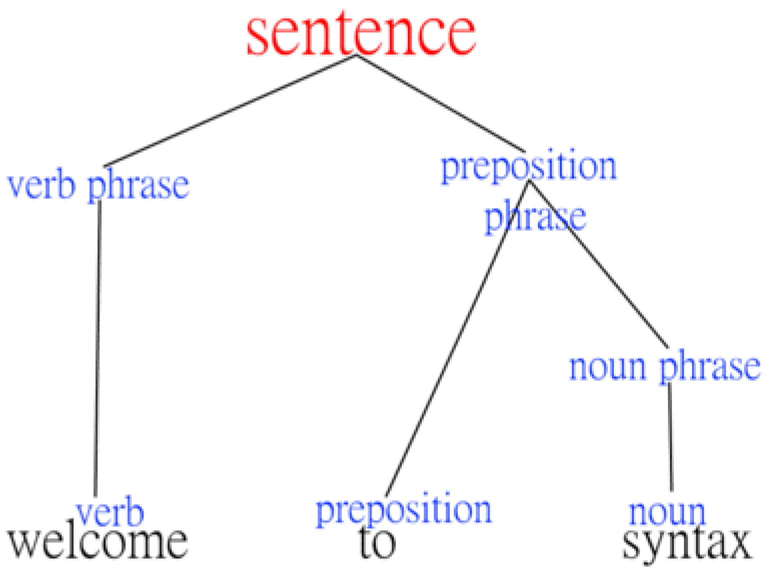
Control theory and cybernetics



A Cybernetic Loop

- How can artifacts operate under their own control?
- Control theory
  - To design systems that maximize an objective function over time
- Differences of control theory and AI:
  - Control theory more care about continuous variables with calculus and matrix algebra as tools
  - AI uses logical inference and computation to deal more discrete problems such as language, vision, and planning

Linguistics

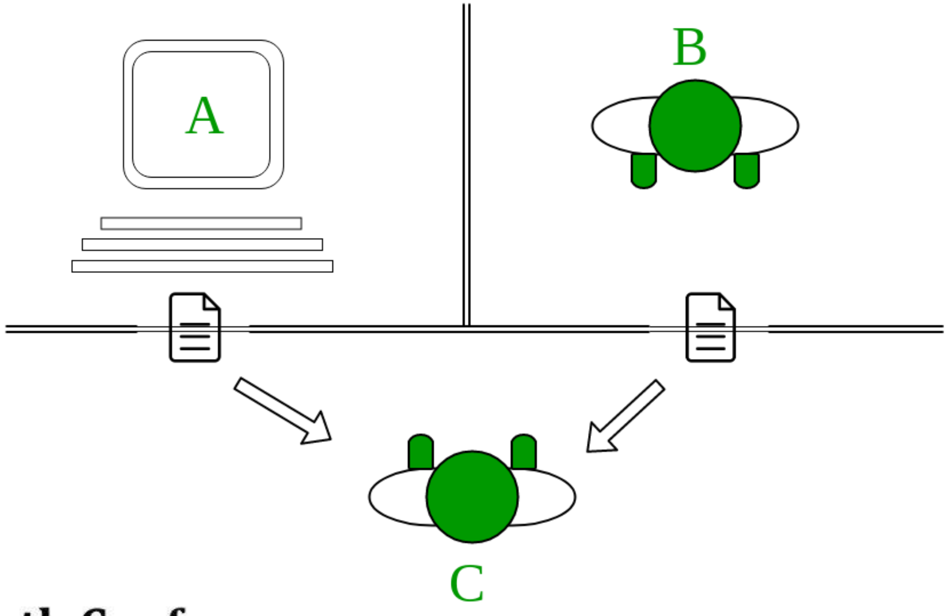


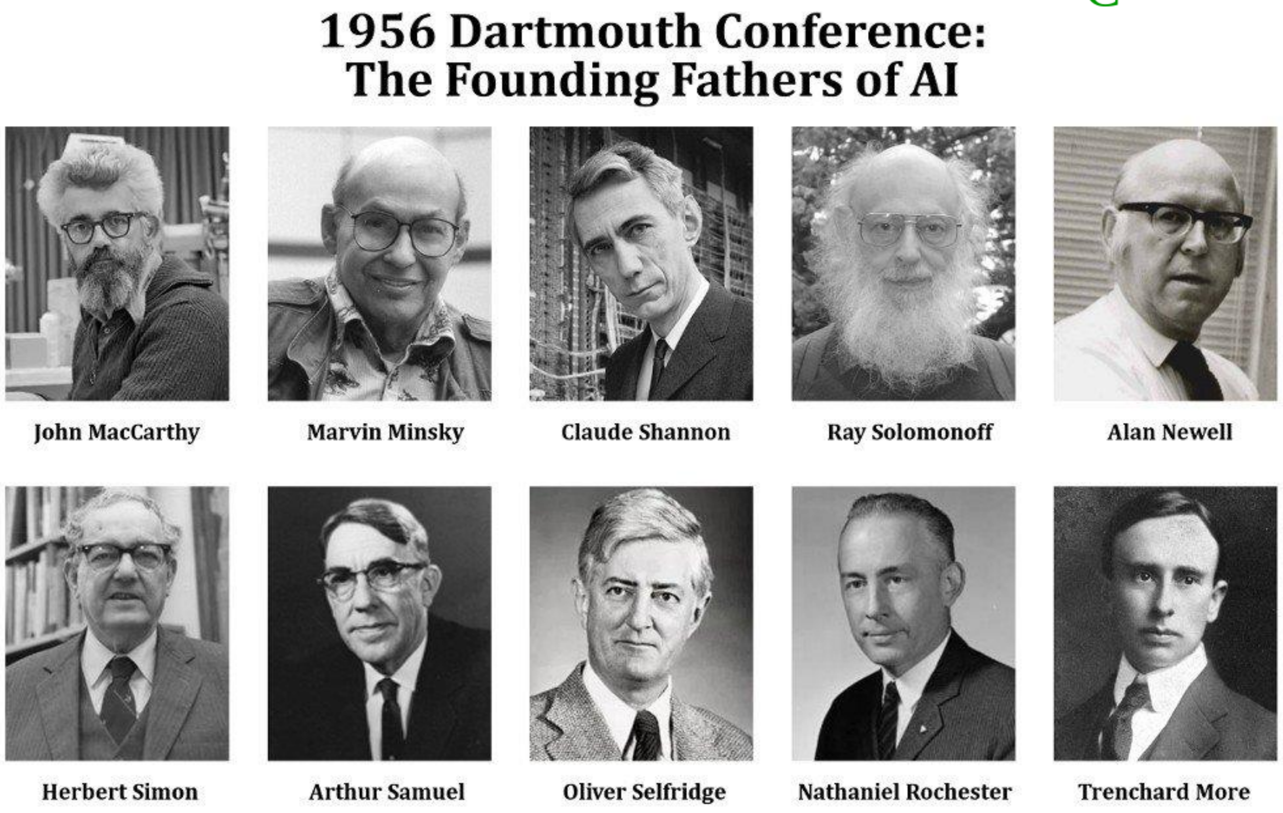
- How does language relate to thought?
- Understanding language requires an understanding of the subject matter and context
  - not just an understanding of the structure of sentences
- Knowledge representation
  - decades of work on the philosophical analysis of language

The History of AI

1950s

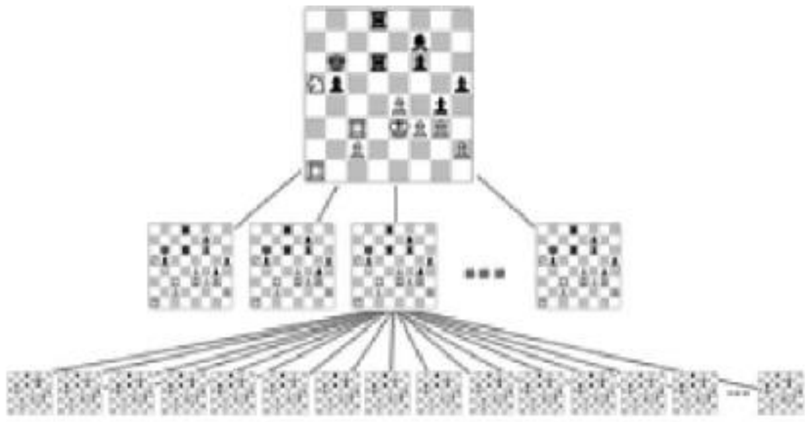
- Turing's test
- Dartmouth Conference 1956: the birth of AI

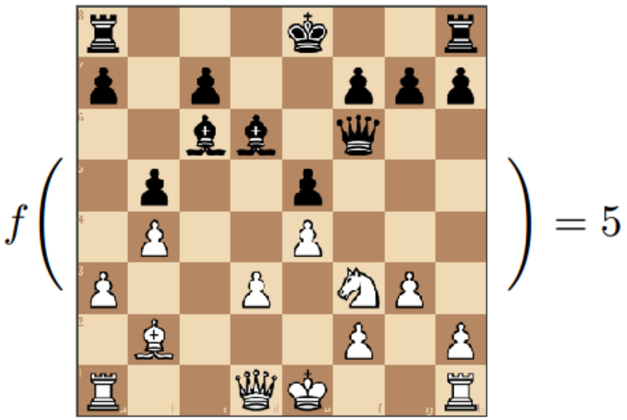


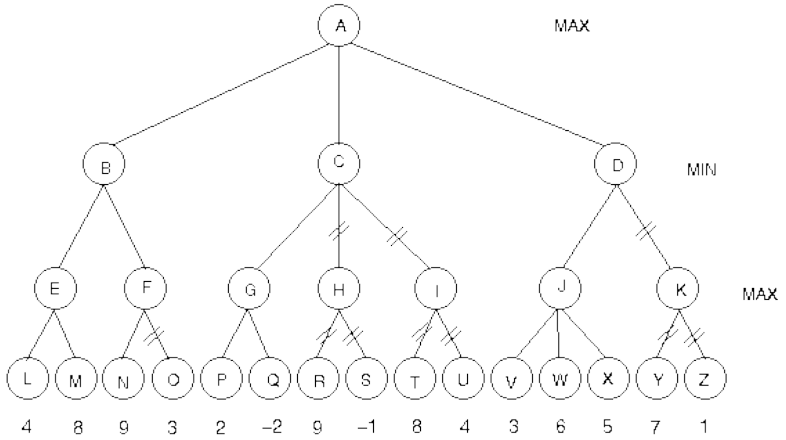


Chess as the first killer app for AI

- Claude Shannon proposed the first chess playing program in 1950
  - It included adversarial search and minimax (later lecture)
  - It also included many heuristics for faster searching







Chess by 1958

TABLE 1 Comparison of Current Chess Programs

	Turing	Kister, Stein, Ulam, Walden, Wells (Los Alamos)	Bernstein, Roberts, Arbuckle, Belsky (Bernstein)	Newell, Shaw, Simon (NSS)
Vital statistics				
Date	1951	1956	1957	1958
Board	8 × 8	6 × 6	8 × 8	8 × 8
Computer	Hand simulation	MANIAC-I 11,000 ops./sec	IBM 704 42,000 ops./sec	RAND JOHNNIAC 20,000 ops./sec
Chess program				
Alternatives	All moves	All moves	7 plausible moves Sequence of move generators	Variable Sequence of move generators
Depth of analysis	Until dead (exchanges only)	All moves 2 moves deep	7 plausible moves 2 moves deep	Until dead Each goal generates moves
Static evaluation	Numerical Many factors	Numerical Material, mobility	Numerical Material, mobility Area control King defense	Nonnumerical Vector of values Acceptance by goals
Integration of values	Minimax	Minimax (modified)	Minimax	Minimax
Final choice	Material dominates Otherwise, best value	Best value	Best value	1. First acceptable 2. Double function
Programming				
Language		Machine code	Machine code	IPL-IV, interpretive
Data scheme		Single board No records	Single board Centralized tables Recompute	Single board Decentralized List structure Recompute
Time	Minutes	12 min/move	8 min/move	1–10 hr/move (est.)
Space		600 words	7000 words	Now 6000 words, est. 16,000
Results				
Experience	1 game	3 games (no longer exists)	2 games	0 games Some hand simulation
Description	Loses to weak player Aimless Subtleties of evaluation lost	Beats weak player Equivalent to human with 20 games experience	Passable amateur Blind spots Positional	Good in spots (opening) No aggressive goals yet

45

Allen Newell
J. C. Shaw
H. A. Simon

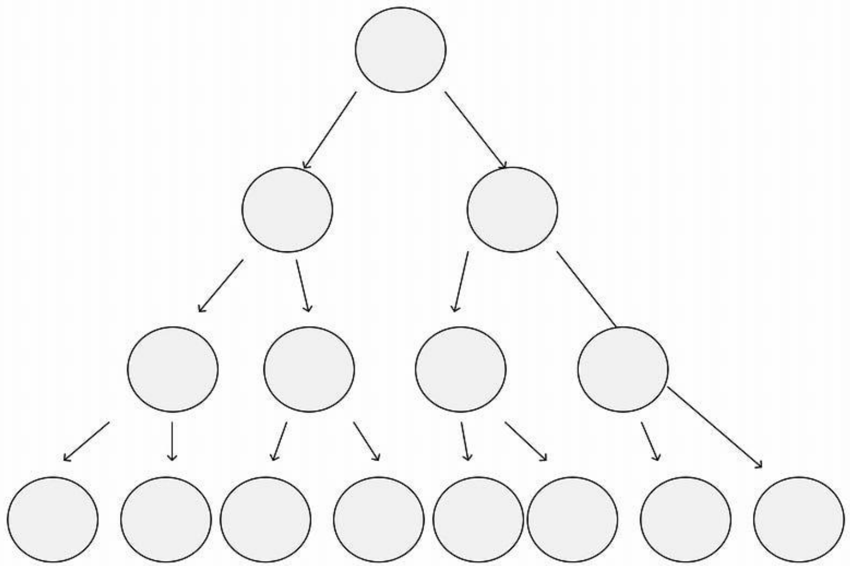
Chess-Playing Programs and the Problem of Complexity

The promise of AI

- In 1965, Herbert Simon predicted that "machines will be capable, within 20 years, of doing any work a man can do"
- In 1967, AI pioneer Marvin Minsky predicted "in from three to eight years we will have a machine with the general intelligence of an average human being."
- In 1967, John McCarthy told the U.S. government that it would be possible to build "a fully intelligent machine" in the space of a decade

1970s - first AI winter

- Limited computer power
- Intractability and the combinatorial explosion
- Commonsense knowledge and reasoning
  - Hard to encode so many concepts and rules
  - Didn’t know how to teach computers to learn these

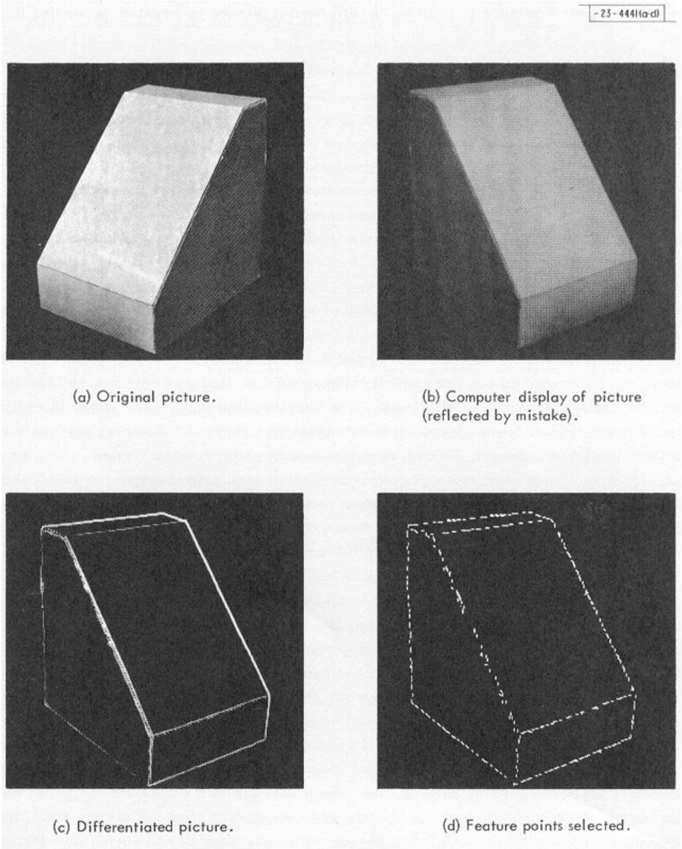


Evolution of AI research: 1970s and 1980s

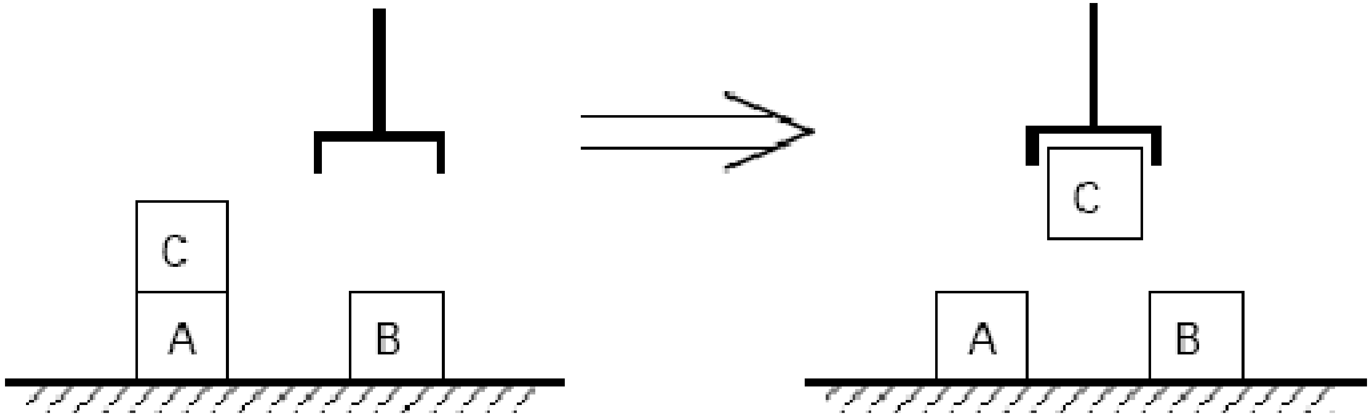
- Focus on:
  - Searching for a solution using general search algorithms
  - Encoding knowledge that humans have and using logic to solve

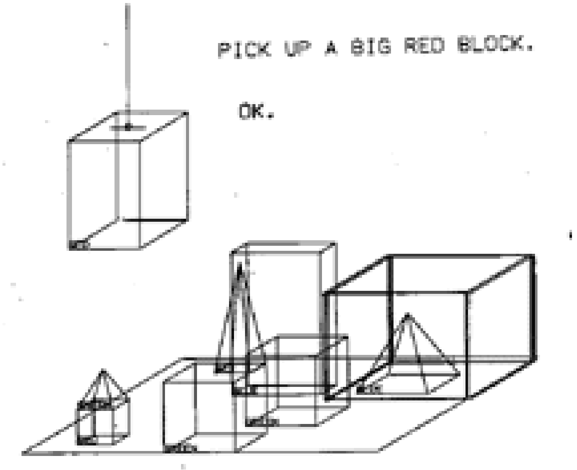
Expert System

Computer vision, blocks world, natural language



Larry Roberts 1963 Thesis





Terry Winograd's 1971 Thesis on SHRDLU
for natural language understanding

Early robots

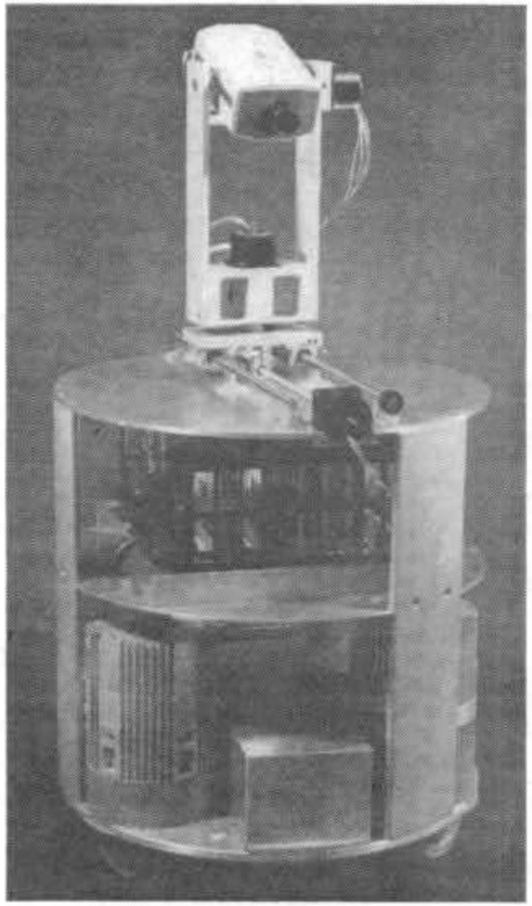


Fig. 8. The CMU Rover.

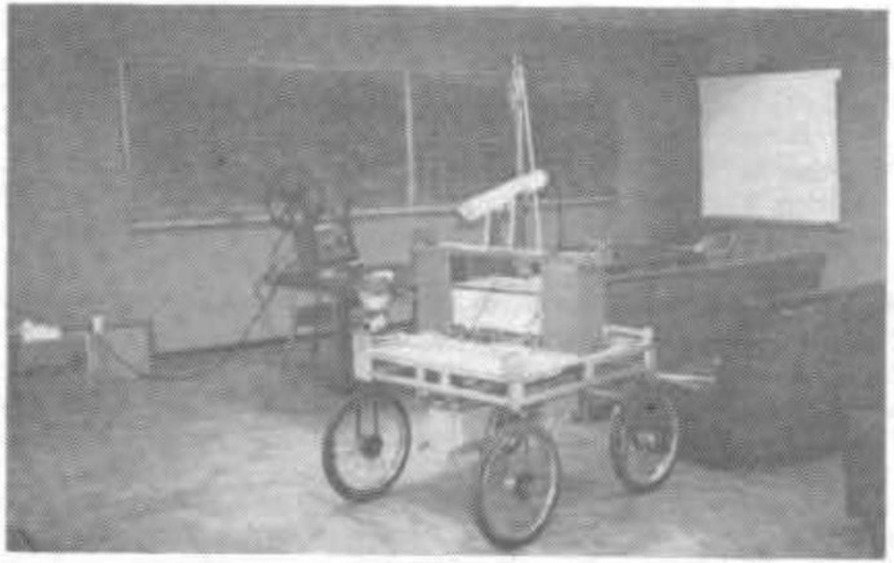


Fig. 1. The Stanford Cart.

1983 – mobile robots by Hans Moravec

Dean Pomerleau (CMU) 1986
NAVLAB controlled by NNs

https://www.nytimes.com/video/science/1247468063802/stanford-cart.html
https://www.youtube.com/watch?v=ntIczNQKfjQ

Rise of statistical approaches: 1990s – 2000s

- Knowledge-based:
  - Search for a solution using general search algorithms
  - Encode knowledge that humans have and use logic to solve
- Statistical:
  - Learning patterns and choosing solutions based on observed likelihood

Deep Blue

- Started in the mid-1980s at CMU, didn’t win until 1997
- Project moved to IBM
- “Good Old-Fashioned” Brute Force Search using custom hardware

- Win Garry Kasparov by 3.5:2.5 on Chess
- Search over 12 following steps

- https://www.youtube.com/watch?v=KF6sLCeBj0s

Evolution of AI research:1990s

Evolution of AI research: 2000s

Evolution of AI research: 2010s

2010s-now

- Deep learning
  - The return of neural networks
- Big data
  - Large datasets, like ImageNet
- Computational power
- Artificial general intelligence (AGI)

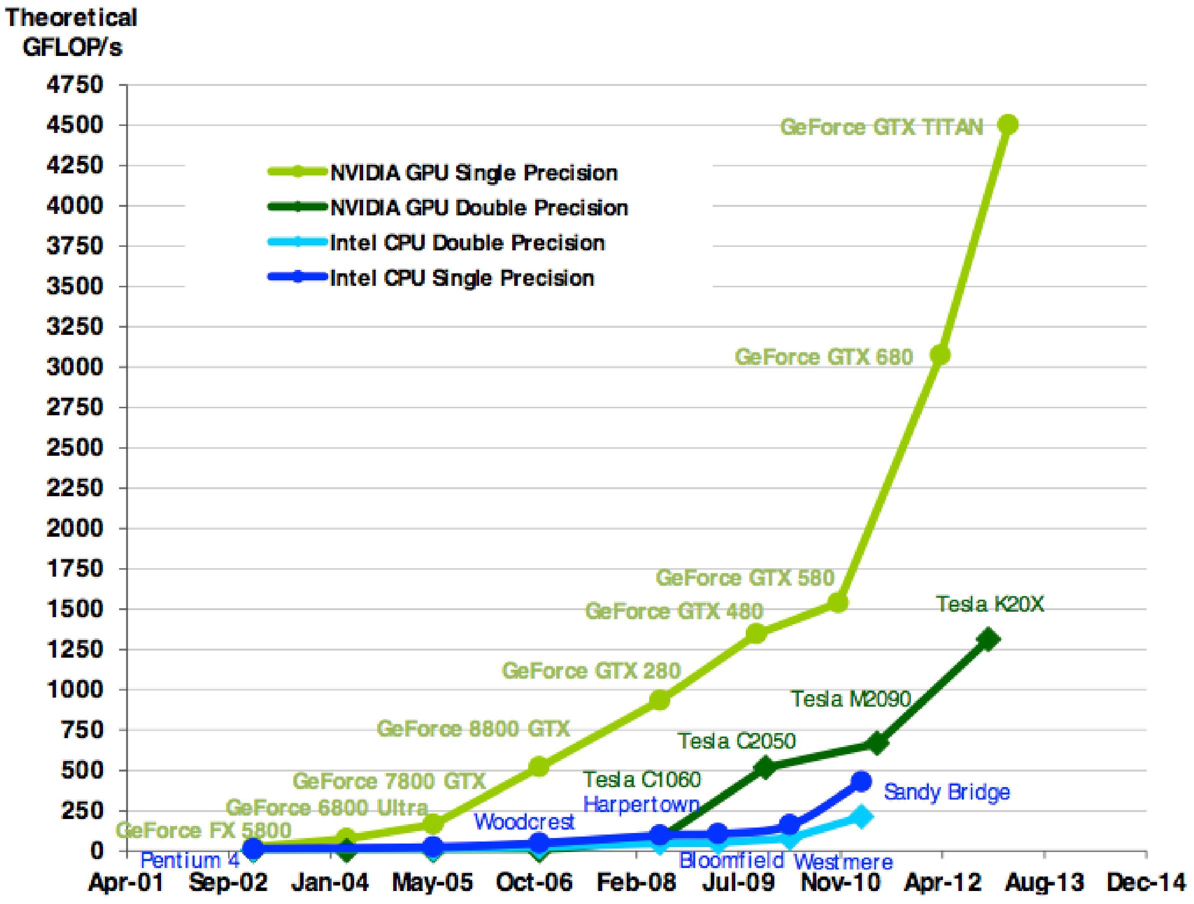
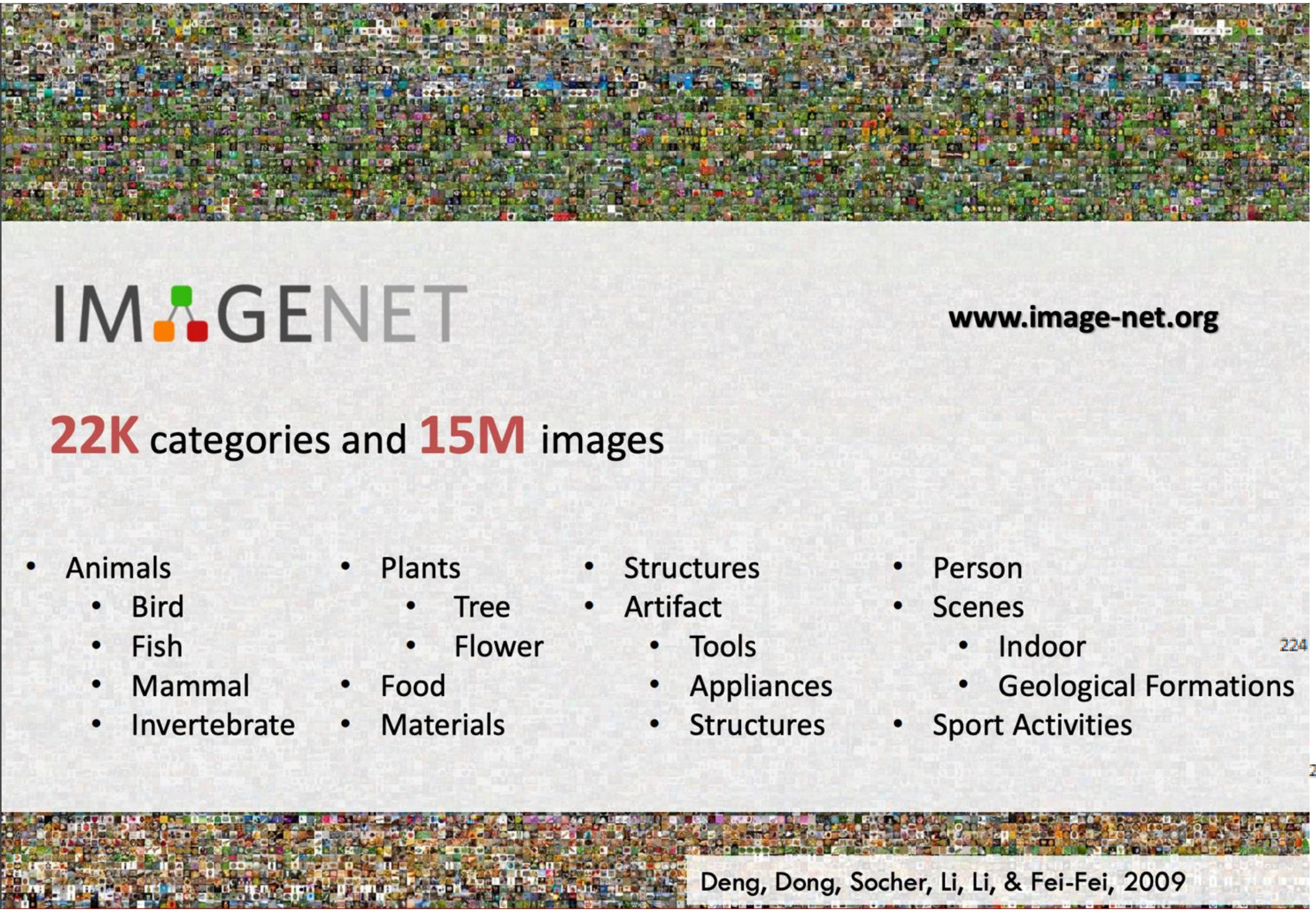


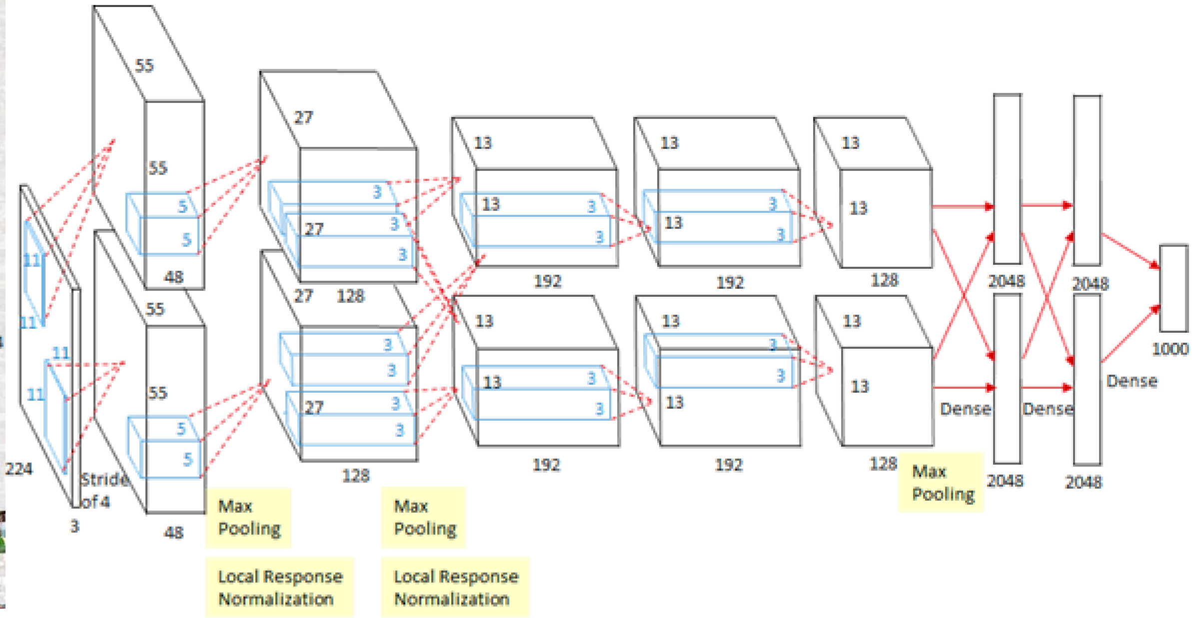
Figure 1 Floating-Point Operations per Second for the CPU and GPU

Computer Vision (CV) -- ImageNet, AlexNet



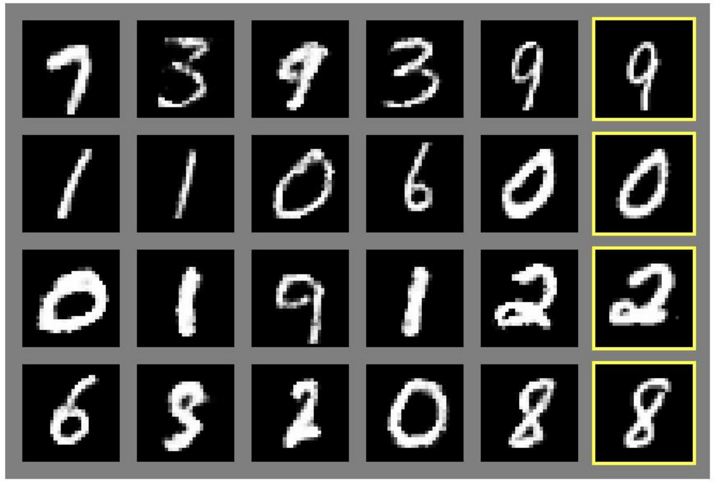
Deng, J., Dong, W., Socher, R., Li, L. J., Li, K., & Fei-Fei, L. (2009, June). Imagenet: A large-scale hierarchical image database. In *2009 IEEE conference on computer vision and pattern recognition* (pp. 248-255). IEEE.

AlexNet, CNN

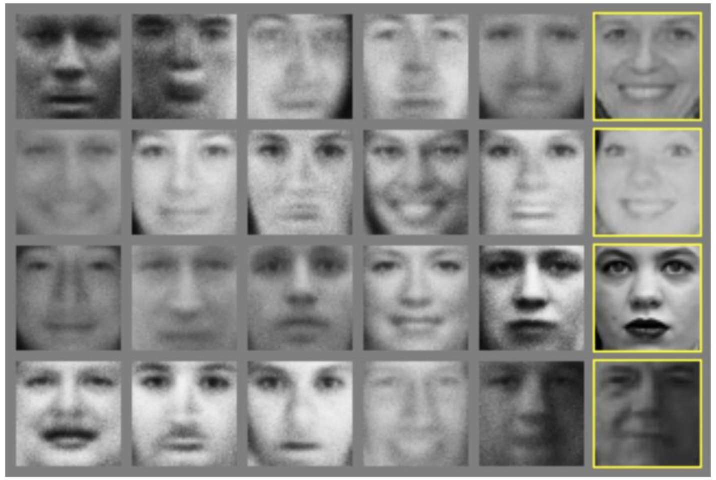


Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). Imagenet classification with deep convolutional neural networks. In *Advances in neural information processing systems* (pp. 1097-1105).

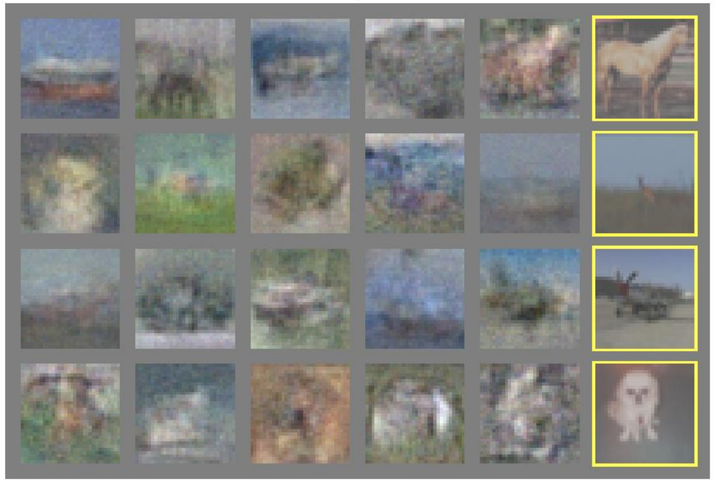
CV -- GAN



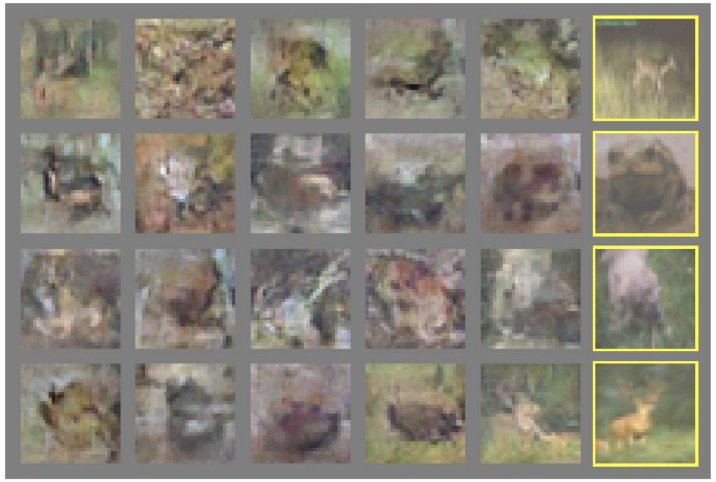
a)



b)



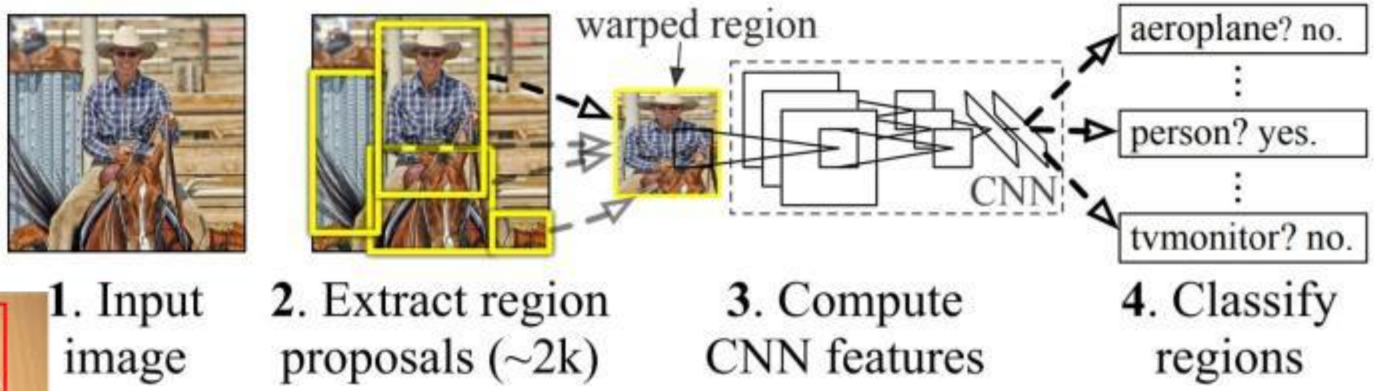
c)

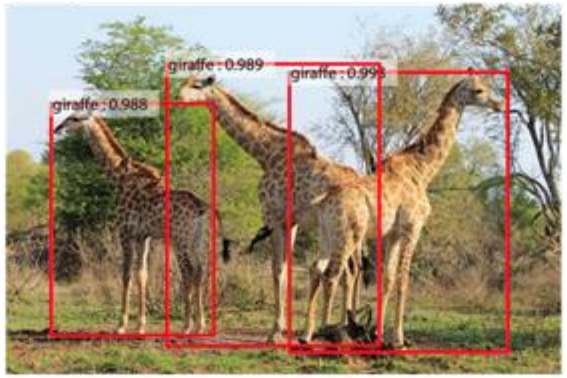


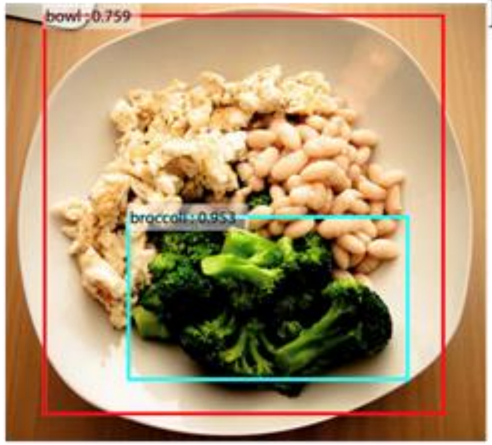
d)

Goodfellow, I., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., ... & Bengio, Y. (2014). Generative adversarial nets. In *Advances in neural information processing systems* (pp. 2672-2680).

CV (Detection) -- R-CNN, Fast R-CNN, Faster R-CNN







1.Girshick, R., Donahue, J., Darrell, T., & Malik, J. (2014). Rich feature hierarchies for accurate object detection and semantic segmentation. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 580-587).
2. Girshick, R. (2015). Fast r-cnn. In *Proceedings of the IEEE international conference on computer vision* (pp. 1440-1448).
3. Ren, S., He, K., Girshick, R., & Sun, J. (2015). Faster r-cnn: Towards real-time object detection with region proposal networks. In *Advances in neural information processing systems* (pp. 91-99).

Speech recognition (Unsupervised, ICA)

Mixed

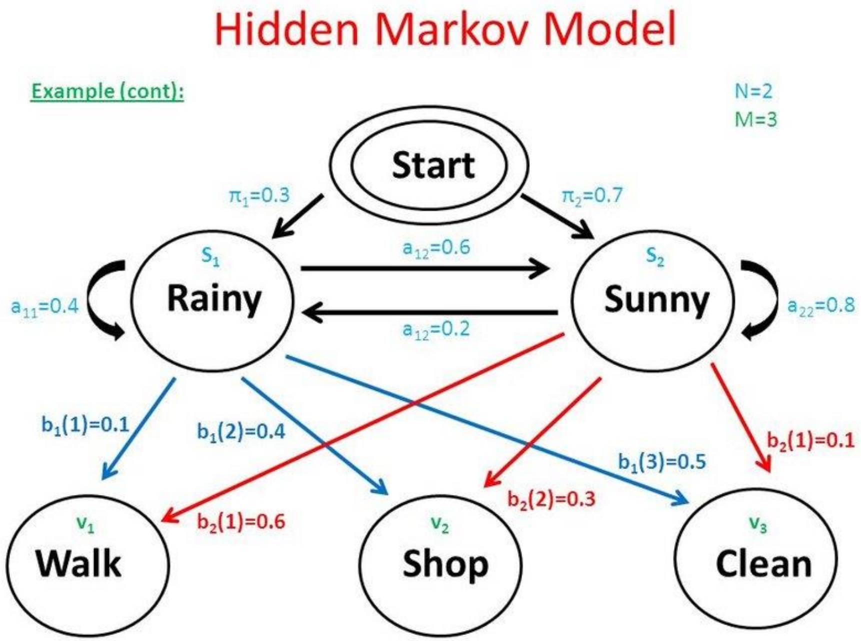
Separated

Speech recognition (Unsupervised, ICA, cont.)

Mixed

Separated

Speech recognition

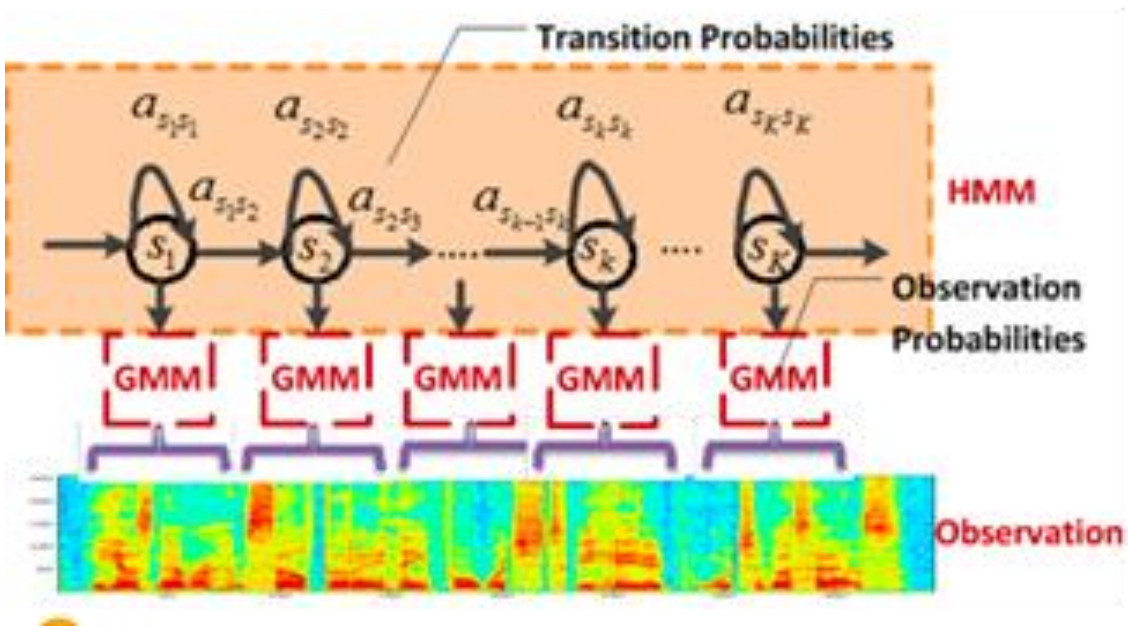


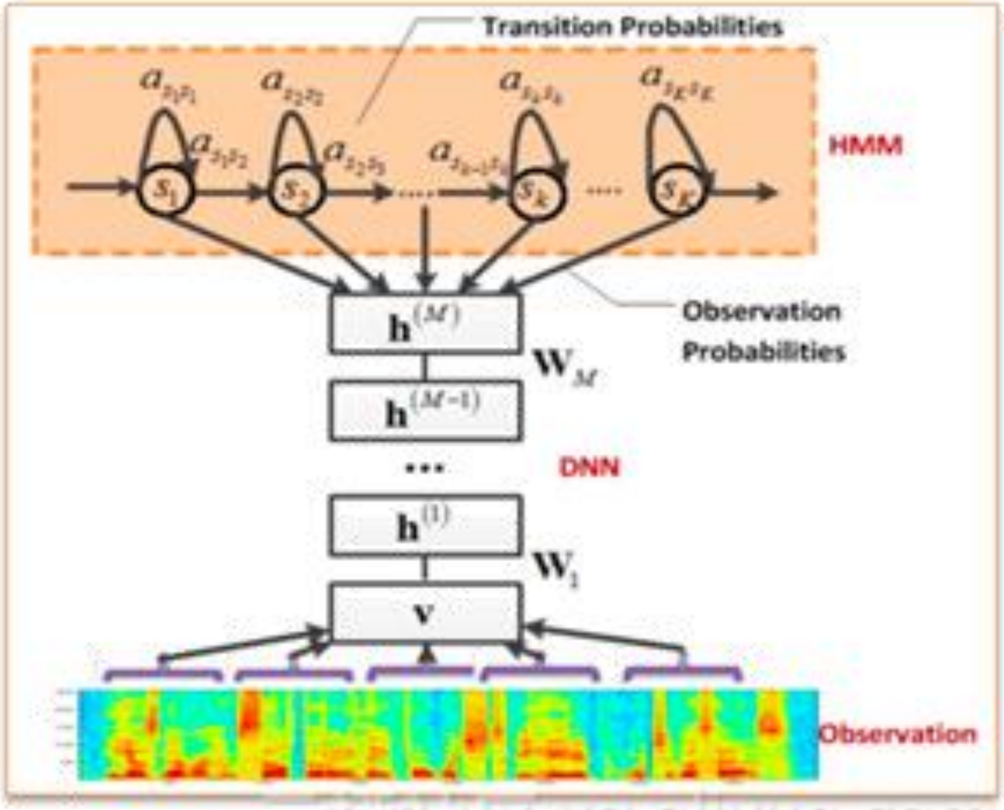
- Previous works use
  - Hidden Markov models (HMMs)
    - Deal with the temporal variability of speech
  - Gaussian mixture models (GMMs)
    - Determine how well each state of each HMM fits a frame or a short window of frames of coefficients that represents the acoustic input
- New
  - Feed-forward neural network
    - Takes several frames of coefficients as input and produces posterior probabilities over HMM states as output

Hinton, G., Deng, L., Yu, D., Dahl, G., Mohamed, A. R., Jaitly, N., ... & Sainath, T. (2012). Deep neural networks for acoustic modeling in speech recognition. *IEEE Signal processing magazine*, *29*.

Speech recognition

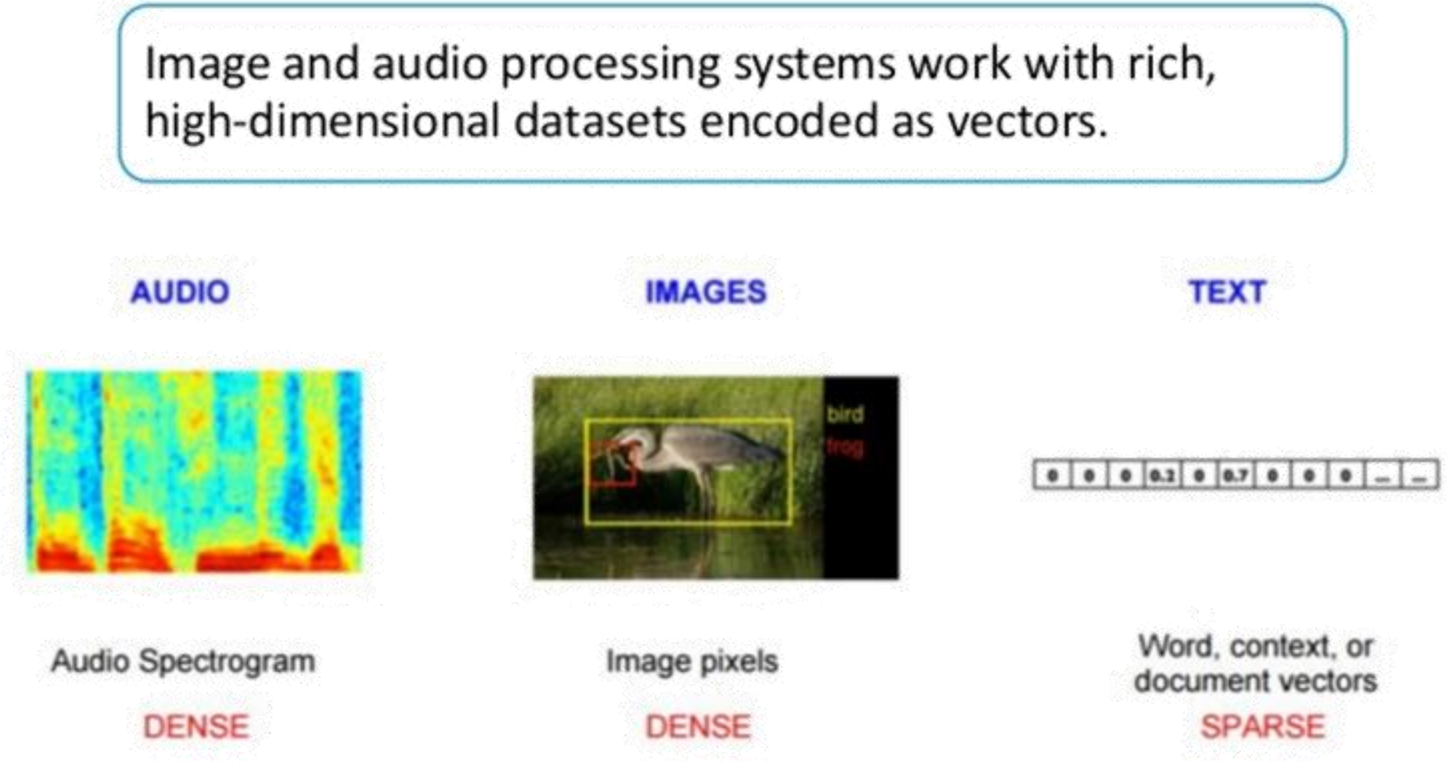
- **Deep Learning: From GMM-HMM to DNN-HMM**





Hinton, G., Deng, L., Yu, D., Dahl, G., Mohamed, A. R., Jaitly, N., ... & Sainath, T. (2012). Deep neural networks for acoustic modeling in speech recognition. *IEEE Signal processing magazine*, *29*.

Natural Language Processing (NLP) -- Word2Vec



Pennington, J., Socher, R., & Manning, C. (2014, October). Glove: Global vectors for word representation. In *Proceedings of the 2014 conference on empirical methods in natural language processing (EMNLP)* (pp. 1532-1543).

Natural Language Processing (NLP) -- Word2Vec (cont.)

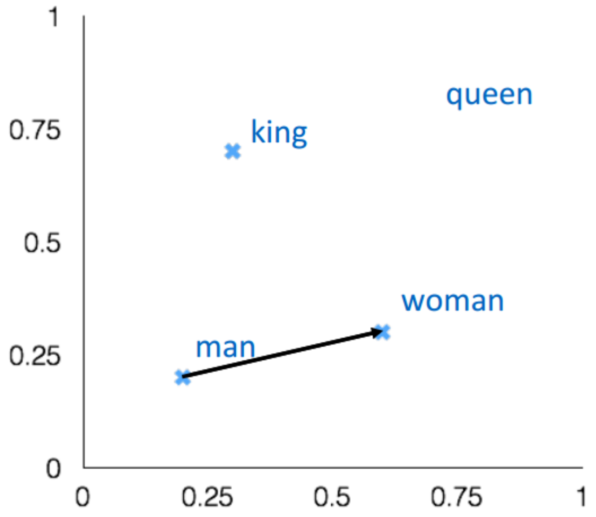
Word Analogies

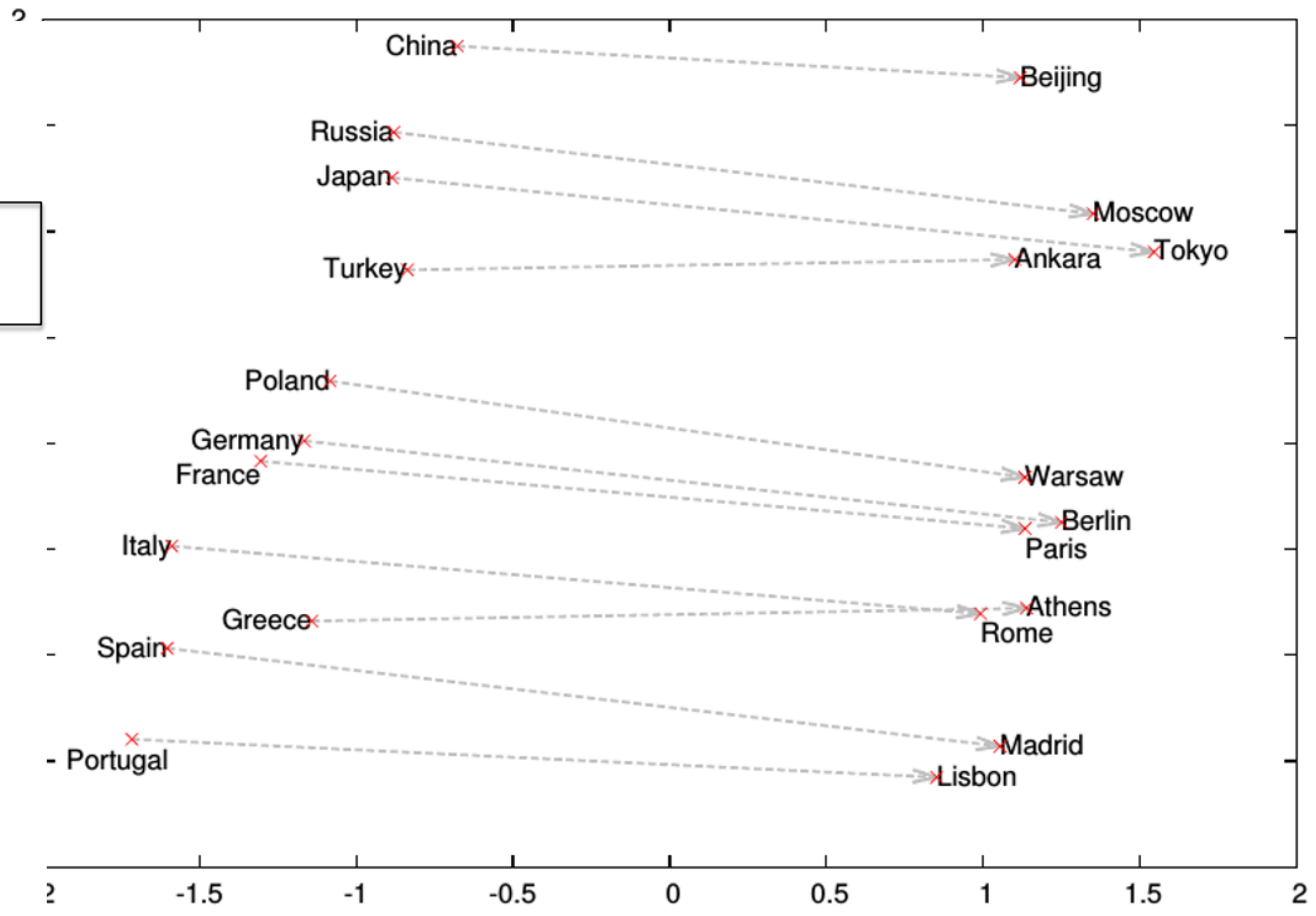
Test for linear relationships, examined by Mikolov et al. (2014)

a:b :: c:? → $$d = \arg\max_x \frac{(w_b - w_a + w_c)^T w_x}{||w_b - w_a + w_c||}$$

man:woman :: king:?

+	king	[0.30 0.70]
-	man	[0.20 0.20]
+	woman	[0.60 0.30]
	queen	[0.70 0.80]





NLP – BERT (Bidirectional Encoder Representations from Transformers)

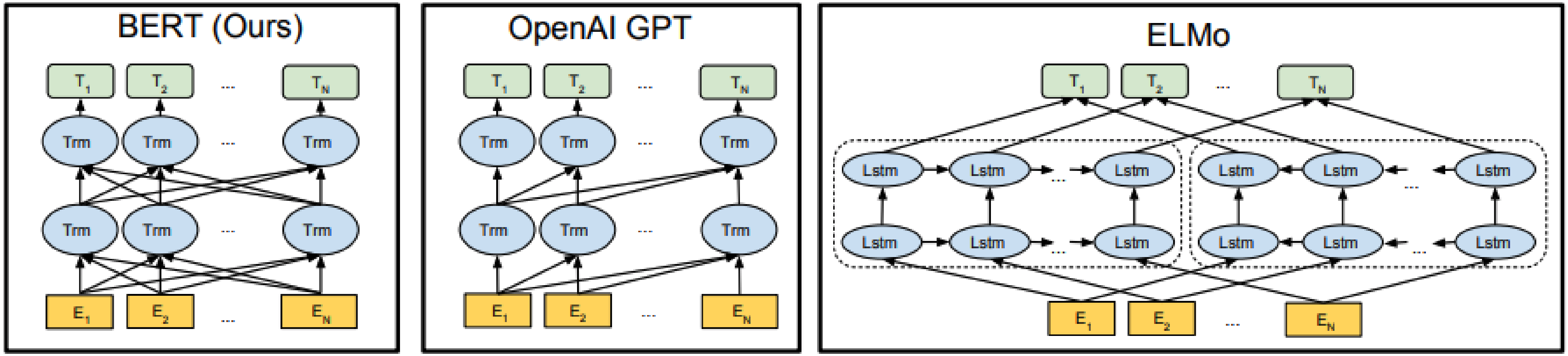


Figure 1: Differences in pre-training model architectures. BERT uses a bidirectional Transformer. OpenAI GPT uses a left-to-right Transformer. ELMo uses the concatenation of independently trained left-to-right and right-to-left LSTM to generate features for downstream tasks. Among three, only BERT representations are jointly conditioned on both left and right context in all layers.

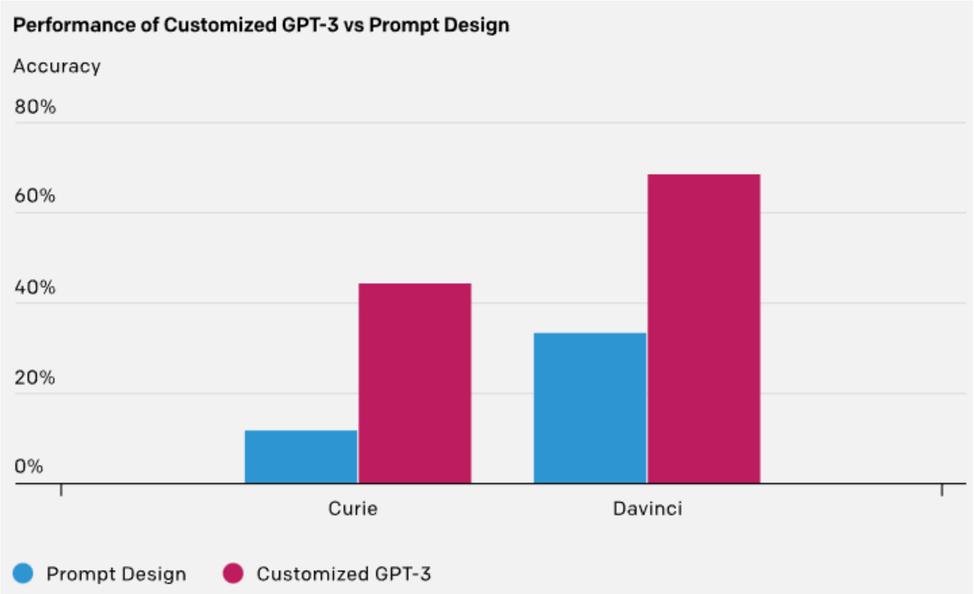
- The pre-trained BERT model can be finetuned with just one additional output layer to create state-of-the-art models for a wide range of tasks, such as question answering and language inference, without substantial task-specific architecture modifications
- It obtains new state-of-the-art results on 11 natural language processing tasks

Devlin, J., Chang, M. W., Lee, K., & Toutanova, K. (2018). Bert: Pre-training of deep bidirectional transformers for language understanding. *arXiv preprint arXiv:1810.04805*.

NLP: GPT-3

- Generative Pre-trained Transformer 3
  - An autoregressive language model that uses deep learning to produce human-like text

- For example, on prompted GPT-3 to tell an amusing short story about what happens when Georg Cantor decides to visit Hilbert's hotel



Two sizes of GPT-3 models, Curie and Davinci, were fine-tuned on 8,000 examples from one of our most challenging research datasets, Grade School Math problems. We compare the models' ability to solve problems when 10 completions are created.

Georg Cantor, the famous mathematician, was having dinner with some other famous mathematicians at a hotel. At the end of the meal, the waiter brought him the bill and Cantor discovered to his horror that the bill was the sum of two inconsistent infinite series, the one a simple geometric series and the other the harmonic series.

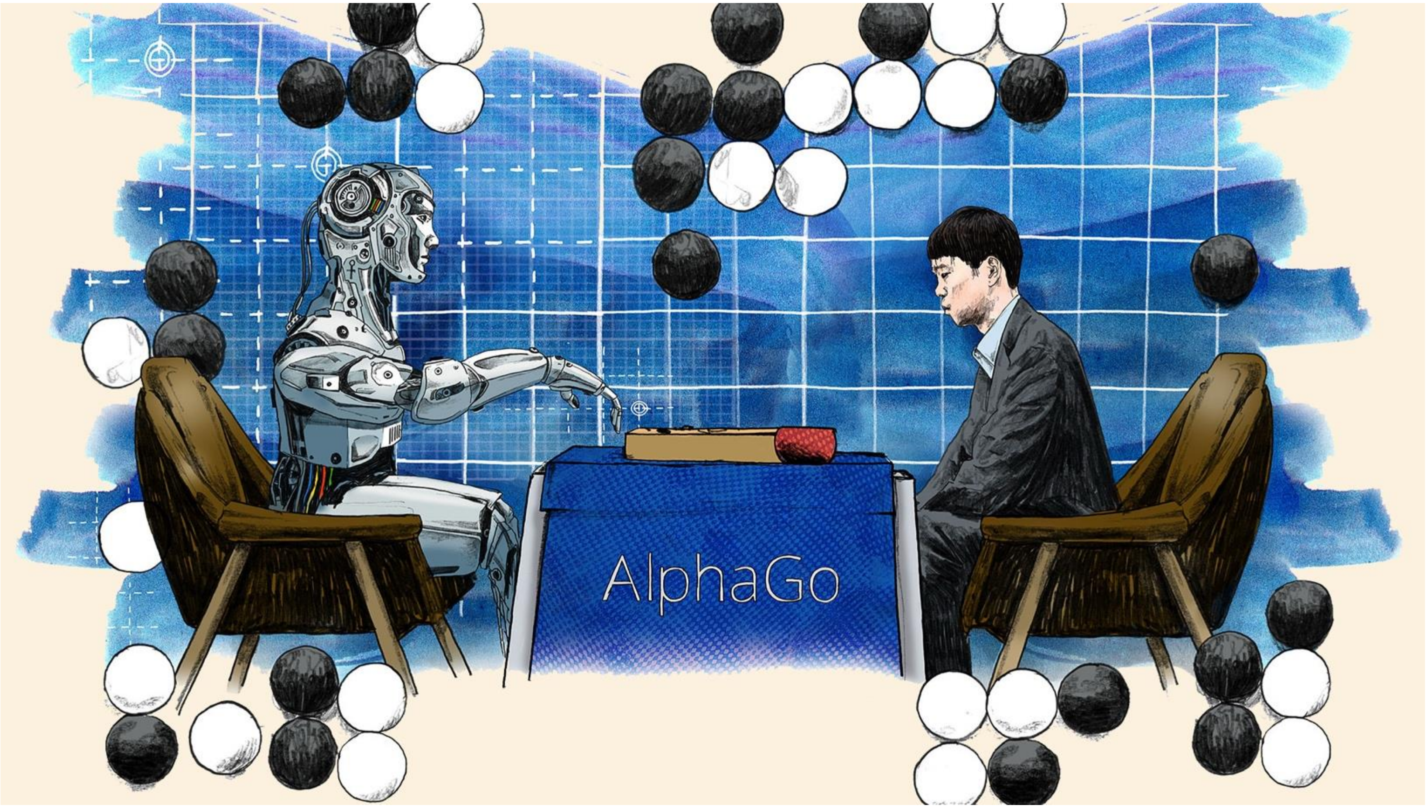
Cantor wrote to the manager of the hotel protesting that it was impossible for the waiter to have computed the bill, and requested that the waiter be sent to talk to him. The waiter came over and started to explain.

Cantor: Excuse me, but I know the sum of the harmonic series is infinitely greater than the sum of the simple geometric series, so you have erred.

Waiter: Yes, but you see, sir, the geometric series was for the dinner, and the harmonic series was for the service.

Large Language Model

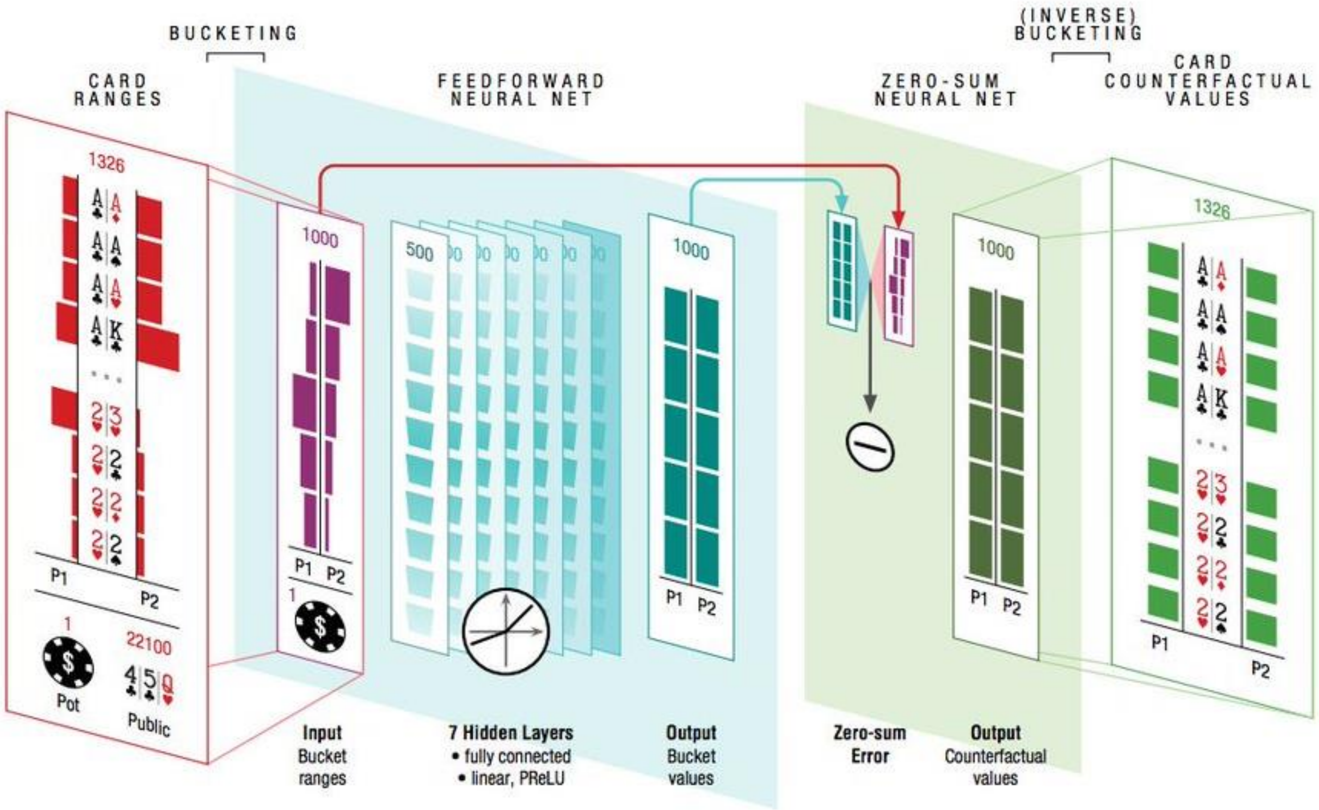
AlphaGo 2016



- Win Lee Sedol by 4:1 on Go
- Efficient search on large solution space

Silver, D., Huang, A., Maddison, C. J., Guez, A., Sifre, L., Van Den Driessche, G., ... & Dieleman, S. (2016). Mastering the game of Go with deep neural networks and tree search. *nature*, *529*(7587), 484.

Texas hold'em 2017



DeepStack

- In a study involving 44,000 hands of poker, DeepStack defeated with statistical significance professional poker players in heads-up no-limit Texas hold'em
- Imperfect information setting

Moravčík, M., Schmid, M., Burch, N., Lisý, V., Morrill, D., Bard, N., ... & Bowling, M. (2017). Deepstack: Expert-level artificial intelligence in heads-up no-limit poker. *Science*, *356*(6337), 508-513.

History of game AI

1956 checkers

1992 backgammon

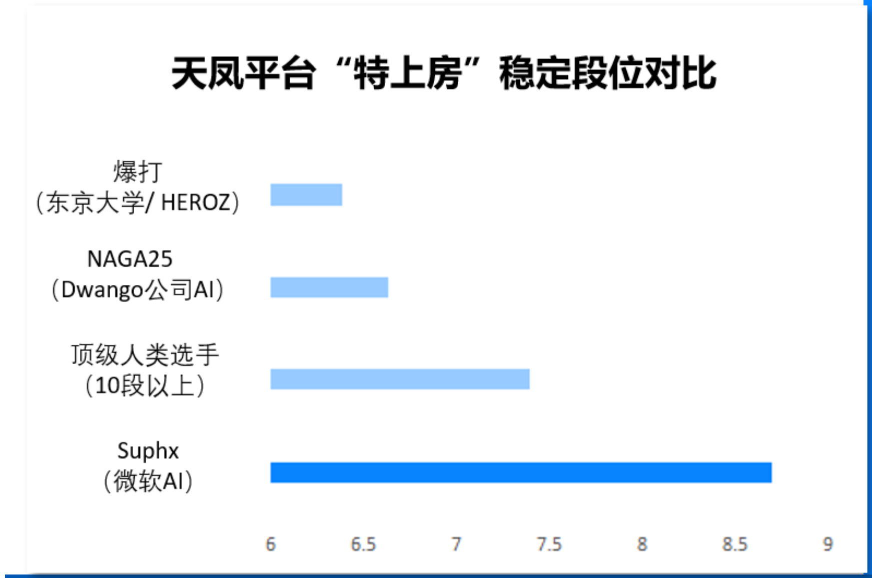
1994 checkers

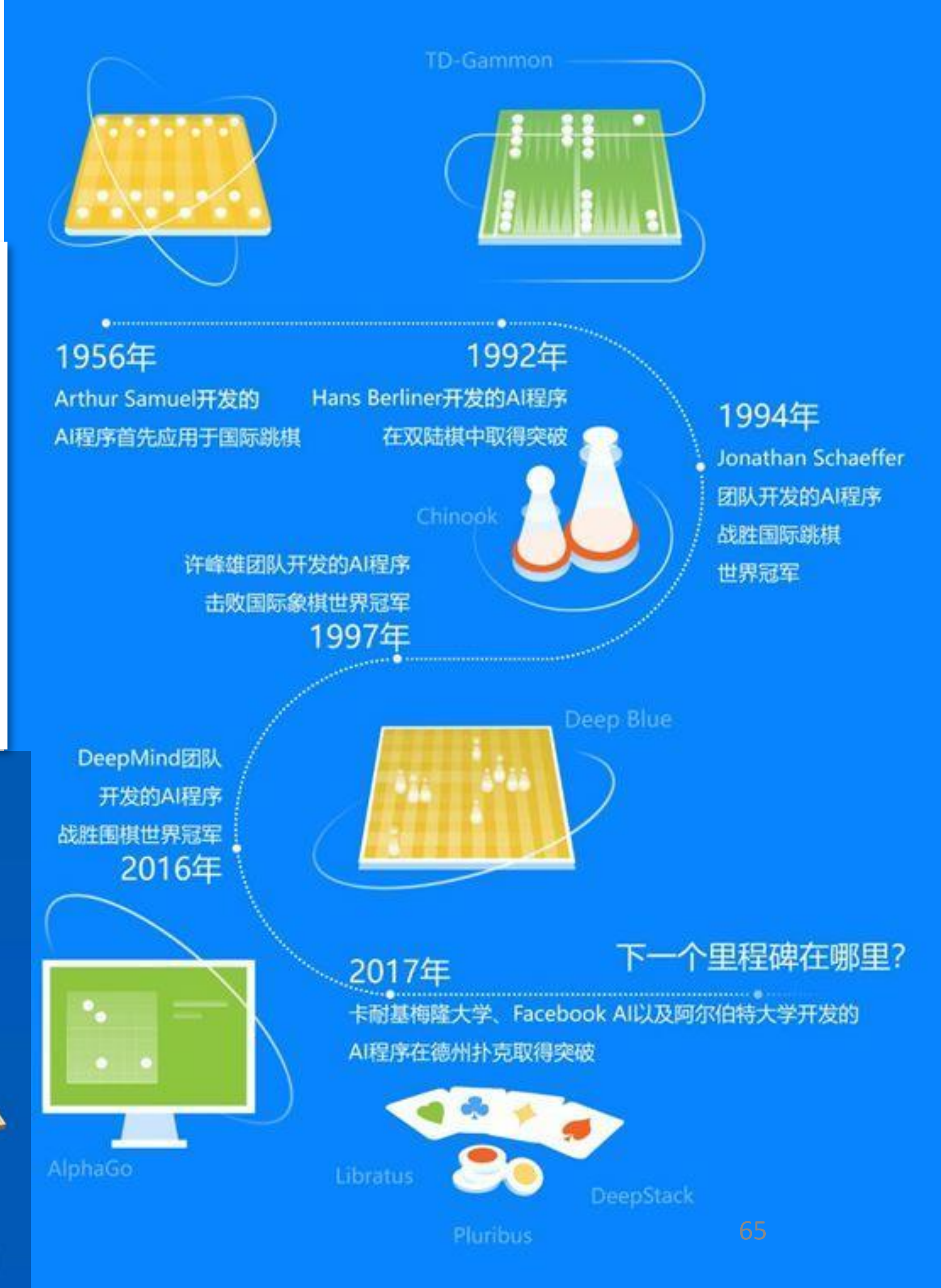
1997 chess

2016 Go

2017 Texas hold’em

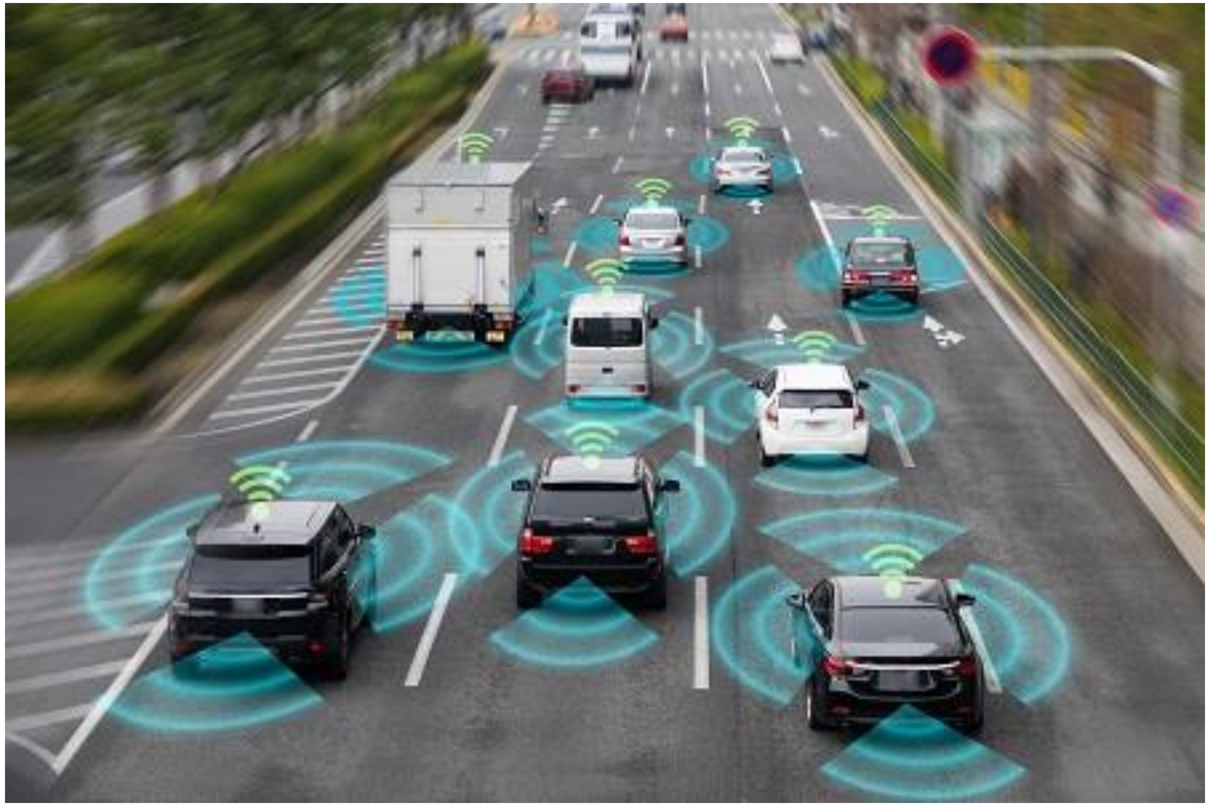
2019 Majiang



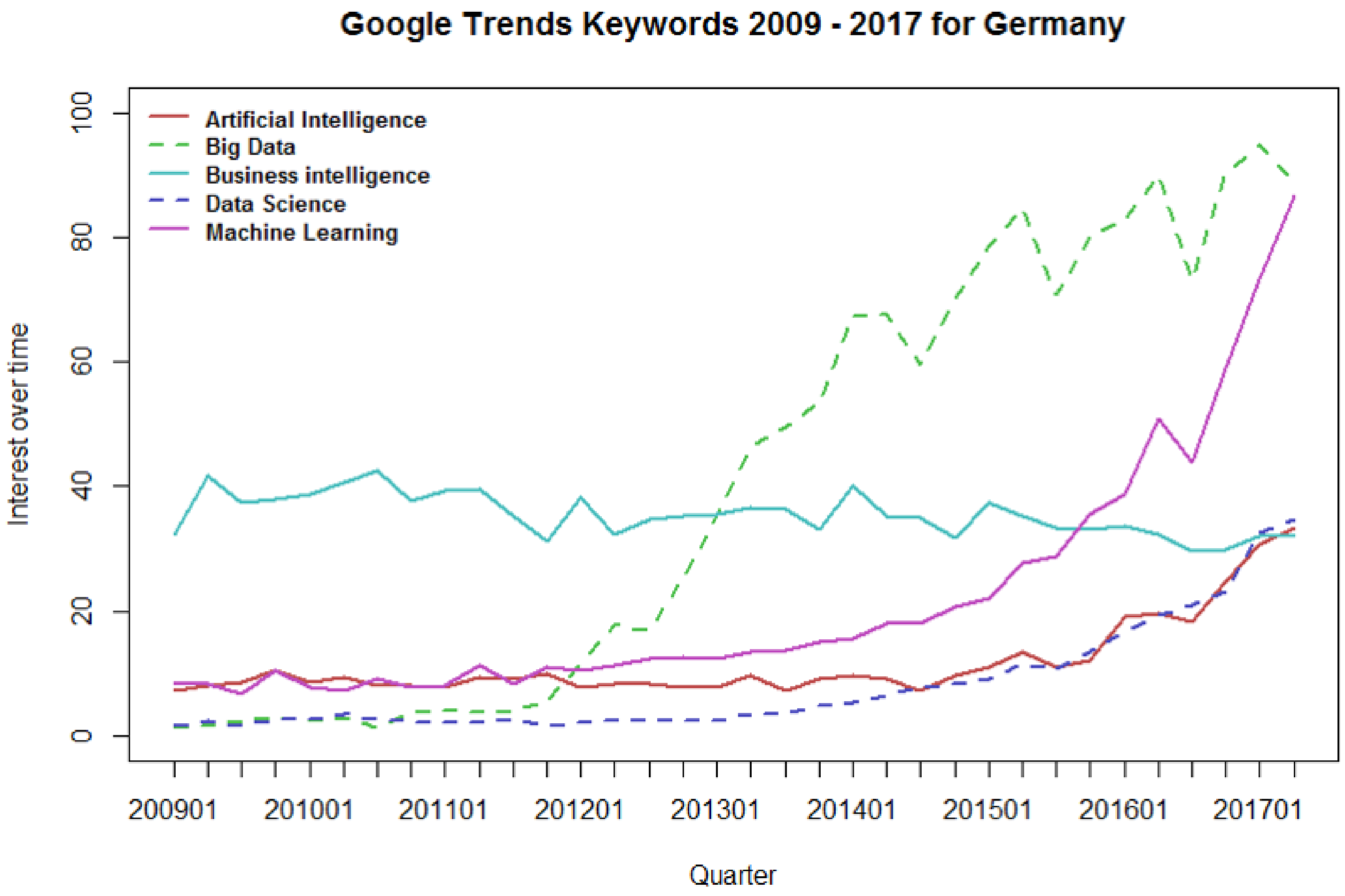


Game playing – state of the art

Autonomous Driving



Recent popularity of AI and ML



AI and machine learning together: 2010s and 2020s

WIRED BUSINESS CULTURE GEAR IDEAS SCIENCE SECURITY TRANSPORTATION SIGN IN SUBSCRIBE

We've spent years feeding neural nets vast amounts of data, teaching them to think like human brains. They're crazy-smart, but they have absolutely no common sense. What if we've been doing it all wrong? BETH HOLZER

CLIVE THOMPSON BUSINESS 11.13.2018 06:00 AM

How to Teach Artificial Intelligence Some Common Sense

We've spent years feeding neural nets vast amounts of data, teaching them to think like human brains. They're crazy-smart, but they have absolutely no common sense. What if we've been doing it all wrong?

2,456 views | Oct 16, 2018, 08:30am

AI Requires More Than Machine Learning

Forbes Technology Council

Jans Aasman Forbes Councils Member
Forbes Technology Council
COUNCIL POST | Paid Program
Innovation

BBC NEWS

Home | UK | World | Business | Politics | Tech | Science | More

Researchers: Are we on the cusp of an 'AI winter'?

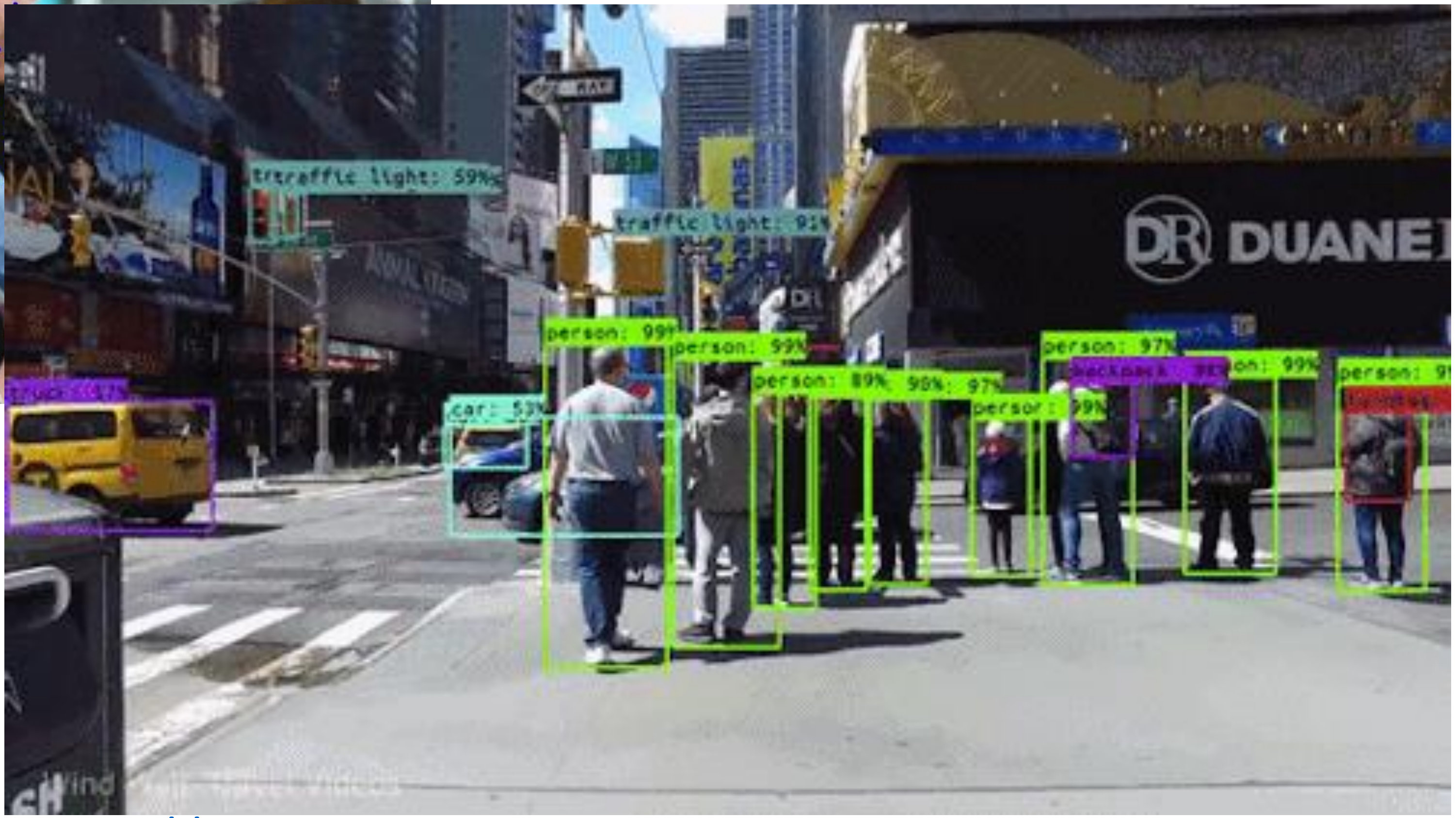
By Sam Shead
Technology reporter

12 January 2020 | Technology

What Can AI Do?

Sci-Fi AI

Face recognition, real-time detection

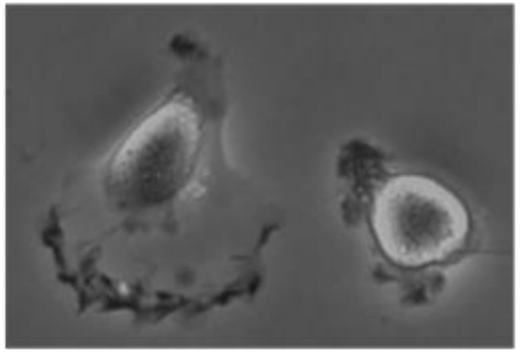


https://bitrefine.group/home/transportation/face-recognition-support-system
https://cdn-images-1.medium.com/max/1600/1*q1uVc-MU-tC-WwFp2yXJow.gif

Medical image analysis

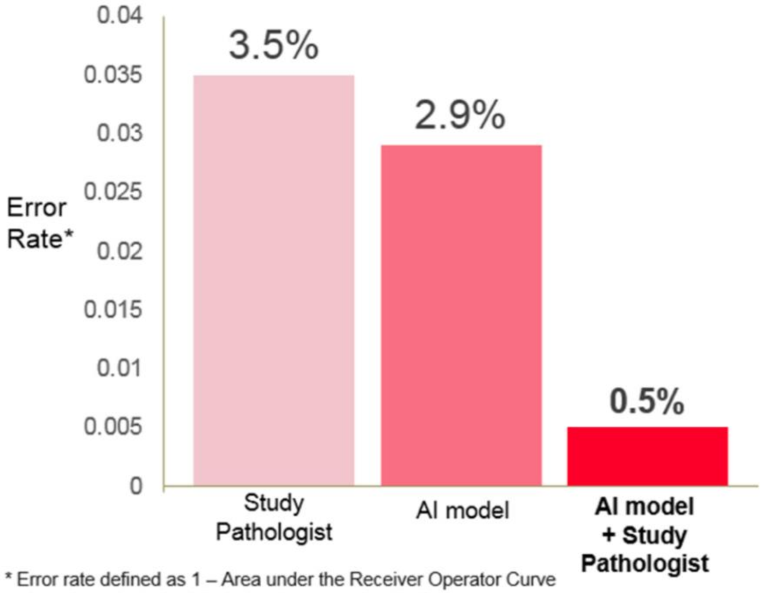
- Segmentation res

a



- Breast Cancer Diagnoses

(AI + Pathologist) > Pathologist

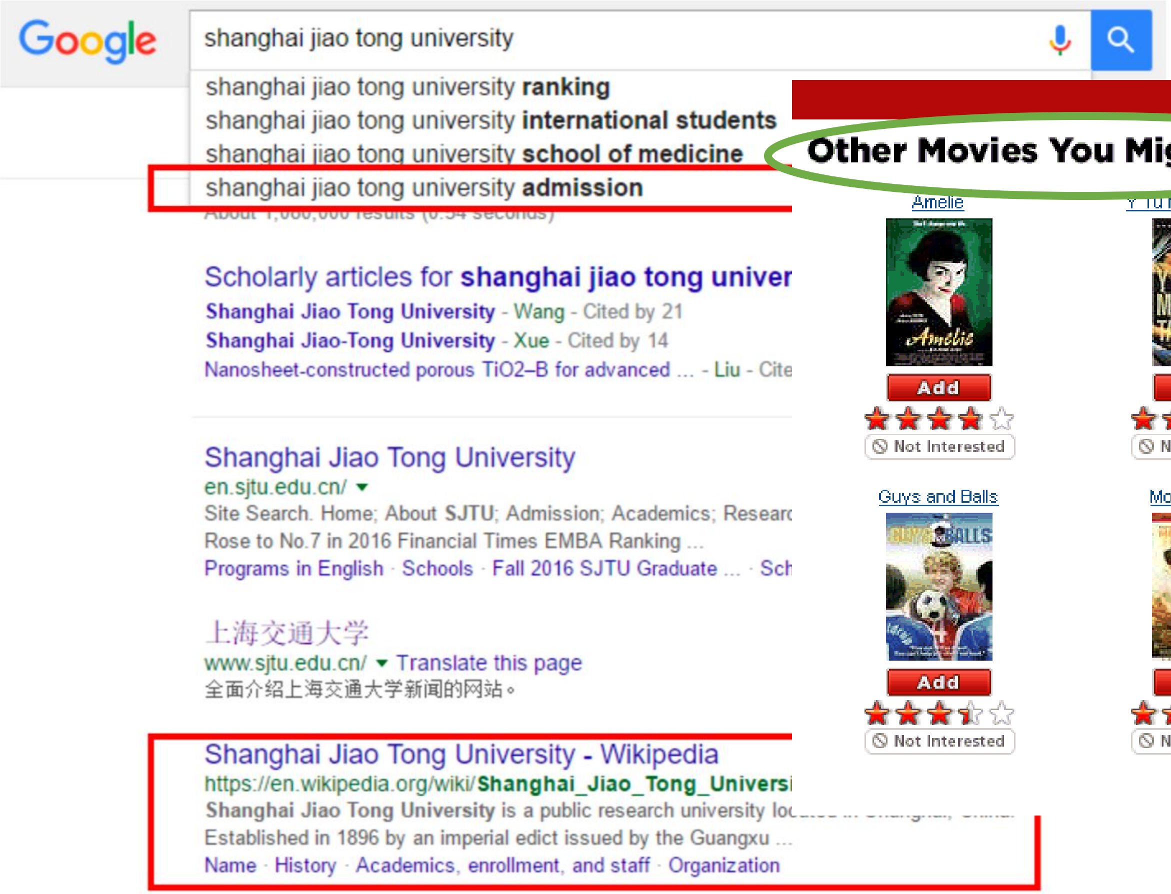


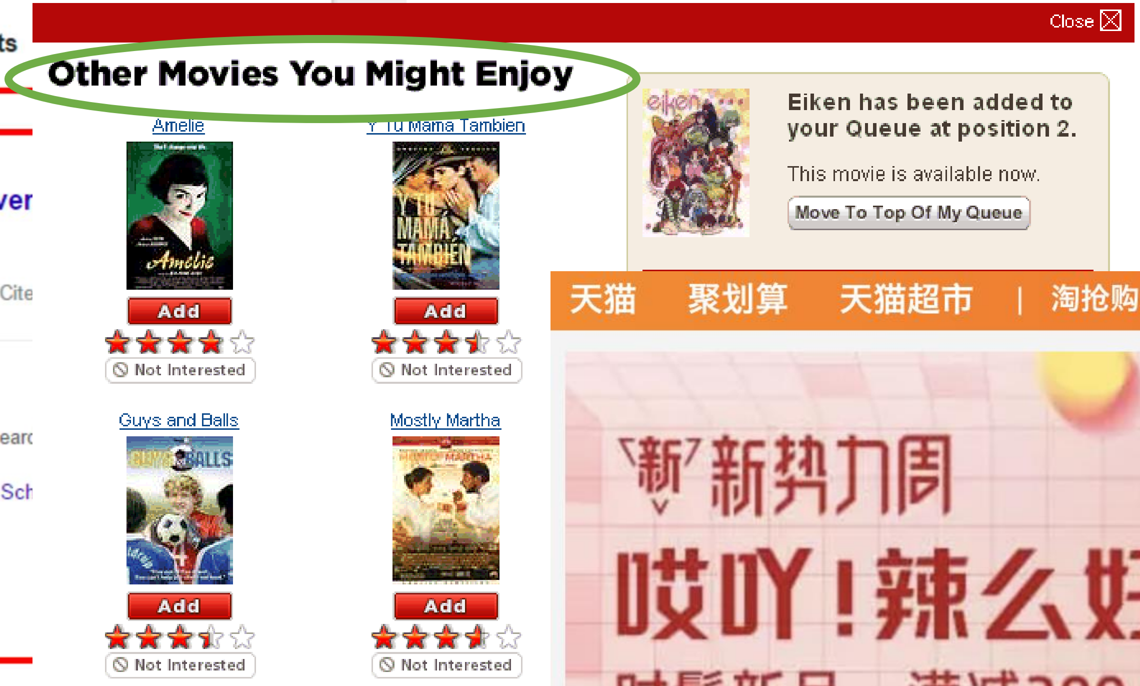
* Error rate defined as 1 – Area under the Receiver Operator Curve
** A study pathologist, blinded to the ground truth diagnoses, independently scored all evaluation slides.

Ronneberger, O., Fisch
segmentation. In *Inter*
234-241). Springer, Cham.

Wang, Dayong, et al. "Deep learning for identifying metastatic breast cancer." arXiv preprint arXiv:1606.05718 (2016).
https://blogs.nvidia.com/blog/2016/09/19/deep-learning-breast-cancer-diagnosis/

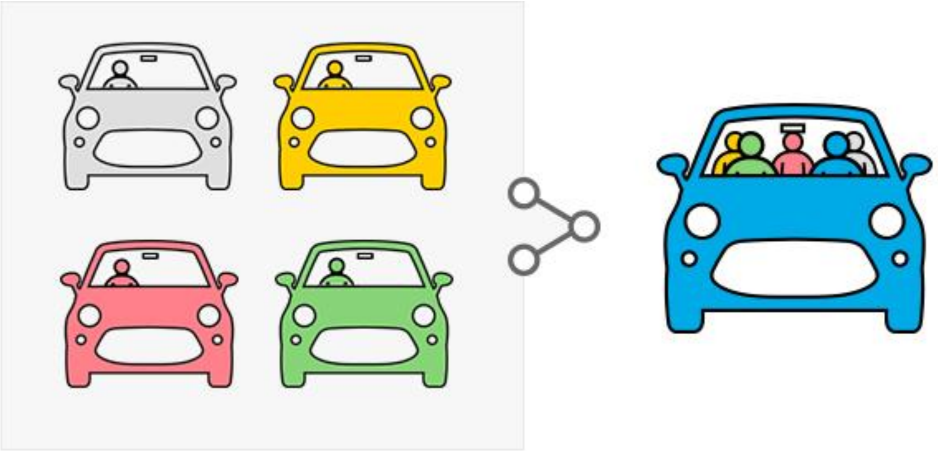
Web app: search, recommendation, ad



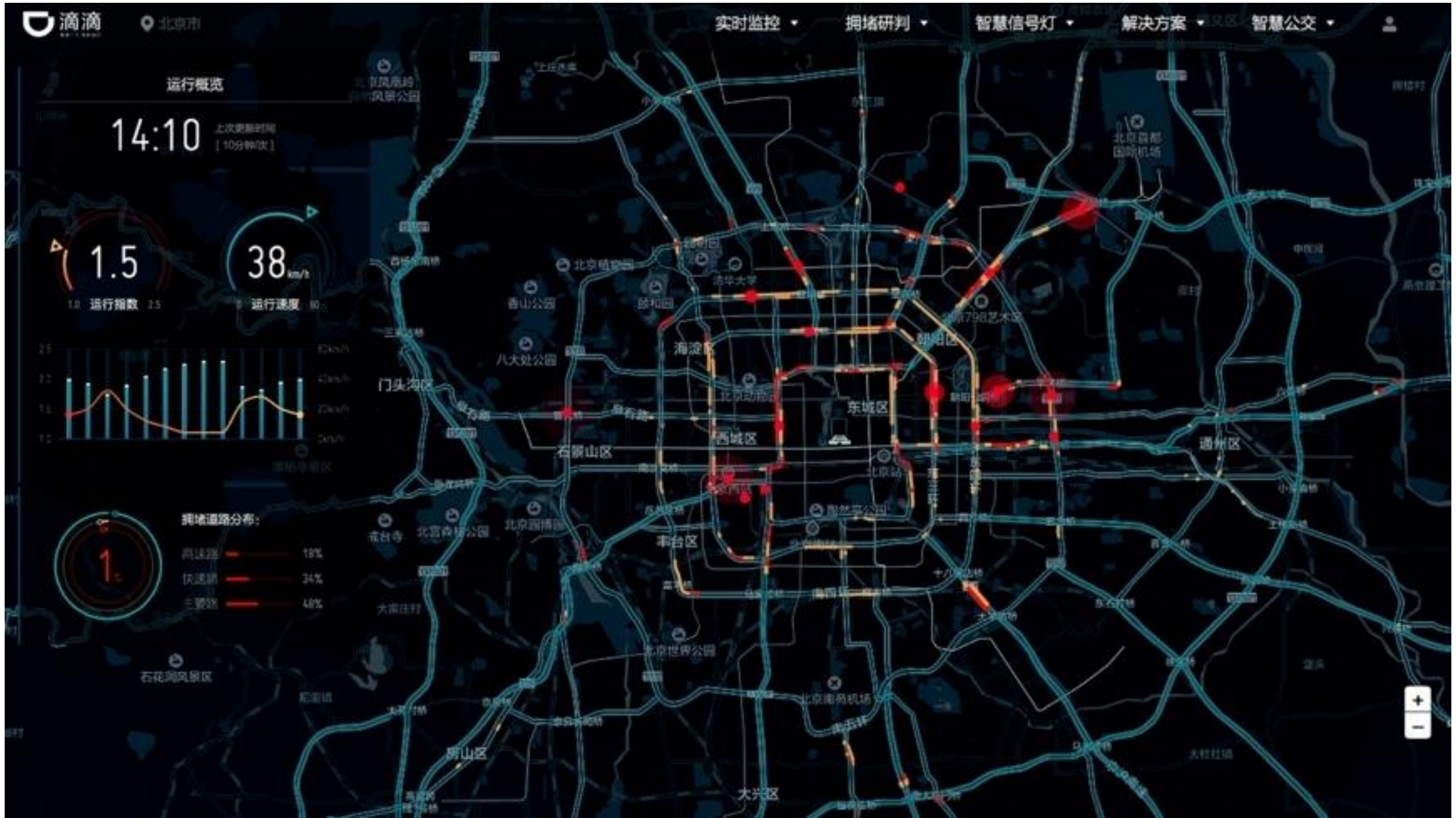


Slide credit: Weinan Zhang

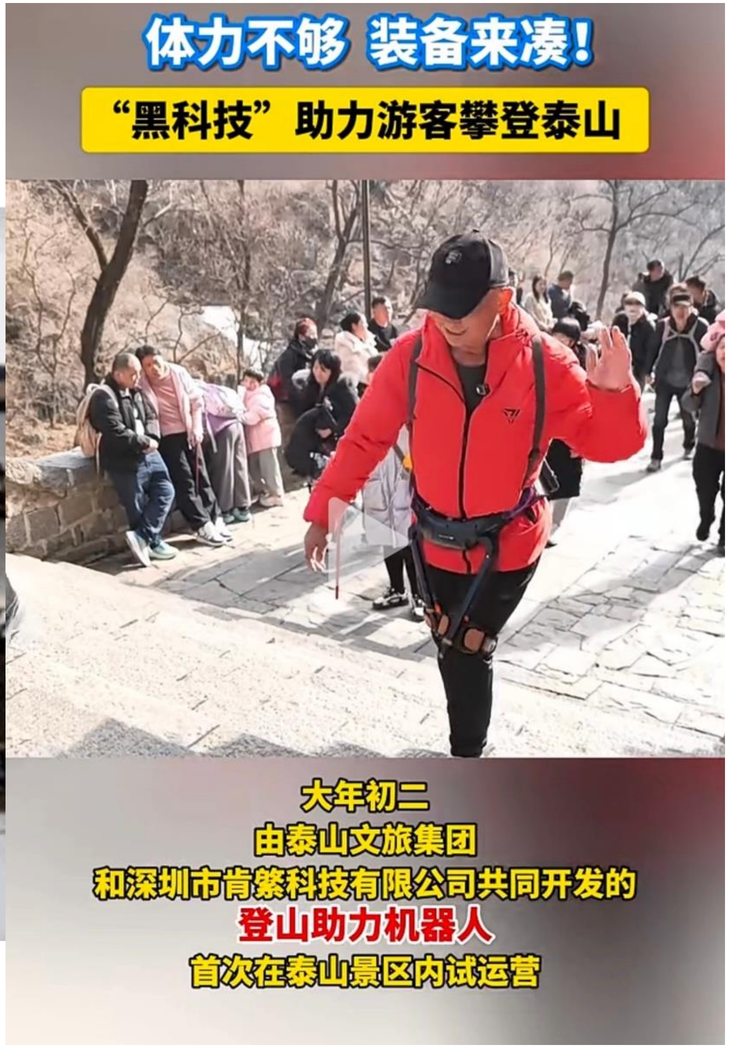
Alleviate traffic congestion



- Ride sharing
- Disperse traffic



Exoskeletons

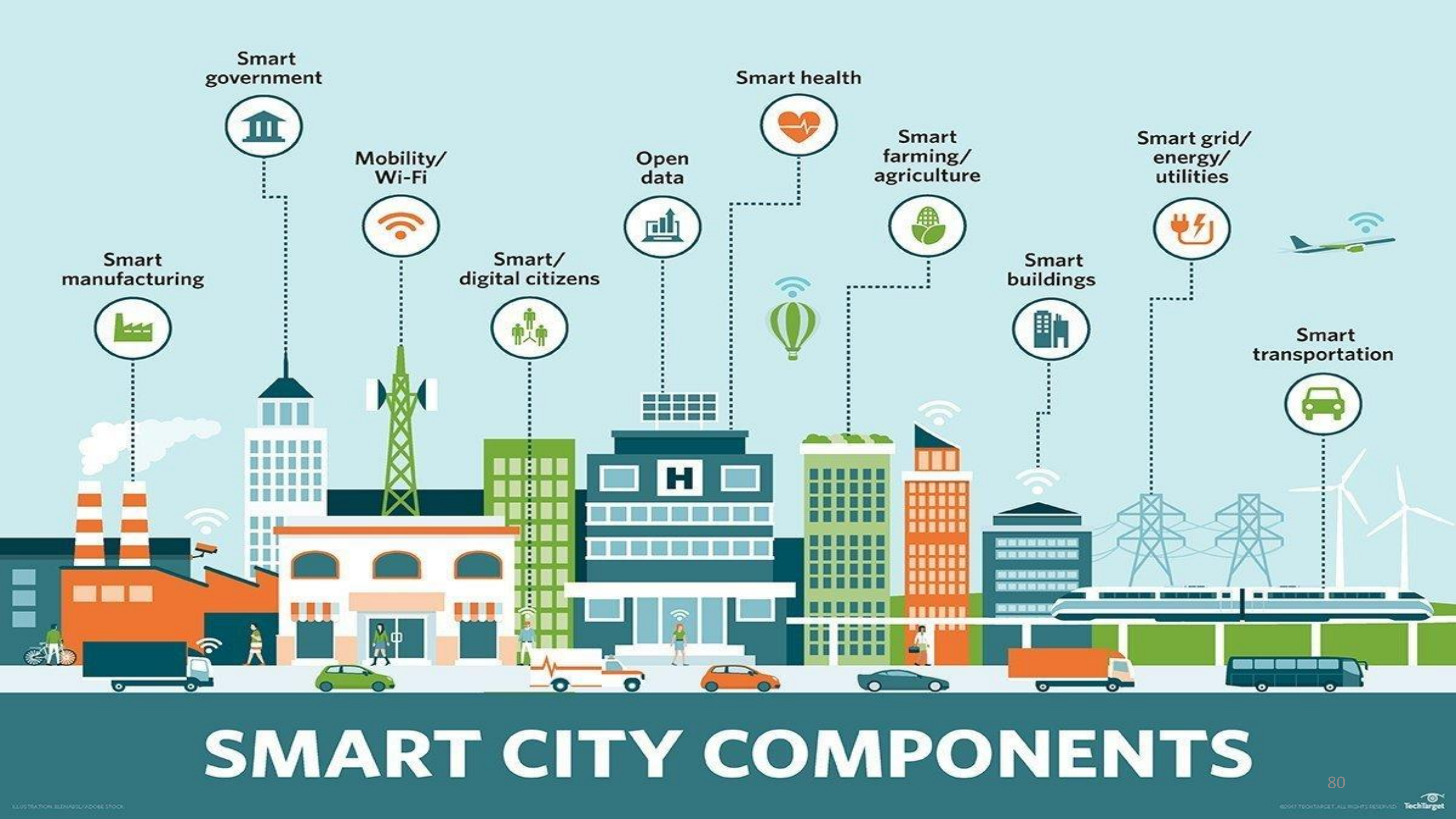


Agriculture: Crop-dusting

- DJI drones (unmanned aerial vehicles)

Transportation: Sorting parcels

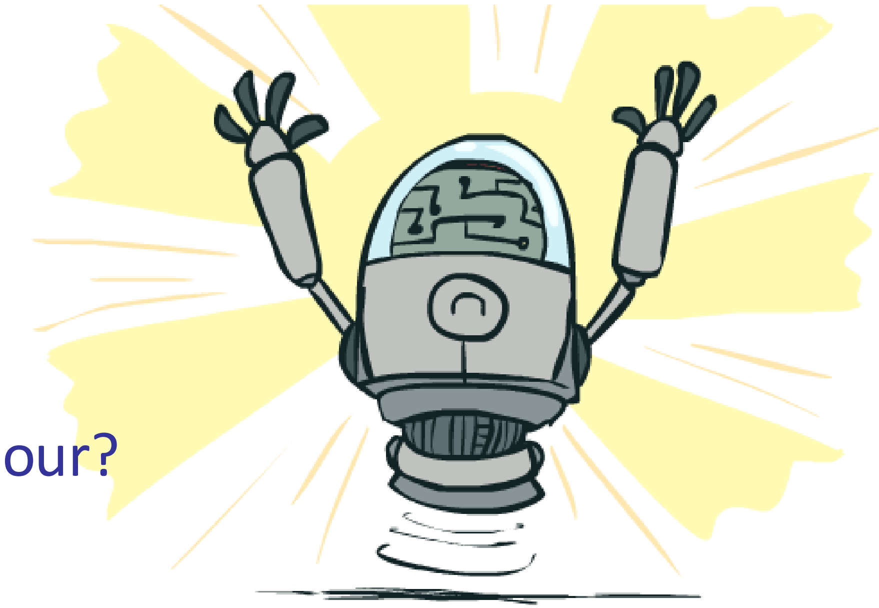
Unitree B2-W


Smart government
Smart health
Mobility/ Wi-Fi
Open data
Smart farming/ agriculture
Smart grid/ energy/ utilities
Smart manufacturing
Smart/ digital citizens
Smart buildings
Smart transportation
H
SMART CITY COMPONENTS
TechTarget

What Can AI Do?

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

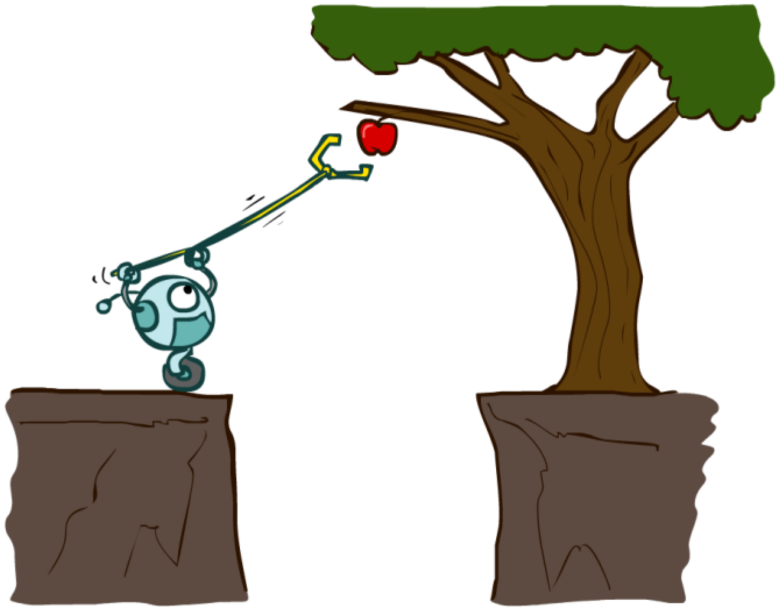
- Play a decent game of table tennis?
- Drive safely along a curving mountain road?
- Drive safely across Shanghai?
- Buy a week's worth of groceries on the web?
- Buy a week's worth of groceries at a local market?
- Discover and prove a new mathematical theorem?
- Converse successfully with another 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?
- Write an intentionally funny story?

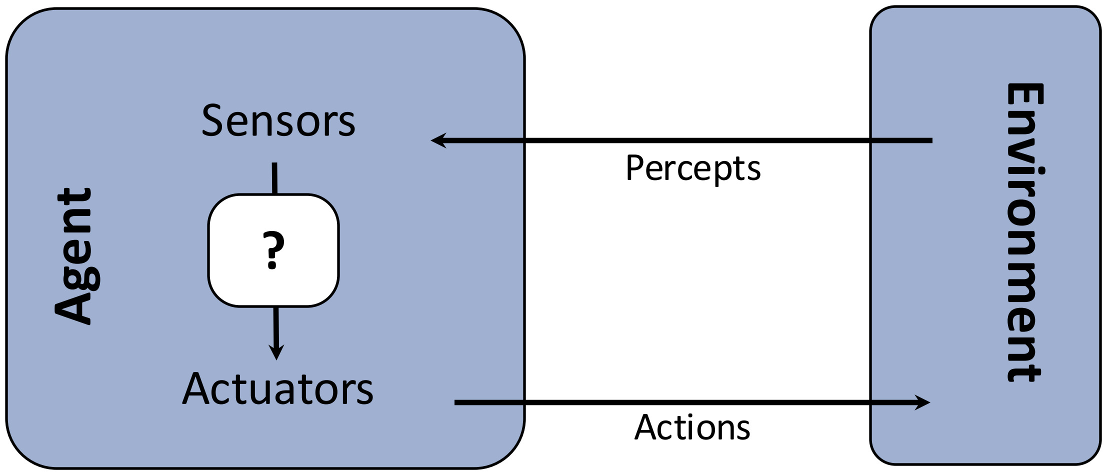


Intelligent Agents

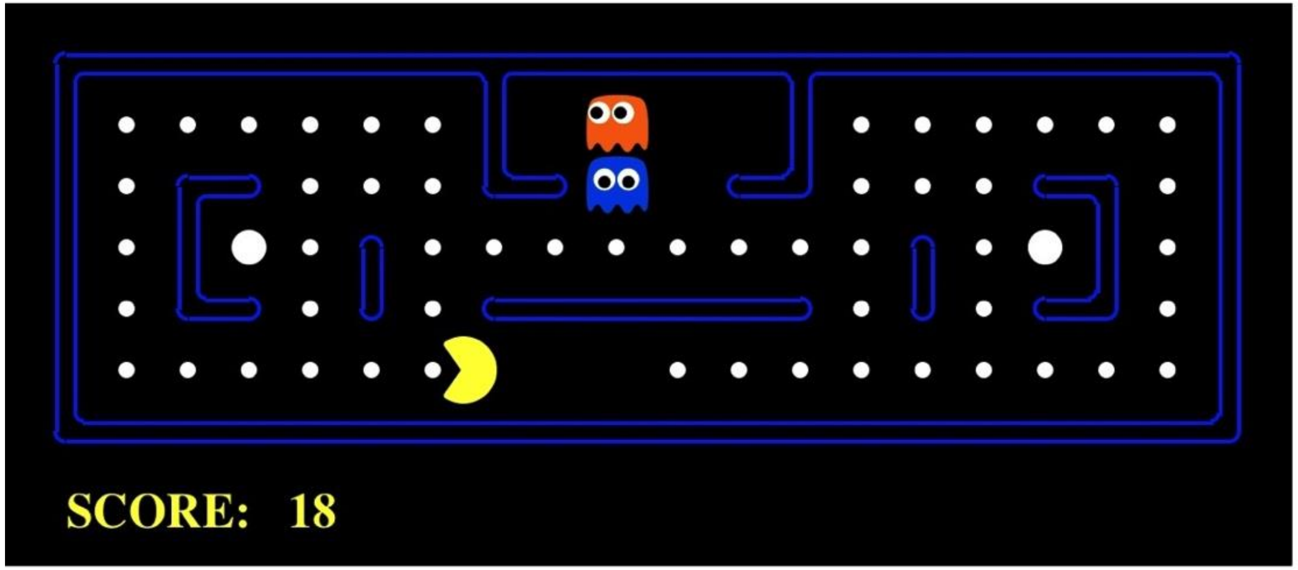
Agents and environments

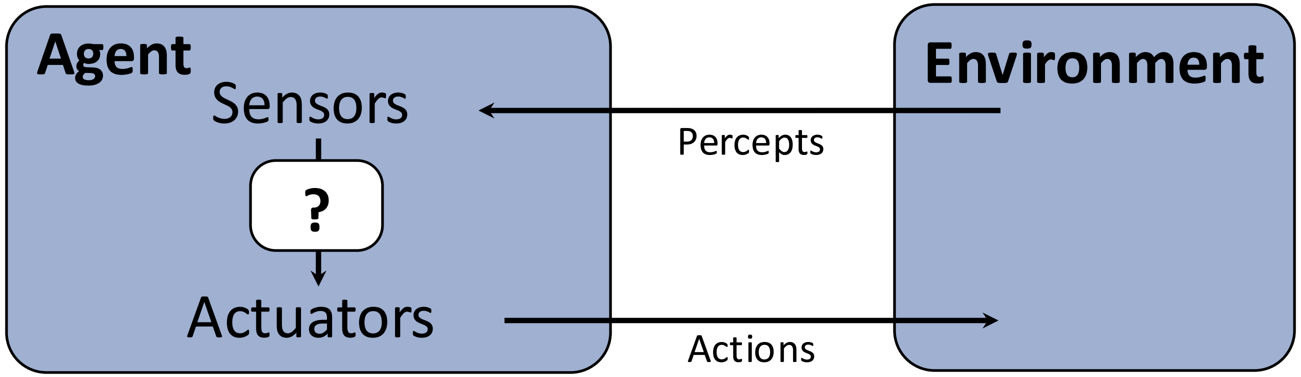
- Agents interact with environments through sensors and actuators
- An agent is an entity that perceives and acts
- A rational agent selects actions that maximize its (expected) utility
- Characteristics of the percepts, environment, and action space dictate techniques for selecting rational actions





Pac-Man as an Agent



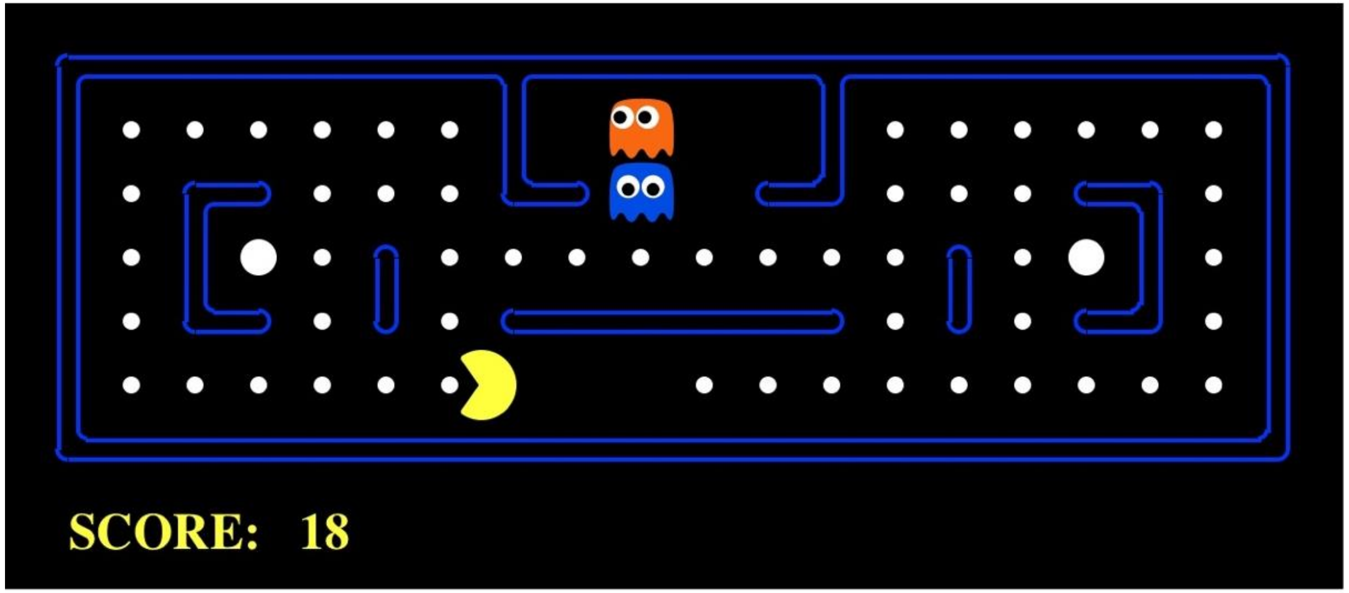


Pac-Man is a registered trademark of Namco-Bandai Games, used here for educational purposes

Demo1: pacman-l1.mp4

Environment 1: Pac-Man

- Performance measure
  - -1 per step; +10 food; +500 win; -500 die; +200 hit scared ghost
- Environment
  - Pacman dynamics (incl ghost behavior)
- Actuators
  - North, South, East, West, (Stop)
- Sensors
  - Entire state is visible



Environment 2: Automated taxi

- Performance measure
  - Income, happy customer, vehicle costs, fines, insurance premiums
- Environment
  - streets, other drivers, customers
- Actuators
  - Steering, brake, gas, display/speaker
- Sensors
  - Camera, radar, accelerometer, engine sensors, microphone

Image: http://nypost.com/2014/06/21/how-google-might-put-taxi-drivers-out-of-business/

Environment Types

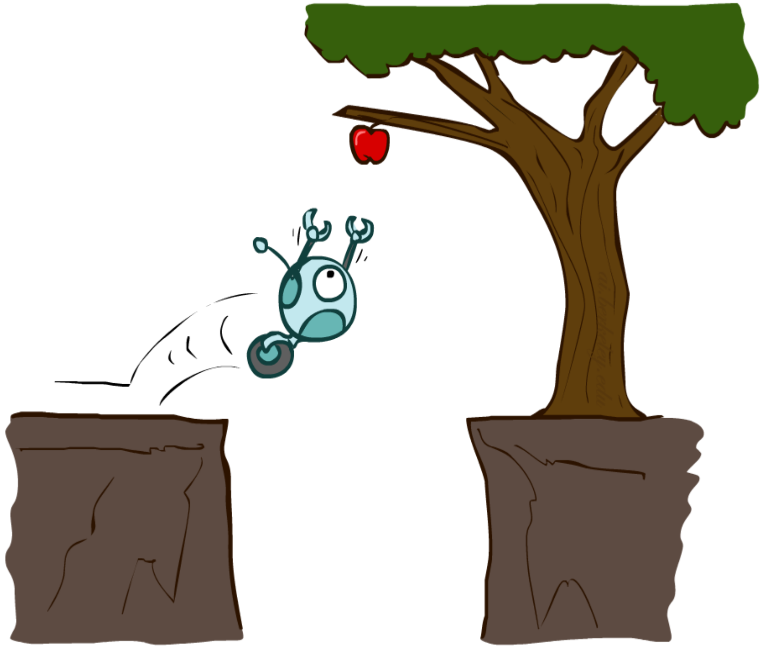
	Pacman	Taxi
Fully or partially observable		
Single agent or multi-agent		
Deterministic or stochastic		
Static or dynamic		
Discrete or continuous		

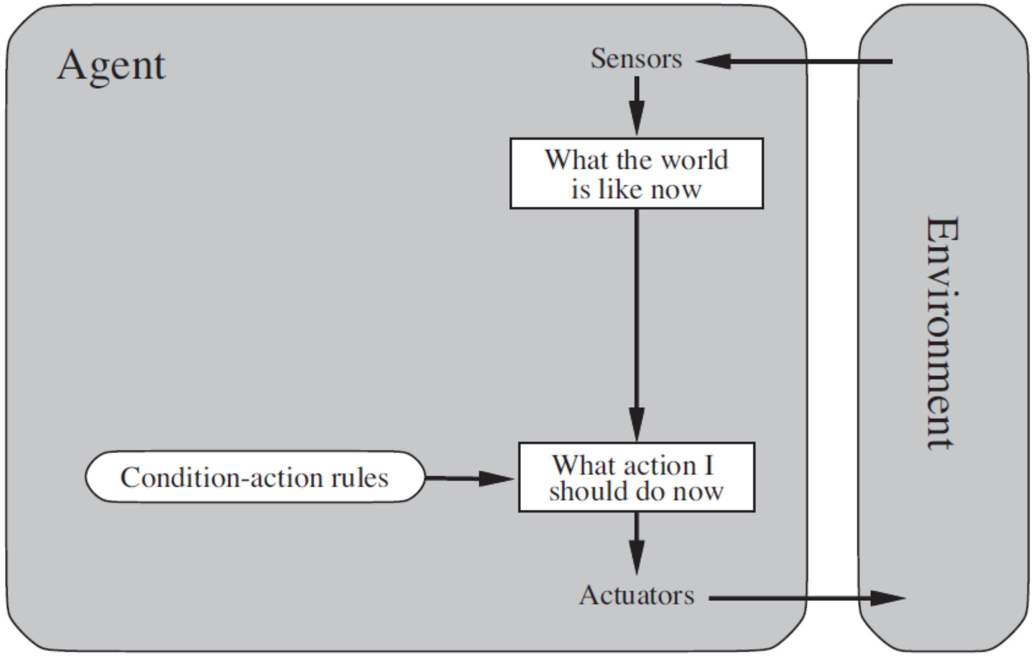
Textbook p44. Static vs. **dynamic**: If the environment can change while an agent is deliberating, then we say the environment is dynamic for that agent; otherwise, it is static.

Simple reflex agents

- Reflex agents:
  - Choose action based on current percept (and maybe memory)
  - May have memory or a model of the world's current state
  - Do not consider the future consequences of their actions
  - Consider how the world IS

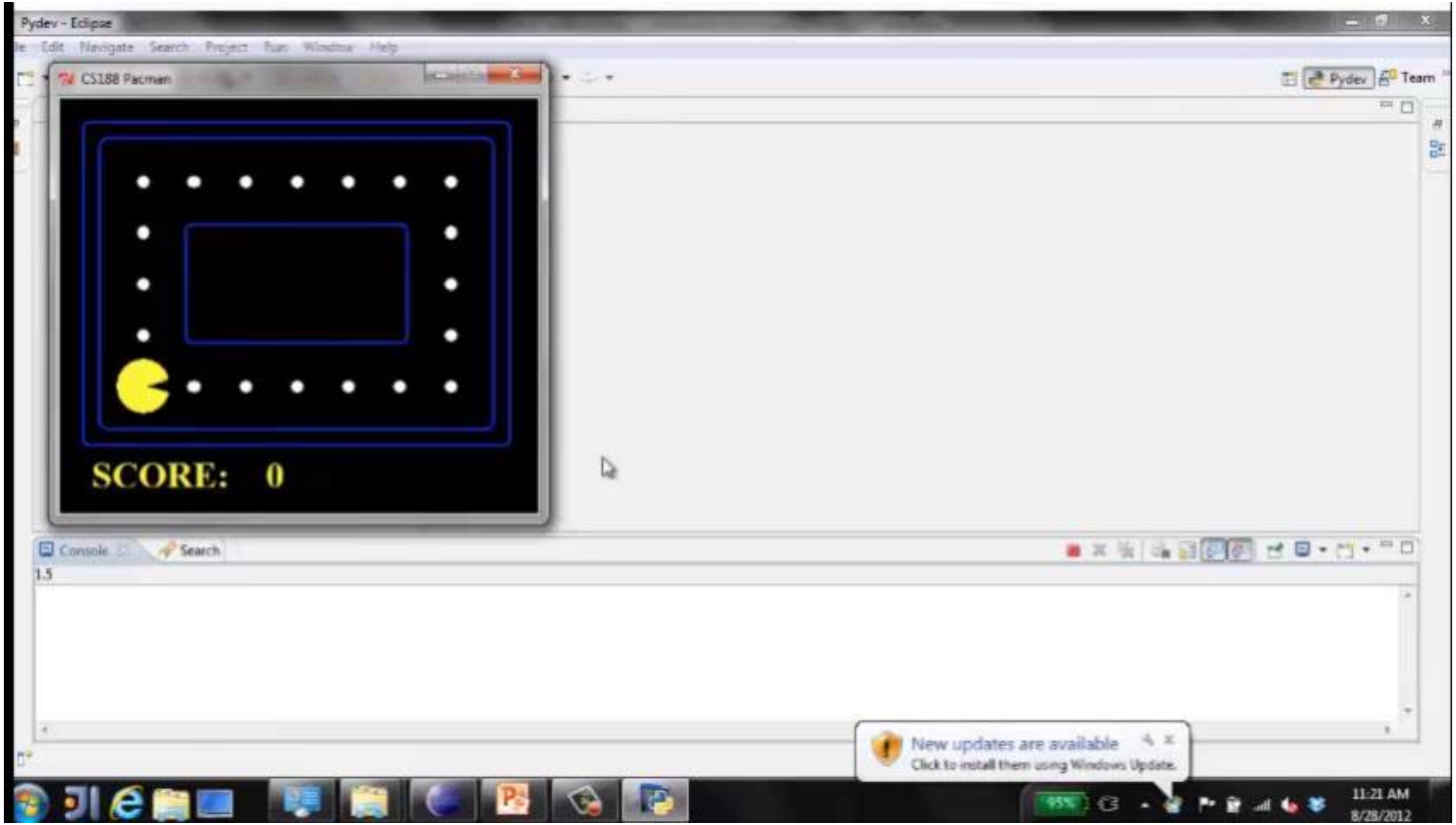
- Can a reflex agent be rational?



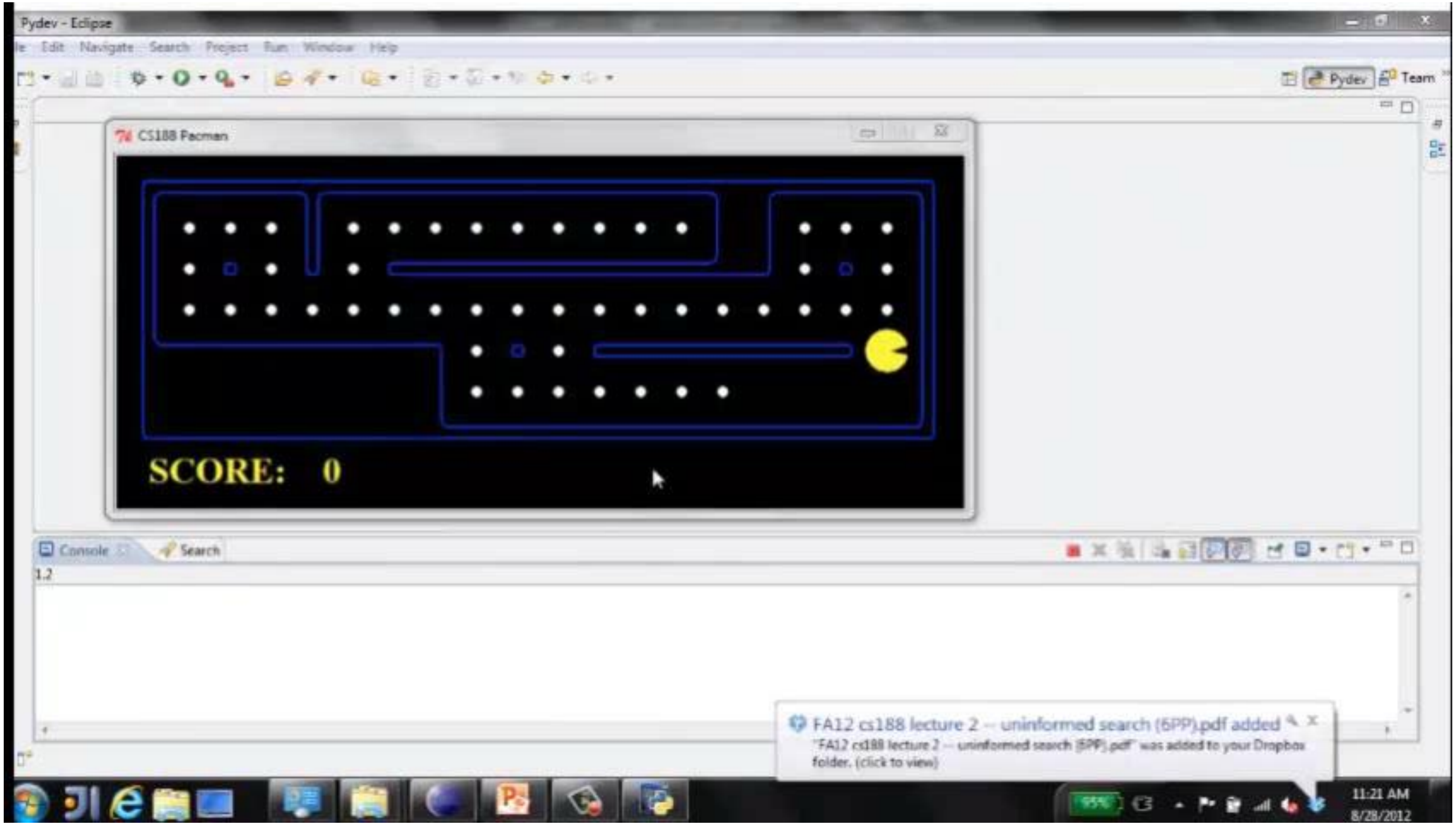


[Demo: reflex optimal (L2D1)]
[Demo: reflex optimal (L2D2)]

Video of Demo Reflex Optimal



Video of Demo Reflex Odd



Summary

Shuai Li

https://shuaili8.github.io

- What is AI and ML
- An example of AI but not ML
  - A* algorithm
- Foundation of AI
- History of AI
- What can AI do
  - Many applications in different industries/many aspects of life
- Intelligent agents
  - reflex agents

Questions?