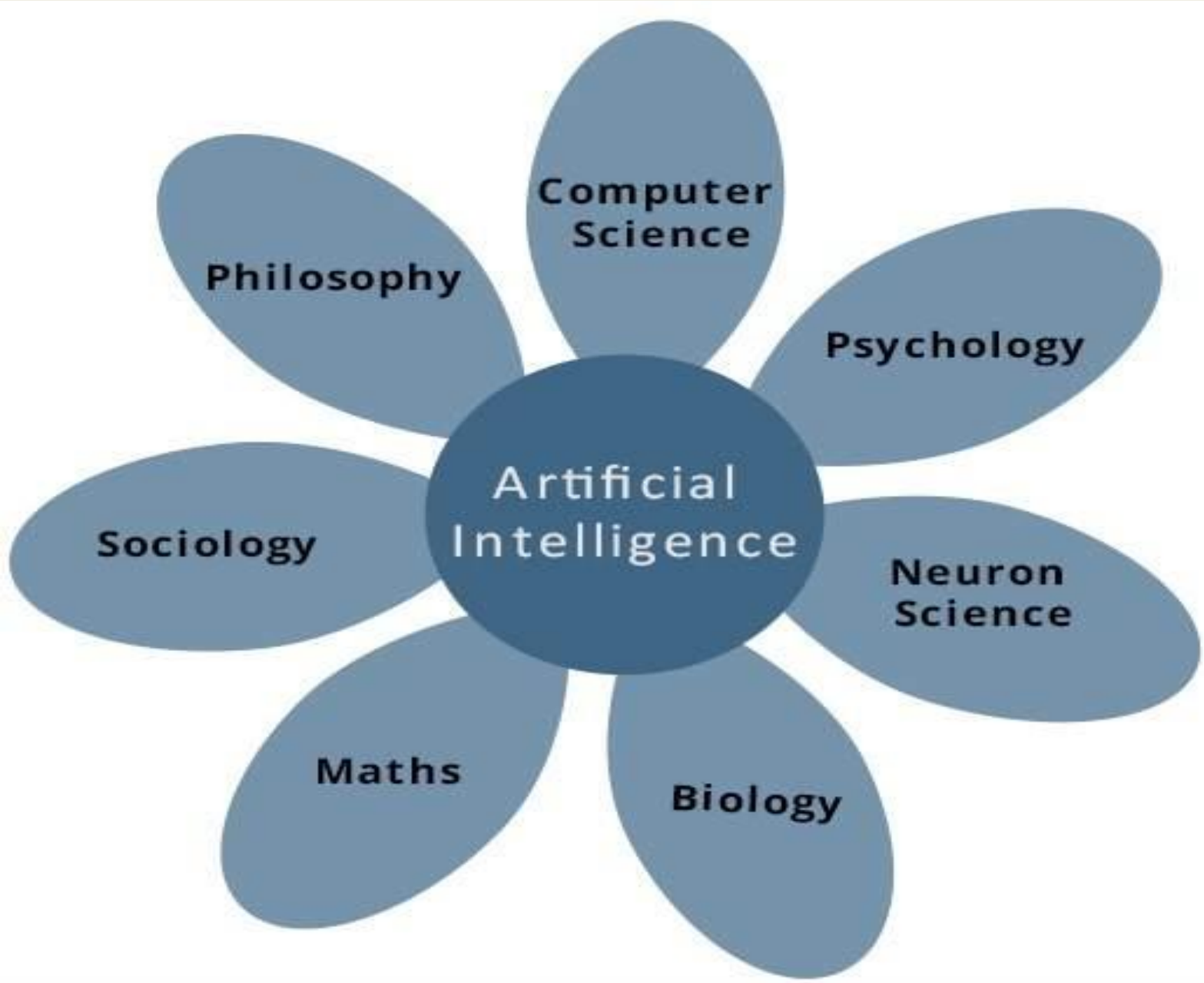
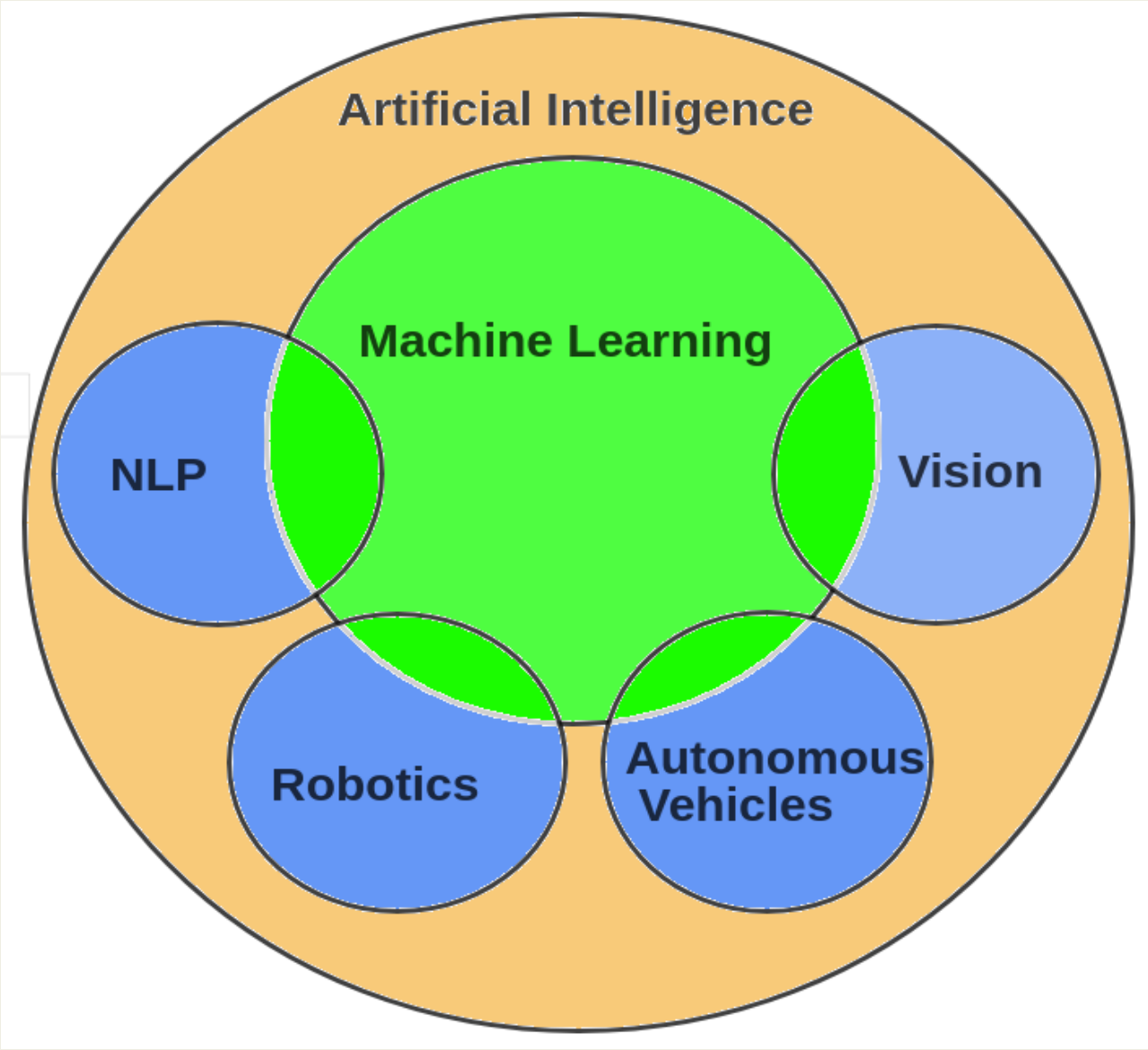
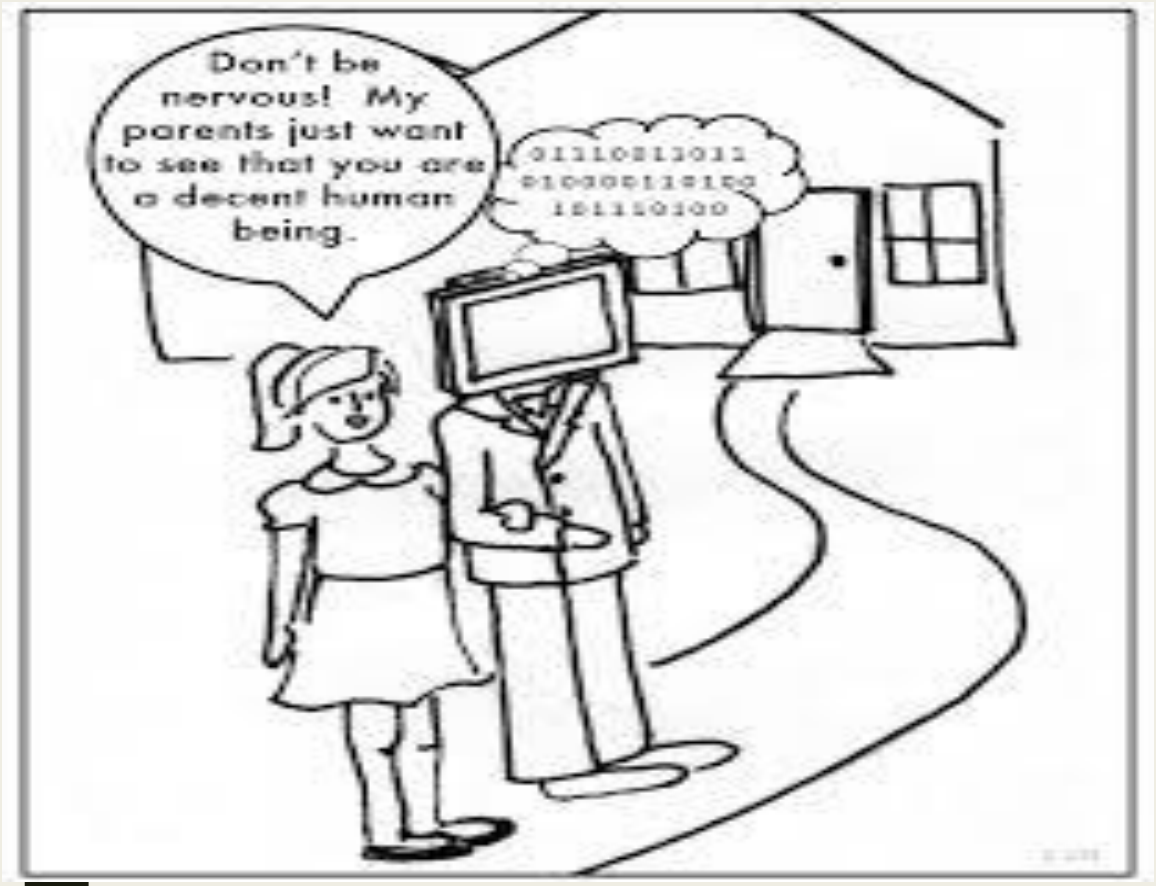
ARTIFICIAL INTELLIGENCE

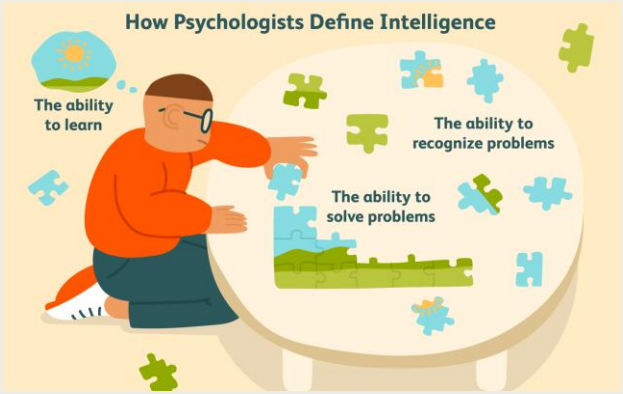

Computer Science
Philosophy
Psychology
Artificial Intelligence
Sociology
Neuron Science
Maths
Biology


Artificial Intelligence
Machine Learning
NLP
Vision
Robotics
Autonomous Vehicles


Don't be nervous! My parents just want to see that you are a decent human being.
011101110011
010000110100
1011100100

What is Intelligence?

- Intelligence:
  - *“the capacity to learn and solve problems” (Websters dictionary)*
  - *in particular,*
    - *the ability to solve novel problems*
    - *the ability to act rationally*
    - *the ability to act like humans*



- Artificial Intelligence
  - *build and understand intelligent entities or agents*
  - *2 main approaches: “engineering” versus “cognitive modeling”*

What is AI?

- **Artificial intelligence** (**AI**) is technology and a branch of computer science that studies and develops intelligent machines and software.
- "The study and design of intelligent agents"
- An intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success.
- John McCarthy coined the term AI in 1955,
- Defines it as "the science and engineering of making intelligent machines".

What's involved in Intelligence?

Ability to interact with the real world

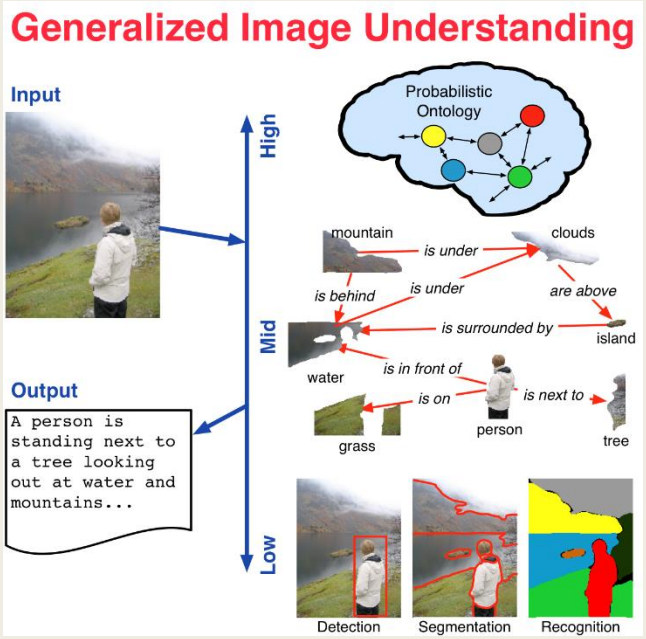
- *to perceive, understand, and act*
- *e.g., speech recognition*
- *e.g., image understanding*

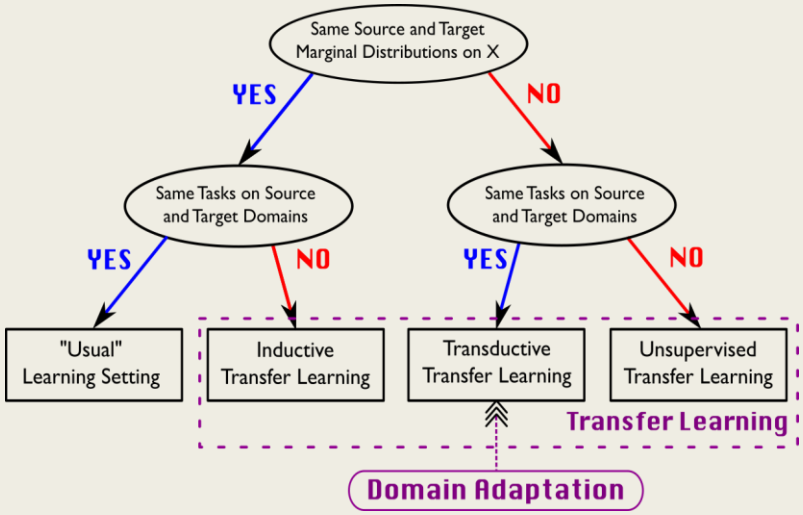
Reasoning and Planning

- *modeling the external world, given input*
- *solving new problems, planning, and making decisions*
- *ability to deal with unexpected problems, uncertainties*

Learning and Adaptation

- *we are continuously learning and adapting*
- *our internal models are always being "updated"*
  - e.g., a baby learning to categorize and recognize animals

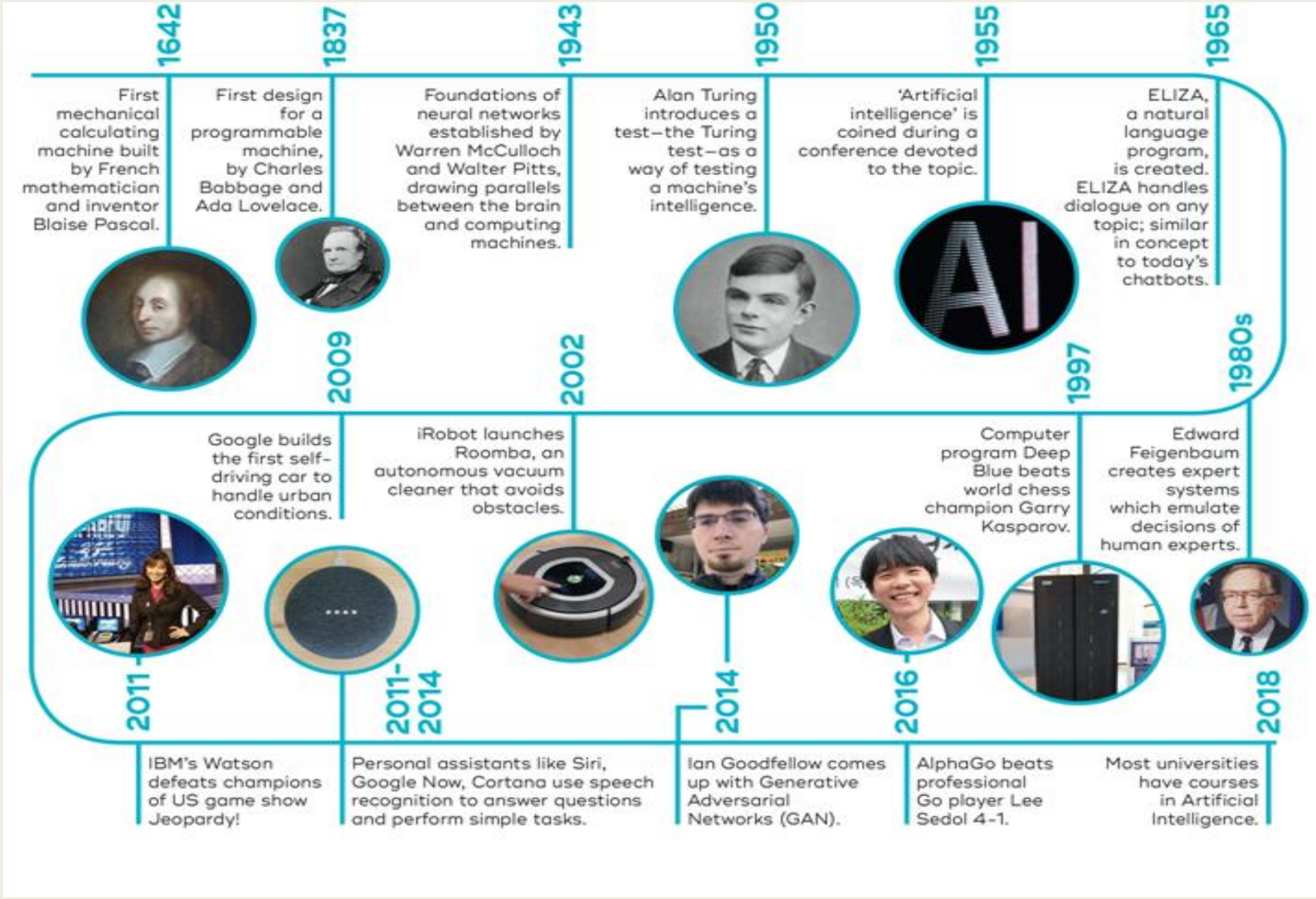




Why AI?

- One reason to study AI: to learn more about ourselves.
- Philosophy and Psychology : concerned with intelligence
- AI strives to ***build intelligent entities and understand*** them.
- Another reason to study AI : these constructed intelligent entities are interesting and useful in their own right.
- Computers with human-level intelligence (or better) would have a huge impact on our everyday lives and on the future course of civilization.
- The study of intelligence is one of the oldest disciplines. For over 2000 years, philosophers have tried to understand how seeing, learning, remembering, and reasoning could, or should, be done.
- The advent of usable computers in the early 1950s turned the learned into a real experimental and theoretical discipline.

History of AI



Four approaches of AI

Thinking humanly	Thinking rationally
How human brain works Psychological theories	Aristotle 'Right Thinking' Syllogisms
Acting humanly	**Acting rationally**
Turing test	The rational agent approach

Syllogisms: Study of patterns for argument structures that always gave correct conclusions given correct premises.

Turing Test: The computer should be questioned by a human via a teletype. The computer passes the test if the human cannot tell if the answerer is a computer or a human.

Agent: something that perceives and acts.

Rational: Consistent with or based on reason; logical.
In this course, AI is concerned mainly with **rational action.**

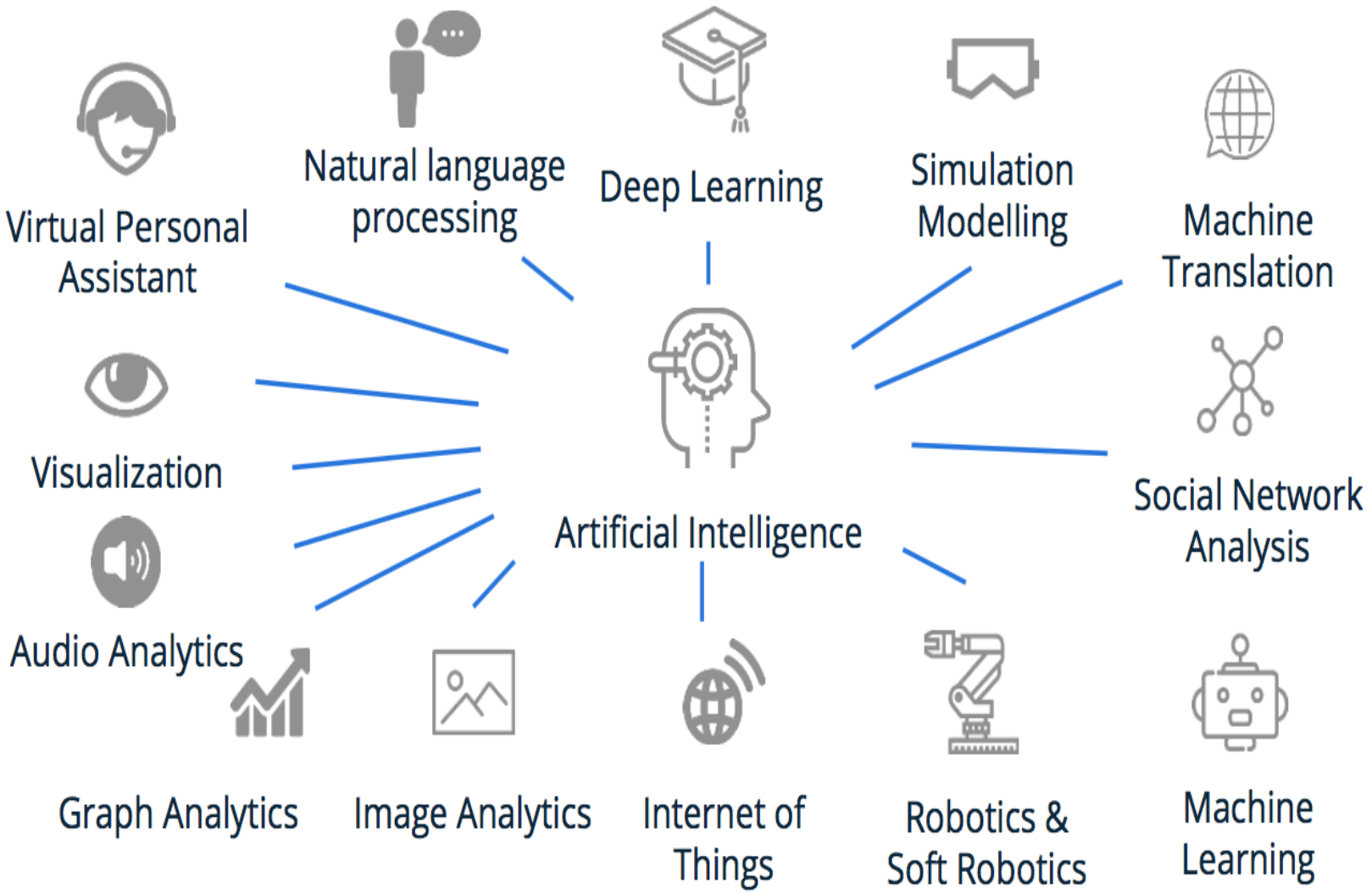
Components to pass Turing Test

- Programming a computer to pass the Turing test provides plenty to work on.
- The computer would need to possess the following capabilities:
  - *Natural Language Processing*
    - enables the computer to communicate successfully in English
  - *Knowledge Representation*
    - store information provided before or during the interrogation
  - *Automated Reasoning*
    - use the stored information to answer questions and draw new conclusions
  - *Machine Learning*
    - adapt to new circumstances and to detect and extrapolate patterns
  - *Computer Vision - perceive objects*
  - *Robotics - move the perceived objects about.*

Overview of Artificial Intelligence

- Artificial intelligence (AI)
  - *Computers with the ability to mimic or duplicate the functions of the human brain*
- Artificial intelligence systems
  - *The people, procedures, hardware, software, data, and knowledge needed to develop computer systems and machines that demonstrate the characteristics of intelligence*

Possible applications for Artificial Intelligence



Overview of Artificial Intelligence

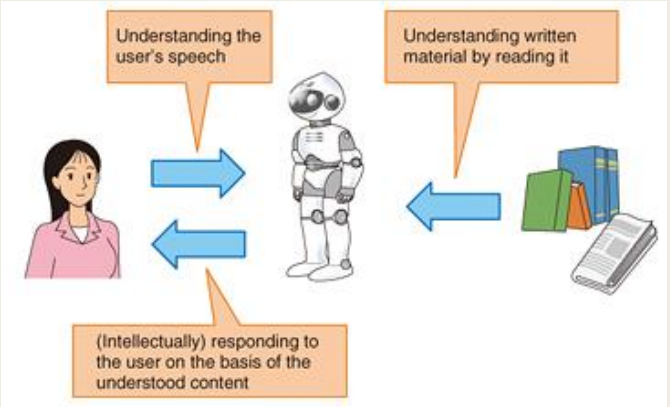
- Intelligent behavior
  - *Learn from experience*
  - *Apply knowledge acquired from experience*
  - *Handle complex situations*
  - *Solve problems when important information is missing*
  - *Determine what is important*
  - *React quickly and correctly to a new situation*
  - *Understand visual images*
  - *Process and manipulate symbols*
  - *Be creative and imaginative*
  - *Use heuristics*

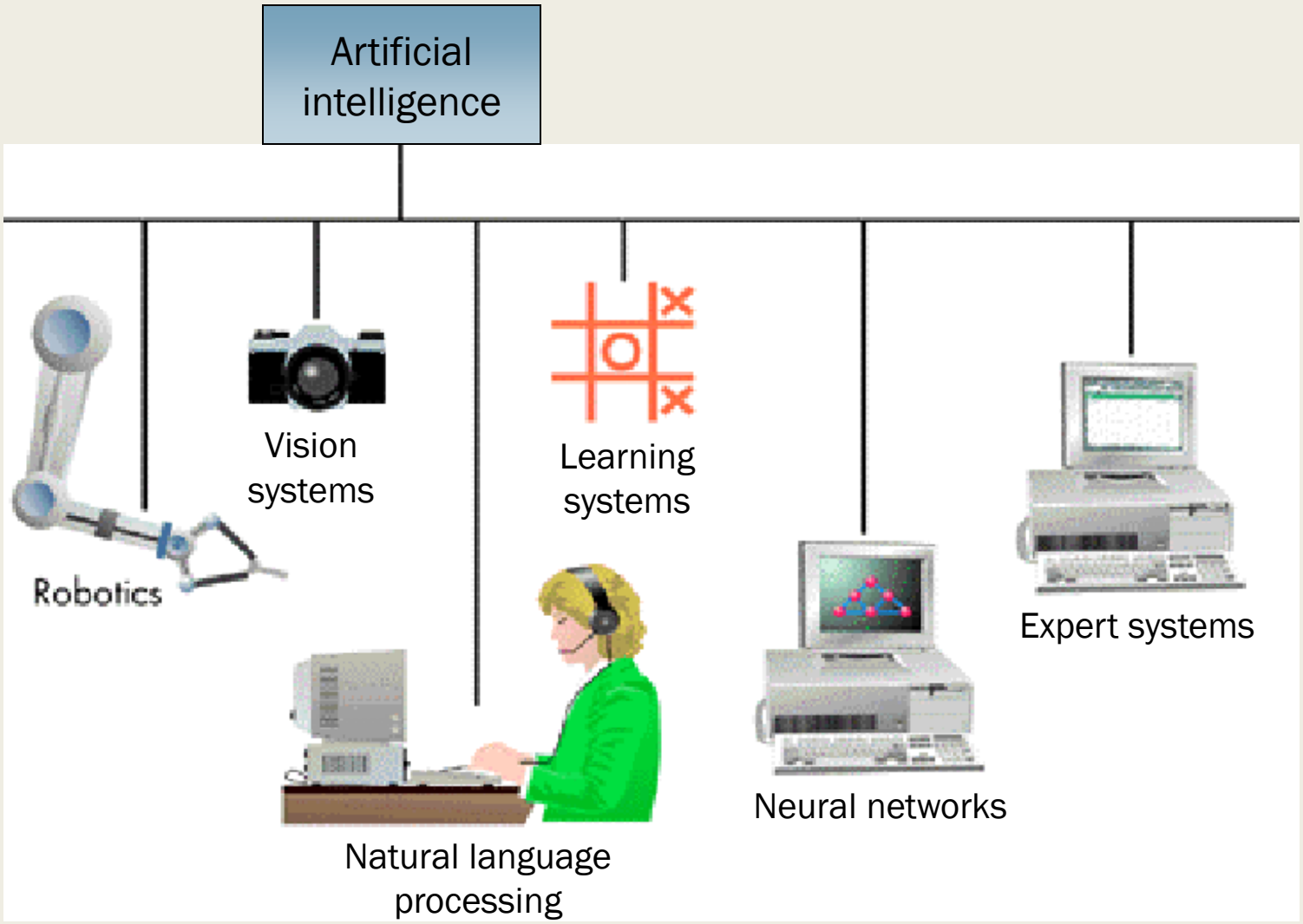
Major Branches of AI

- *Perceptive system*
  - A system that approximates the way a human sees, hears, and feels objects
- *Vision system*
  - Capture, store, and manipulate visual images and pictures
- *Robotics*
  - Mechanical and computer devices that perform tedious tasks with high precision
- *Expert system*
  - Stores knowledge and makes inferences

Major Branches of AI

- *Learning system*
  - Computer changes how it functions or reacts to situations based on feedback
- *Natural language processing*
  - Computers understand and react to statements and commands made in a “natural” language, such as English
- *Neural network*
  - Computer system that can act like or simulate the functioning of the human brain




Artificial intelligence
Robotics
Vision systems
Learning systems
Expert systems
Natural language processing
Neural networks

Artificial Intelligence

The branch of computer science concerned with making computers behave like humans. The term was coined in 1956 by John McCarthy at the Massachusetts Institute of Technology (MIT).

Artificial intelligence includes

- ***games playing:*** *programming computers to play games such as chess and checkers*
- ***expert systems :*** *programming computers to make decisions in real-life situations (for example, some expert systems help doctors diagnose diseases based on symptoms)*
- ***natural language :*** *programming computers to understand natural human languages*
- ***neural networks :*** *Systems that simulate intelligence by attempting to reproduce the types of physical connections that occur in animal brains*
- ***robotics :*** *programming computers to see and hear and react to other sensory stimuli*

Achievements of AI

- Currently, no computers exhibit full artificial intelligence (that is, are able to simulate human behavior). The greatest advances have occurred in the field of games playing. The best computer chess programs are now capable of beating humans. In May, 1997, an IBM super-computer called Deep Blue defeated world chess champion Gary Kasparov in a chess match.

- In the area of robotics, computers are now widely used in assembly plants, but they are capable only of very limited tasks. Robots have great difficulty identifying objects based on appearance or feel, and they still move and handle objects clumsily.

Achievements of AI

- Natural-language processing offers the greatest potential rewards because it would allow people to interact with computers without needing any specialized knowledge. You could simply walk up to a computer and talk to it.
- Unfortunately, programming computers to understand natural languages has proved to be more difficult than originally thought. Some rudimentary translation systems that translate from one human language to another are in existence, but they are not nearly as good as human translators.

Achievements of AI

- There are also voice recognition systems that can convert spoken sounds into written words, but they do not understand what they are writing; they simply take dictation. Even these systems are quite limited -- you must speak slowly and distinctly.

- Today, the hottest area of artificial intelligence is neural networks, which are proving successful in a number of disciplines such as voice recognition and natural-language processing.

- There are several programming languages that are known as AI languages because they are used almost exclusively for AI applications. The two most common are LISP and Prolog.

Can Computers Recognize Speech?

- Speech Recognition:
  - *mapping sounds from a microphone into a list of words*
  - *classic problem in AI, very difficult*
    - "Lets talk about how to wreck a nice beach"
    - (I really said "_____")

- Recognizing single words from a small vocabulary
  - systems can do this with high accuracy (order of 99%)
  - e.g., directory inquiries
    - *limited vocabulary (area codes, city names)*
    - *computer tries to recognize you first, if unsuccessful hands you over to a human operator*
    - *saves millions of dollars a year for the phone companies*

Recognizing human speech (ctd)

- **Recognizing normal speech is much more difficult**
  - *speech is continuous: where are the boundaries between words?*
    - e.g., "John's car has a flat tire"
  - *large vocabularies*
    - can be many thousands of possible words
    - we can use **context** to help figure out what someone said
      - *e.g., hypothesize and test*
      - *try telling a waiter in a restaurant: "I would like some dream and sugar in my coffee"*
  - *background noise, other speakers, accents, colds, etc*
  - *on normal speech, modern systems are only about 60-70% accurate*

- Conclusion:
  - *NO, normal speech is too complex to accurately recognize*
  - *YES, for restricted problems (small vocabulary, single speaker)*

Can Computers Understand speech?

- **Understanding is different to recognition:**
  - *“Time flies like an arrow”*
    - assume the computer can recognize all the words
    - how many different interpretations are there?

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      - *2. command: time the flies the way an arrow times the flies*
      - *3. command: only time those flies which are like an arrow*
      - *4. “time-flies” are fond of arrows*

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      - *4. “time-flies” are fond of arrows*
    - only 1. makes any sense,
      - *but how could a computer figure this out?*
      - *clearly humans use a lot of implicit commonsense knowledge in communication*

- Conclusion: NO, much of what we say is beyond the capabilities of a computer to understand at present

Can Computers Learn and Adapt ?

- Learning and Adaptation
  - *consider a computer learning to drive on the freeway*
  - *we could teach it lots of rules about what to do*
  - *or we could let it drive and steer it back on course when it heads for the embankment*
    - systems like this are under development (e.g., Daimler Benz)
    - e.g., RALPH at CMU
      - *in mid 90's it drove 98% of the way from Pittsburgh to San Diego without any human assistance*
  - ***machine learning** allows computers to learn to do things without explicit programming*
  - *many successful applications:*
    - requires some "set-up": does not mean your PC can learn to forecast the stock market or become a brain surgeon

- Conclusion: YES, computers can learn and adapt, when presented with information in the appropriate way

Can Computers “see”?

- Recognition v. Understanding (like Speech)
  - *Recognition and Understanding of Objects in a scene*
    - look around this room
    - you can effortlessly recognize objects
    - human brain can map 2d visual image to 3d “map”

- Why is visual recognition a hard problem?

- Conclusion:
  - *mostly NO: computers can only “see” certain types of objects under limited circumstances*
  - *YES for certain constrained problems (e.g., face recognition)*

Can Computers Talk?

- This is known as “speech synthesis”
  - *translate text to phonetic form*
    - e.g., “fictitious” -> fik-tish-es
  - *use pronunciation rules to map phonemes to actual sound*
    - e.g., “tish” -> sequence of basic audio sounds
- Difficulties
  - *sounds made by this “lookup” approach sound unnatural*
  - *sounds are not independent*
    - e.g., “act” and “action”
    - modern systems (e.g., at AT&T) can handle this pretty well
  - *a harder problem is emphasis, emotion, etc*
    - humans understand what they are saying
    - machines don’t: so they sound unnatural
- Conclusion:
  - *NO, for complete sentences*
  - *YES, for individual words*

–

Can we build hardware as complex as the brain?

- How complicated is our brain?
  - *a neuron, or nerve cell, is the basic information processing unit*
  - *estimated to be on the order of 10^{12} neurons in a human brain*
  - *many more synapses (10^{14}) connecting these neurons*
  - *cycle time: 10^{-3} seconds (1 millisecond)*

- How complex can we make computers?
  - *10^8 or more transistors per CPU*
  - *supercomputer: hundreds of CPUs, 10^{12} bits of RAM*
  - *cycle times: order of 10^{-9} seconds*

- Conclusion
  - *YES: in the near future we can have computers with as many basic processing elements as our brain, but with*
    - far fewer interconnections (wires or synapses) than the brain
    - much faster updates than the brain
  - *but building hardware is very different from making a computer behave like a brain!*

Can computers plan and make optimal decisions?

- Intelligence
  - *involves solving problems and making decisions and plans*
  - *e.g., you want to take a holiday in Brazil*
    - you need to decide on dates, flights
    - you need to get to the airport, etc
    - involves a sequence of decisions, plans, and actions
- What makes planning hard?
  - *the world is not predictable:*
    - your flight is canceled or there's a backup on the 405
  - *there are a potentially huge number of details*
    - do you consider all flights? all dates?
      - *no: commonsense constrains your solutions*
  - *AI systems are only successful in constrained planning problems*
- Conclusion: NO, real-world planning and decision-making is still beyond the capabilities of modern computers
  - *exception: very well-defined, constrained problems*

Intelligent Systems in Your Everyday Life

- Post Office
  - *automatic address recognition and sorting of mail*
- Banks
  - *automatic check readers, signature verification systems*
  - *automated loan application classification*
- Customer Service
  - *automatic voice recognition*
- The Web
  - *Identifying your age, gender, location, from your Web surfing*
  - *Automated fraud detection*
- Digital Cameras
  - *Automated face detection and focusing*
- Computer Games
  - *Intelligent characters/agents*

AI Applications: Machine Translation

- Language problems in international business
  - *e.g., at a meeting of Japanese, Korean, Vietnamese and Swedish investors, no common language*
  - *or: you are shipping your software manuals to 127 countries*
  - *solution; hire translators to translate*
  - *would be much cheaper if a machine could do this*
- How hard is automated translation
  - *very difficult! e.g., English to Russian*
    - *"The spirit is willing but the flesh is weak" (English)*
    - *"the vodka is good but the meat is rotten" (Russian)*
  - *not only must the words be translated, but their meaning also!*
  - *is this problem "AI-complete"?*
- Nonetheless….
  - *commercial systems can do a lot of the work very well (e.g.,restricted vocabularies in software documentation)*
  - *algorithms which combine dictionaries, grammar models, etc.*
  - *Recent progress using "black-box" machine learning techniques*

AI and Web Search