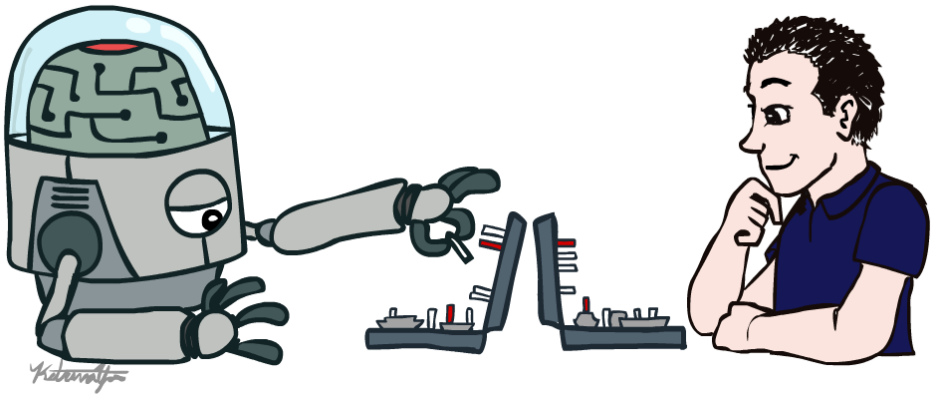
Artificial Intelligence

Introduction

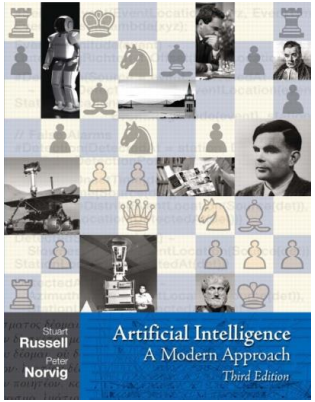


Zahoor Tanoli (PhD)

CUI Attock

Textbook

- **Russell & Norvig, AI: A Modern Approach, 3rd Ed.**

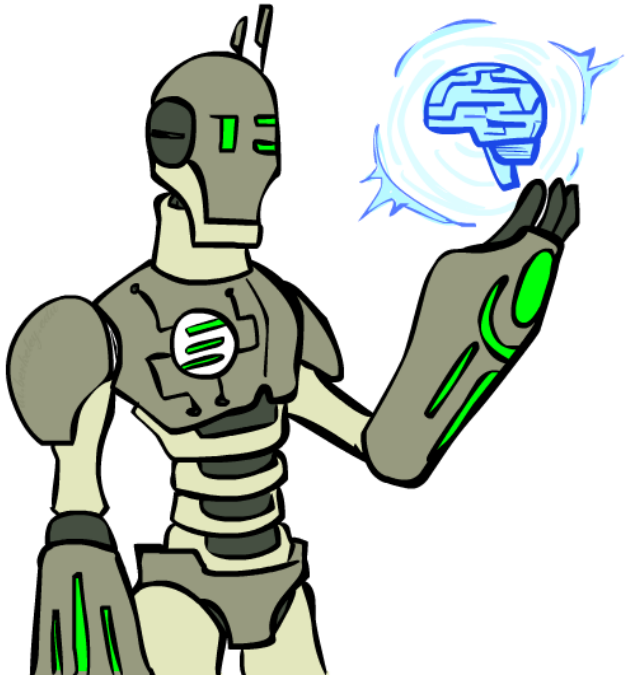


- **Warning: Not a course textbook, so our presentation does not necessarily follow the presentation in the book.**

Today

After this lecture, students will be able to Answer:

- What is artificial intelligence and its history?
- What can AI do?
- What are the applications of AI?



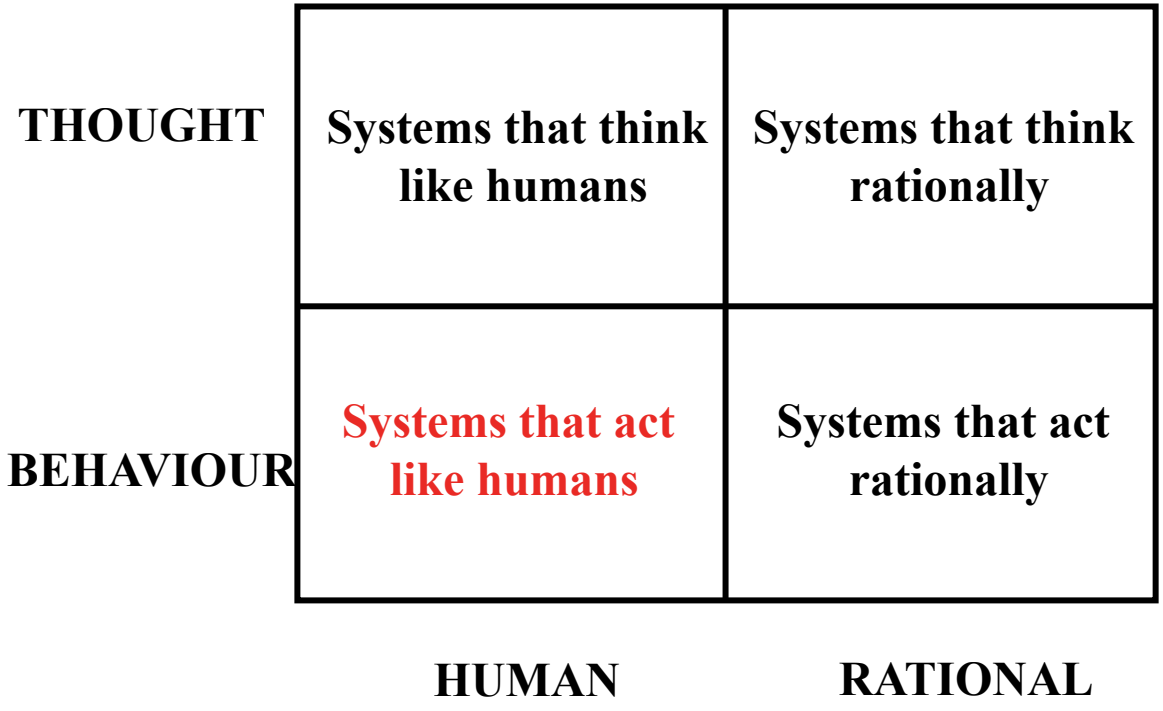
Sci-Fi in AI

- Ex Machina
- 2001: A Space Odyssey
- https://www.youtube.com/watch?v=i1ja9VlZZmM

Can Machine Think

- Reasoning
- Learning
- Problem solving
- Perception
- Some Examples are:
  - Google assistant, Alexa (NLP and Peta, Exa, and Zetta bytes of data processing)
  - Self driving cars
  - Netflix, YouTube, Amazon, Alibaba, etc.

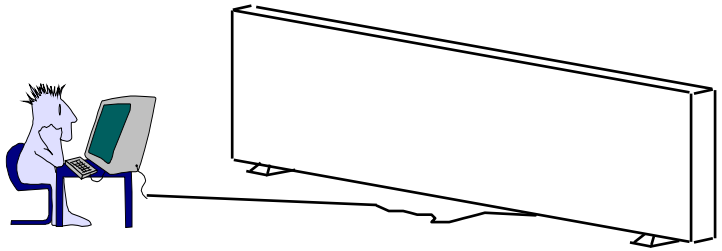
What is Artificial Intelligence ?



Systems that act like humans: Turing Test

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

Systems that act like humans



?

- You enter a room which has a computer terminal. You have a fixed period of time to type what you want into the terminal, and study the replies. At the other end of the line is either a human being or a computer system.
- If it is a computer system, and at the end of the period you cannot reliably determine whether it is a system or a human, then the system is deemed to be intelligent.

Systems that act like humans

- The Turing Test approach
  - a human questioner cannot tell if
    - there is a computer or a human answering his question, via teletype (remote communication)
  - The computer must behave intelligently
- Intelligent behavior
  - to achieve human-level performance in all cognitive tasks

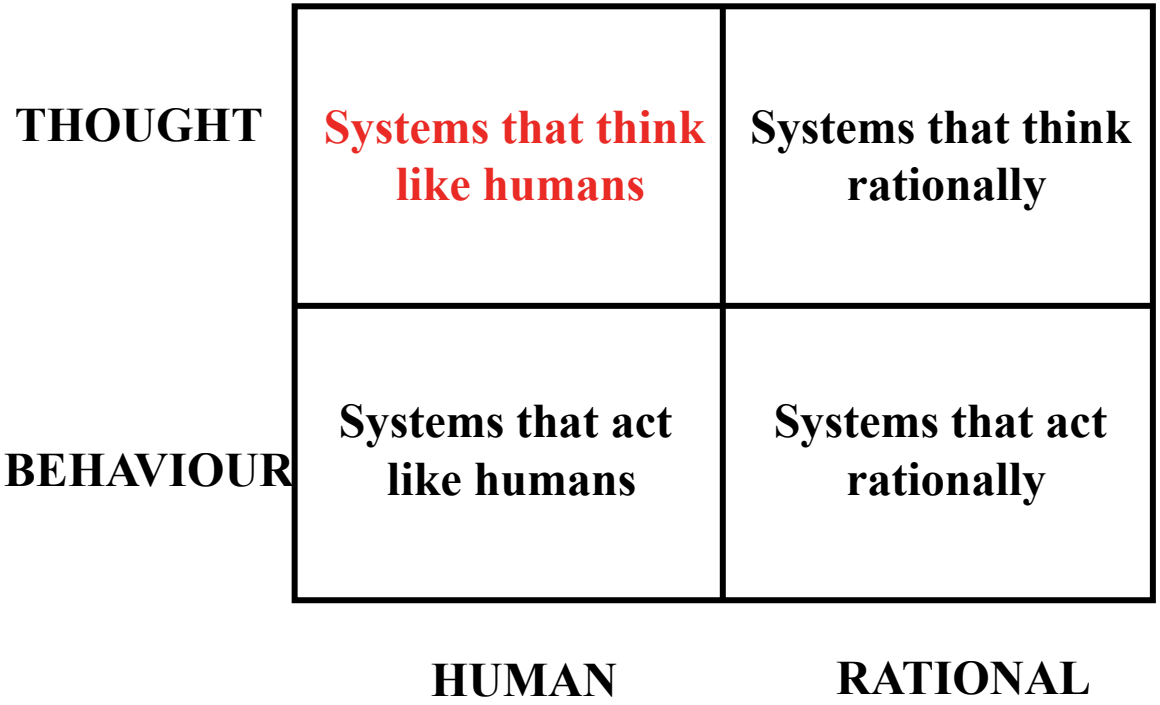
Systems that act like humans

- **These cognitive tasks include:**
  - *Natural language processing*
    - for communication with human
  - *Knowledge representation*
    - to store information effectively & efficiently
  - *Automated reasoning*
    - to retrieve & answer questions using the stored information
  - *Machine learning*
    - to adapt to new circumstances

The total Turing Test

- Includes two more issues:
  - *Computer vision*
    - to perceive objects (seeing)
  - *Robotics*
    - to move objects (acting)

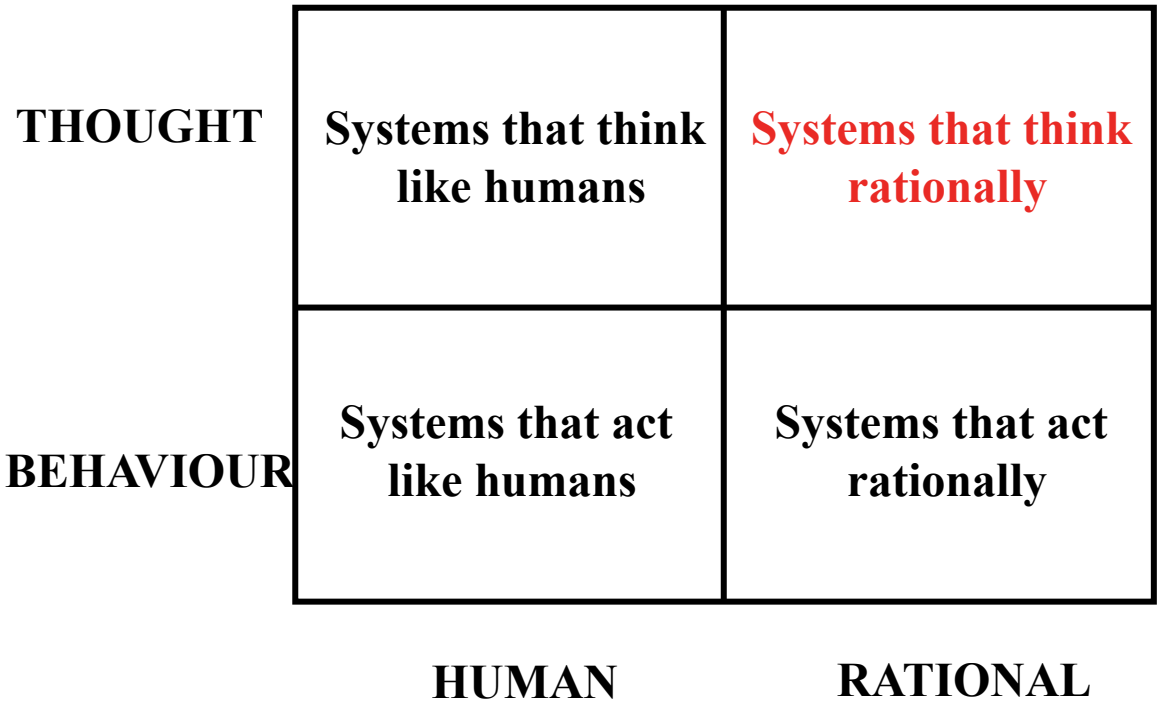
What is Artificial Intelligence ?



Systems that think like humans

- Humans as observed from ‘inside’
- How do we know how humans think?
  - Introspection vs. psychological experiments
- Cognitive Science
- “The exciting new effort to make computers think … machines with *minds* in the full and literal sense” (Haugeland)
- “[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning …” (Bellman)

What is Artificial Intelligence ?



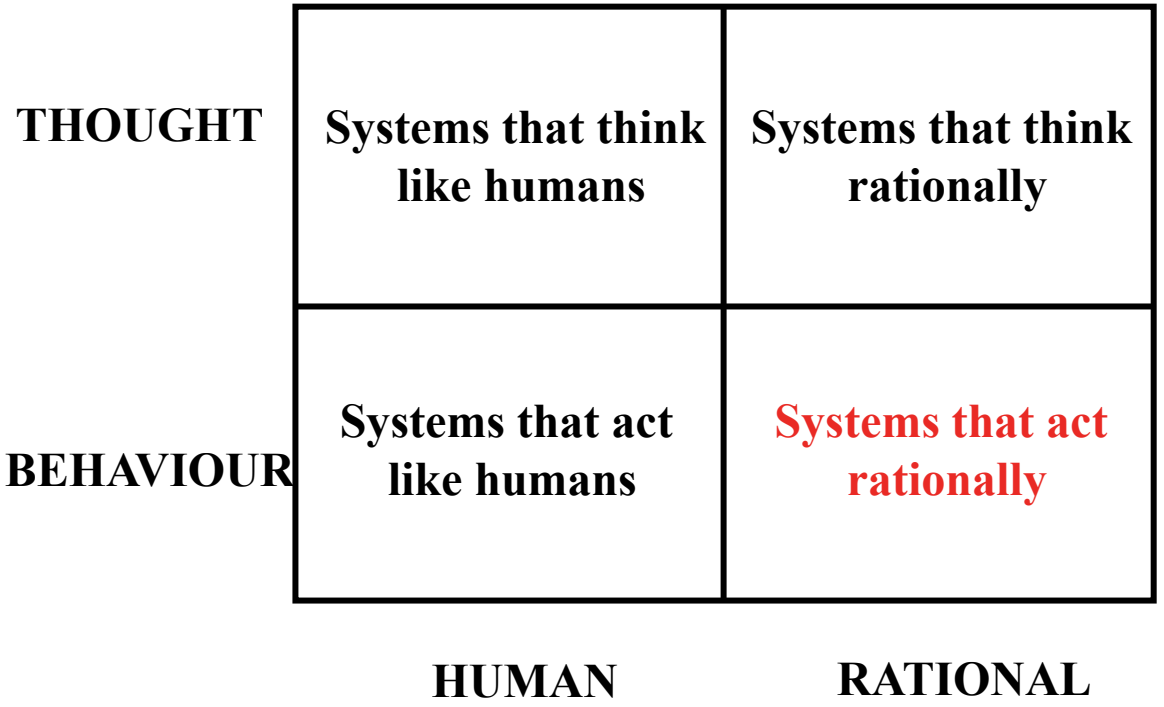
Thinking Rationally: Laws of Thought

- Aristotle (~ 450 B.C.) attempted to codify "right thinking"
  What are correct arguments/thought processes?
- E.g., "Socrates is a man, all men are mortal; therefore Socrates is mortal"

- Several Greek schools developed various forms of logic:
  notation plus rules of derivation for thoughts.

- Problems:
  1) Uncertainty: Not all facts are certain (e.g., *the flight might be delayed).*
  2) Resource limitations: There is a difference between solving a problem in principle and solving it in practice under various resource limitations such as time, computation, accuracy etc. (e.g., *purchasing a car)*

What is Artificial Intelligence ?



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

Systems that act rationally

- Logic → only *part* of a rational agent, not *all* of rationality
  - Sometimes logic cannot reason a correct conclusion
  - At that time, some *specific (in domain) human knowledge* or information is used
- Thus, it covers more generally different situations of problems
  - Compensate the incorrectly reasoned conclusion

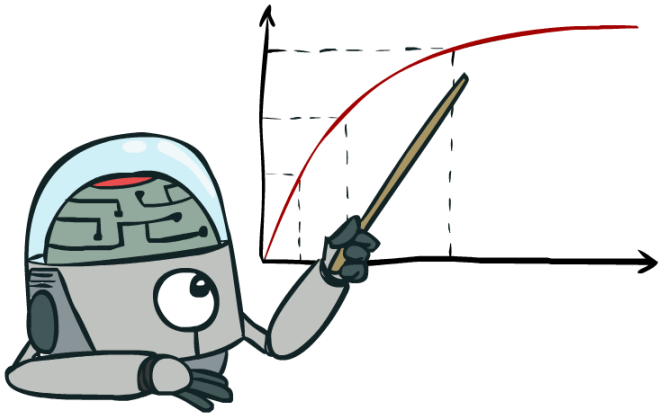
Systems that act rationally

- Study AI as rational agent –

2 advantages:

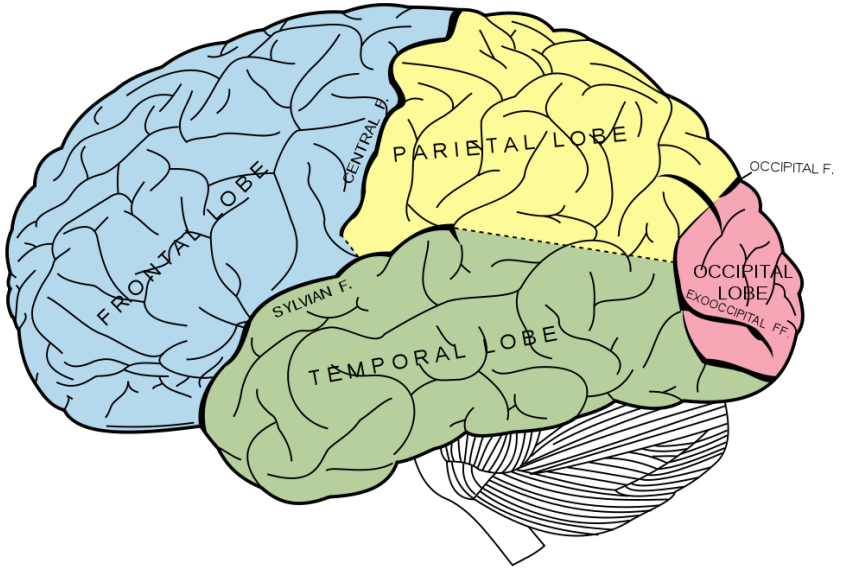
  - It is more general than using logic only
    - Because: LOGIC + Domain knowledge
  - It allows extension of the approach with more scientific methodologies

Maximize Your Expected Utility



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



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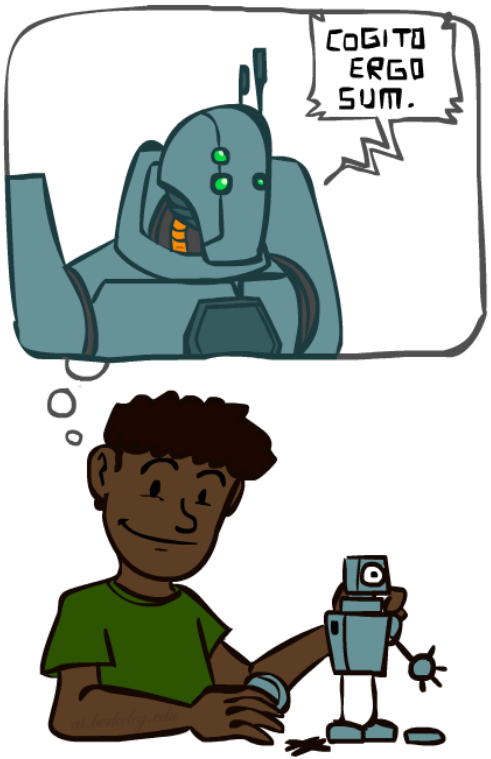
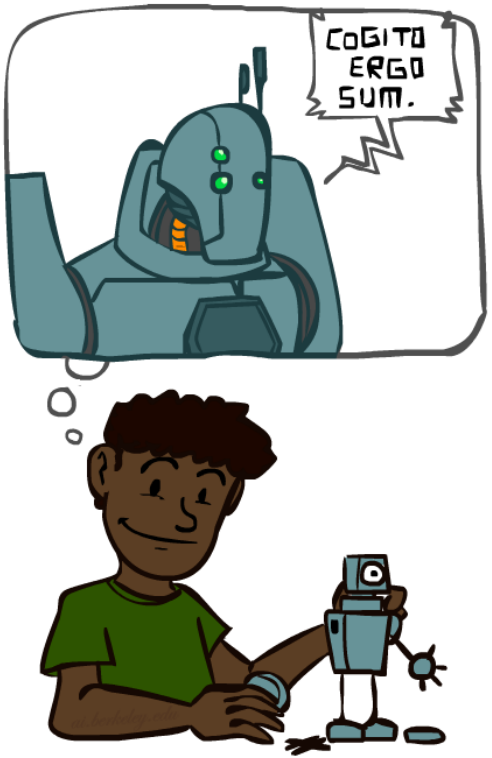
A (Short) History of AI



A (Short) History of AI

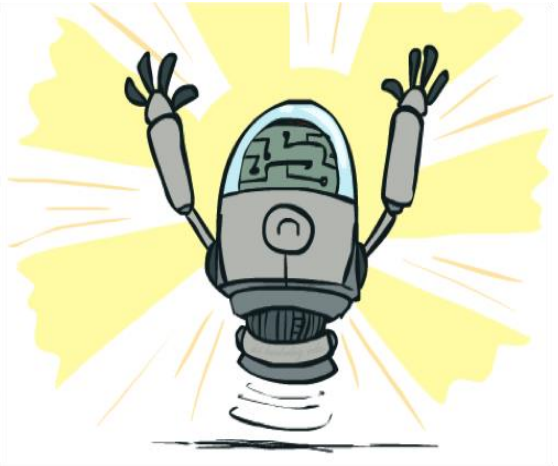
- **1940-1950: Early days**
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's “Computing Machinery and Intelligence”
- **1950—70: Excitement:**
  - 1950s: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
  - 1956: Dartmouth meeting: “Artificial Intelligence” adopted
  - 1965: Robinson's complete algorithm for logical reasoning
- **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? Some excitement**
  - Big data, big computation, Neural network, deep learning
  - Reunification of sub-fields and AI in the industry



What Can AI Do?

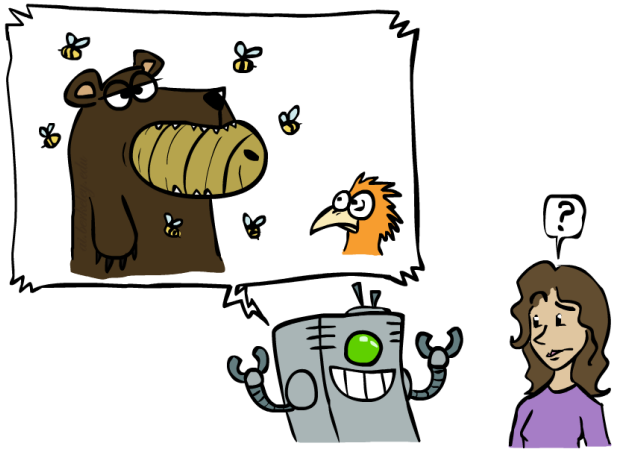
Quiz: Which of the following can be done at present?

- ✓ Play a decent game of table tennis?
- ✓ Play a decent game of Jeopardy?
- ✓ Drive safely along a curving mountain road?
- ? Drive safely along pladdar lane Attock?
- ✓ Buy a week's worth of groceries on the web?
- ? Buy a week's worth of groceries at Blue Area?
- ? 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?



Unintentionally Funny Stories

- One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe walked to the oak tree. He ate the beehive. The End.



- Henry Squirrel was thirsty. He walked over to the river bank where his good friend Bill Bird was sitting. Henry slipped and fell in the river. Gravity drowned. The End.

- Once upon a time there was a dishonest fox and a vain crow. One day the crow was sitting in his tree, holding a piece of cheese in his mouth. He noticed that he was holding the piece of cheese. He became hungry, and swallowed the cheese. The fox walked over to the crow. The End.

Strong AI

"I find it useful to distinguish what I will call "strong" AI from "weak" or "cautious" AI.

According to weak AI, the principle value of the computer in the study of the mind is that it gives us a very powerful tool. For example, it enables us **to formulate and test hypothesis in a more rigorous and precise fashion.**

But according to strong AI,

the computer is not merely a tool in the study of the mind; rather, **the appropriately programmed computer really *is* a mind**, in the sense that computers given the right programs can be literally said to *understand* and have other cognitive states."

[Searle, 1980, *Minds, Brains and Programs*]

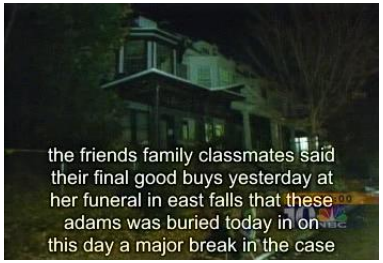
Weak and Strong AI Claims

- Weak AI:
  - Machines can be made to act *as if* they were intelligent.
- Strong AI:
  - Machines that act intelligently have real, conscious minds.

Applications of AI

Natural Language

- Speech technologies (e.g. Siri)
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems



Natural Language

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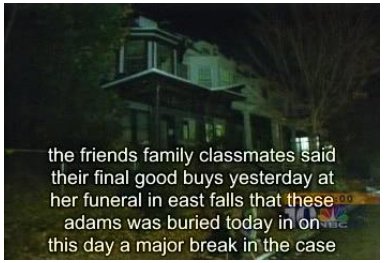


- Language processing technologies
  - Question answering
  - Machine translation

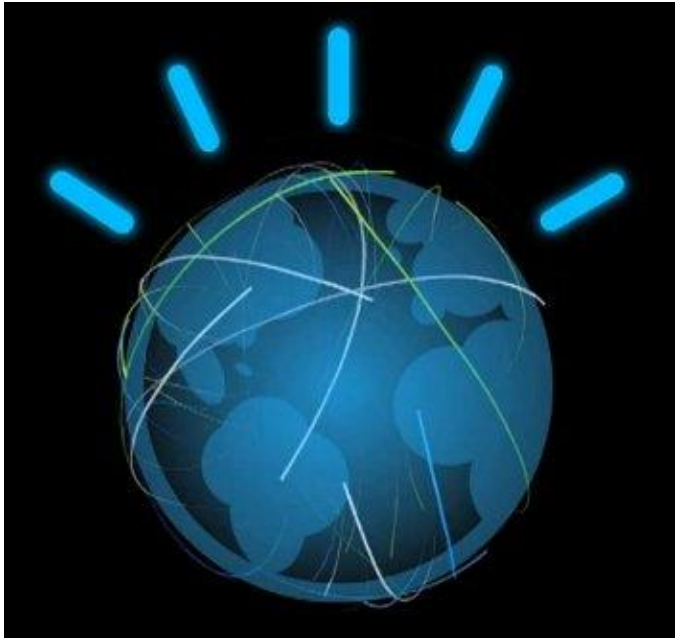
  - Web search
  - Text classification, spam filtering, etc…

Watson

- “The goal is to have computers start to interact in natural human terms across a range of applications and processes, understanding the questions that humans ask and providing answers that humans can understand and justify” - IBM

Watson

- IBM’s Artificial Intelligence computer system
- Capable of answering questions in natural language
- Competed against champions on Jeopardy and won



Watson

- IBM describes this AI as:

  "an application of advanced Natural Language Processing, Information Retrieval, Knowledge Representation and Reasoning, and Machine Learning technologies to the field of open domain question answering“

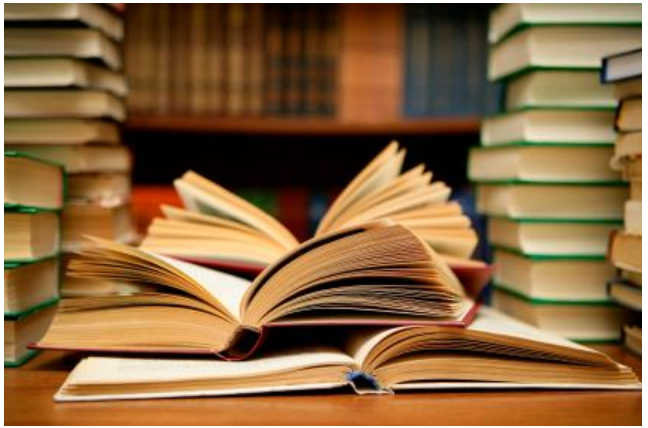
- What this means…

Watson

- Specifics
  - 16 Terabytes of RAM
  - Can process 500 gigabytes (1 million books) per second
  - Content was stored in Watson's RAM rather than memory to be more easily accessed
  - Cost about $3 Million

Watson’s sources of information

- Encyclopedias
- Dictionaries
- Thesauri
- Newswire articles
- Literary works
- Databases, taxonomies, and ontologies.
- Wikipedia articles
- And more

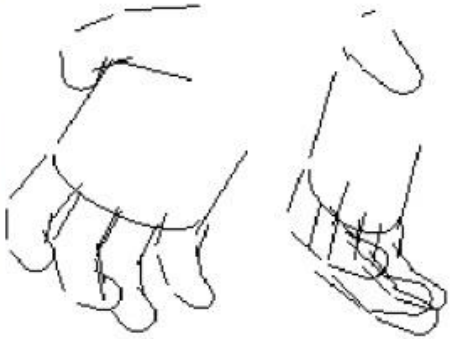


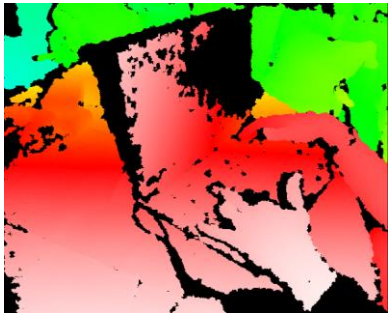
How Watson Works

- Receives the clues (questions) as electronic texts
- It then divides these texts into different keywords and sentence fragments and searches for statistically related phrases
- Quickly executes thousands of language analysis algorithms
- The more algorithms that find the same answer increase Watson's confidence of his answer and it calculates to make a guess

Vision (Perception)

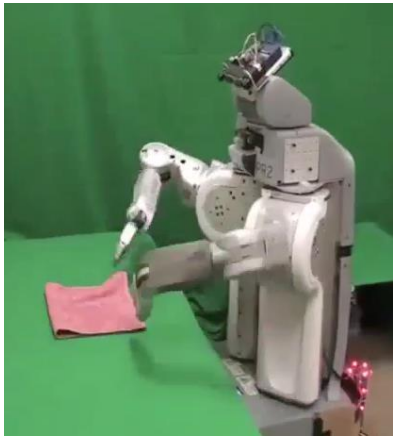
- Object and face recognition
- Scene segmentation
- Image classification

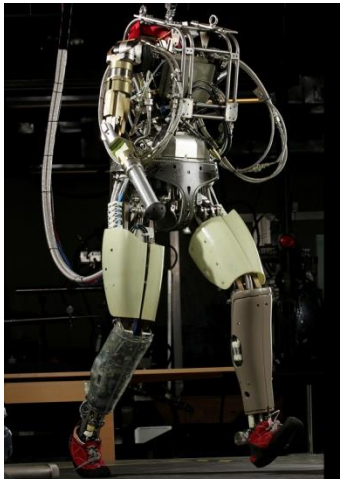




Robotics

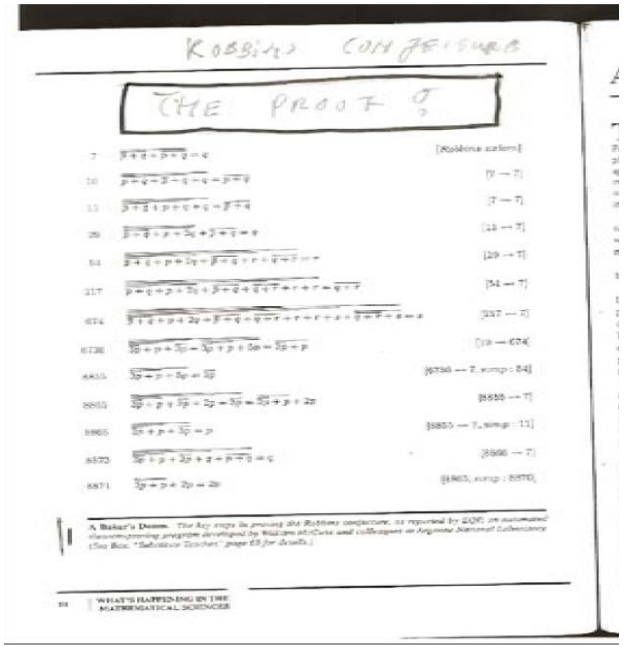
- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!
- Technologies
  - Vehicles
  - Rescue
  - Soccer!
  - Lots of automation…
- In this class:
  - We ignore mechanical aspects
  - Methods for planning
  - Methods for control





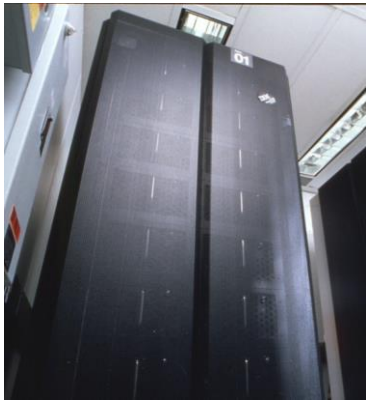
Logic

- Logical systems
  - Theorem provers
  - NASA fault diagnosis
  - Question answering
- Methods:
  - Deduction systems
  - Constraint satisfaction
  - Satisfiability solvers (huge advances!)



Game Playing

- Classic Moment: May, '97: Deep Blue vs. Kasparov
  - First match won against world champion
  - “Intelligent creative” play
  - 200 million board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - Can do about the same now with a PC cluster



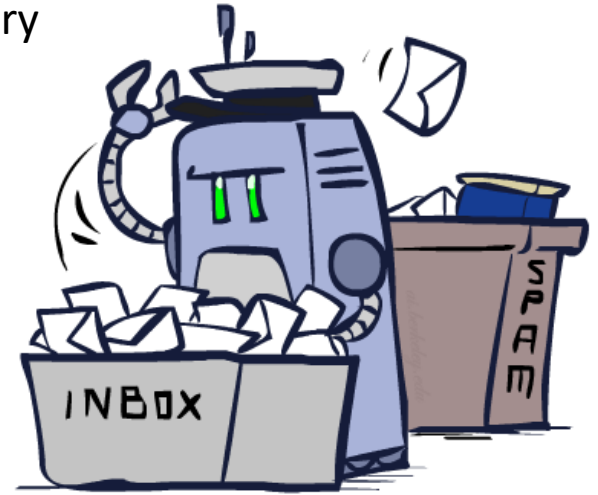
- Open question:
  - How does human cognition deal with the search space explosion of chess?
  - Or: how can humans compete with computers at all??
- 1996: Kasparov Beats Deep Blue
  “I could feel --- I could smell --- a new kind of intelligence across the table.”
- 1997: Deep Blue Beats Kasparov
  “Deep Blue hasn't proven anything.”
- Huge game-playing advances recently, e.g. in Go!

Game Playing — Go

- Why is Go difficult?
  - Chess branching factor: 35
  - Go branching factor: 250
  - Have to be clever about which moves are even worth considering
- 2016: AlphaGo beats Lee Sedol
  - A feat previously thought to be at least a decade away
  - Uses deep learning to evaluate how advantageous board positions are
  - Also uses deep learning to determine promising branches
- Reactions from Go community:
  - "All but the very best Go players craft their style by imitating top players. AlphaGo seems to have totally original moves it creates itself."
  - Lee Sedol: "Robots will never understand the beauty of the game the same way that we humans do."
- Reactions from AI community:
  - DeepMind team: "The end of an era... board games are more or less done and it's time to move on."
  - Russell: "AI methods are progressing much faster than expected, [which] makes the question of the long-term outcome more urgent"
  - Existential risk crowd: Proves that algorithmic insights can lead to instantaneous technological leaps

Decision Making

- Applied AI involves many kinds of automation
  - Scheduling, e.g. airline routing, military
  - Route planning, e.g. Google maps
  - Medical diagnosis
  - Web search engines
  - Spam classifiers
  - Automated help desks
  - Fraud detection
  - Product recommendations
  - … Lots more!



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 **percepts, environment,** and **action space** dictate techniques for selecting rational actions
- **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