Areas of Computer Science

CPSC 231: Introduction to Computer Science for Computer Science Majors I
Fall 2021

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Start of CPSC

231 -> CPSC Majors **(Where you are now)** Python and how to program

233 -> CPSC Majors (Java object-oriented design) **NEXT**

235 -> CPSC Majors (231 and 233 in one class)

Required Courses

251 -> Set theory, graph theory, Boolean logic, truth tables, induction, proofs

(For CPSC 331, 413, AI/theory)

331 -> Data structures, hash tables, stacks, lists, trees, sorting, graphs, performance

351 -> Theoretical Foundations of Computer Science II

355 -> Hardware I: ARM Assembly

413 -> Greedy algorithms, divide and conquer, dynamic programming (theory)

449 -> Programming paradigms (procedural, functional, logical languages)

457 -> Operating systems

SENG 300/301 -> Writing programs with other people

Non-CPSC

PHIL 279/377 -> Mostly sentential logic and truth tables (logic for AI/theory)

PHIL 314 -> Ethics

MATH 211/213 -> Linear Algebra (matrix math for Graphics)

MATH 249/265/275 -> Intro calculus (functions, not a lot directly applicable)

STAT 213 -> Introduction to statistics (simulation, understanding experiments)

[3 of 10 math minor courses]

Above 300

- 300 Level -> 313 Computability, 329 Intro Sec., 359 Hardware 2
- 400 Level -> Introduction into a discipline of computer science (basic skills but rarely enough to be an expert in the area)
- 500 Level -> Intermediate into a discipline of computer science (more targeted understanding of an area)
- 600 Level and Above -> Graduate courses

- Many 500 level courses are grad/undergrad splits with different requirements within the course for either group
- A number of 400/500 level will have their own pre-reqs such as different math courses expected (MATH 311 for linear algebra II for example)

Disciplines

- **Human-Computer Interaction / Information Visualization**
- **Computer Graphics / Computer Vision**
- **Databases**
- **Information Security and Privacy**
- **Theory of Computation**
- **Networking and Distributed Systems**
- **Artificial Intelligence**
- **Software Engineering**
- **Game Development**
- …

Human-Computer Interaction (HCI)

- In HCI the technical side is important but also the users
- The capabilities and weaknesses of the user need to be considered
- How do we make a computer easy to use?
  - User Interface Design
  - How do we measure if an interface is “good”?
  - Includes aspects of biology and behavioral sciences

Computer Graphics

Image generation

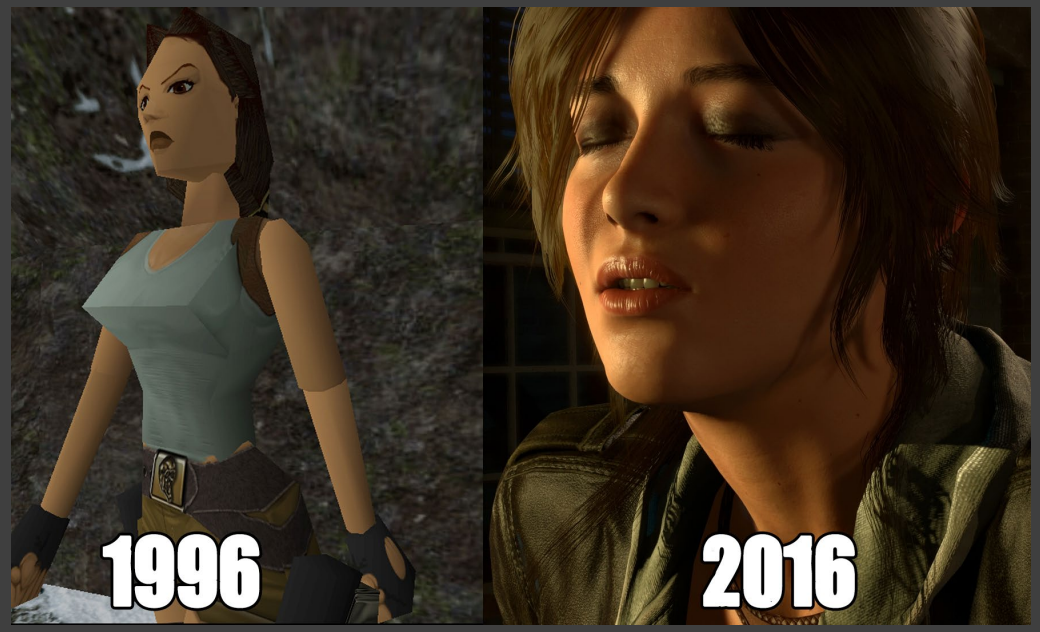
- How do we do it faster?
- How do we make it look more “real”?
- How do we store image data compactly?

Computer vision

- How can we make a computer “see”?

Computer graphics

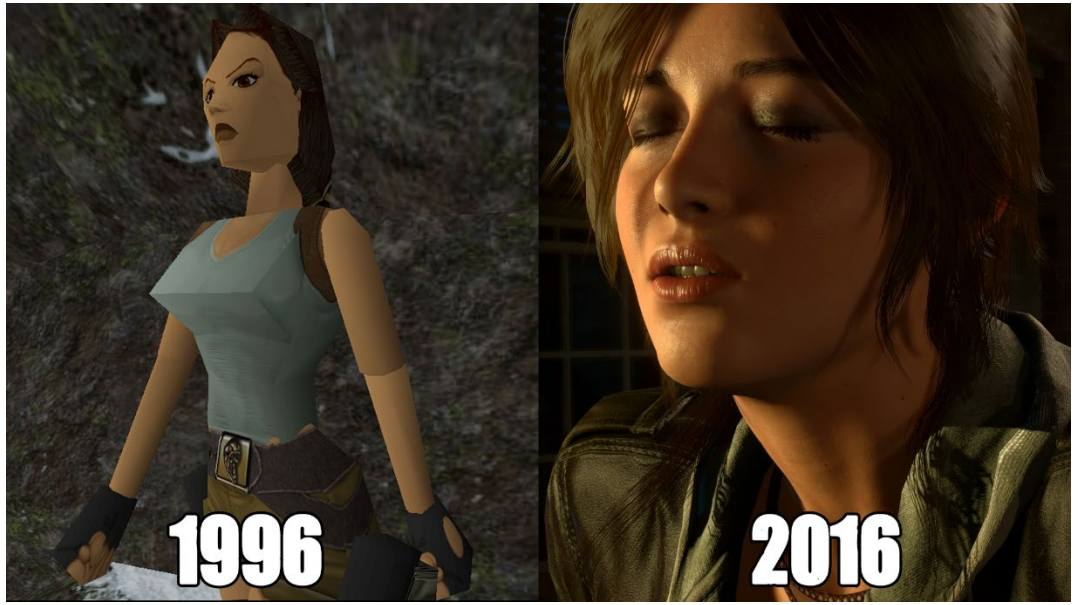
- Producing realistic images using technology



Tomb raider

Computer graphics

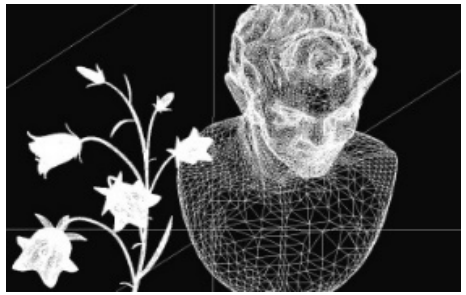
- Computer graphics is not about “Photoshopping” images
  - It is about writing the programs that produce graphical effects rather than using those programs



There is still room for improvement!

Computer graphics

- Sub-areas of graphics
  - Animations
    - producing realistic motion
  - Rendering



Xin Liu

Xin Liu

  - Image processing: implementing common graphical effects

James Tam

James Tam

Computer Vision

- The focus is on interpreting and understanding visual information.
  - Example applications:
    - Handwriting analysis
    - Fingerprint and facial recognition

- Self-driving cars or AR is a big application

→ Not producing images (graphics)

Databases

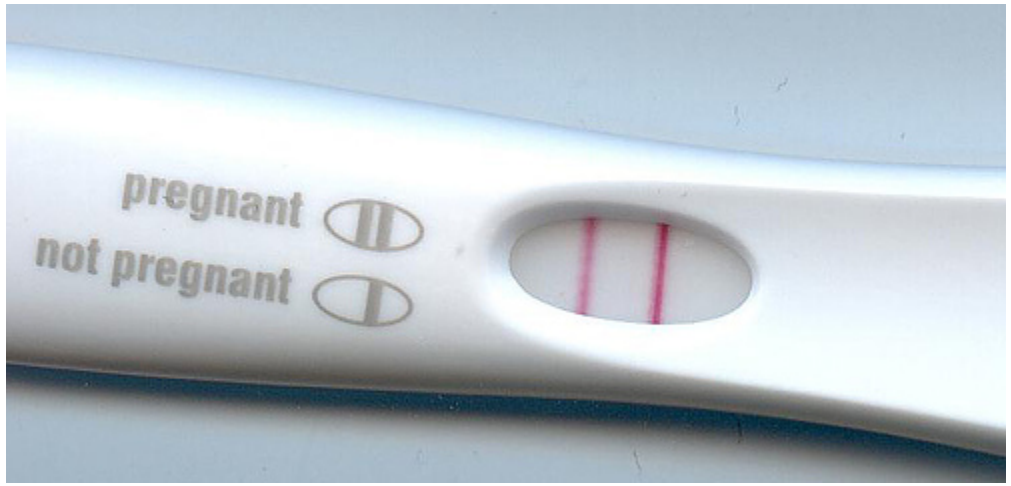
- How can we get new information out of large dataset?
- Data mining?
  - Figure out what you buy together at grocery stores. Amazon recommendations.
- Privacy of data? Netflix.
  - Those fears were highlighted in December, 2010 when an in-the-closet lesbian mother sued Netflix for privacy invasion, alleging the movie-rental company made it possible for her to be outed when it disclosed insufficiently anonymous information about nearly half-a-million customers as part of its $1 million contest.

Databases

Headlines from February 2012:

"How Target Figured Out A Teen Girl Was Pregnant Before Her Father Did"

"How Target knows when its shoppers are pregnant - and figured out a teen was before her father did"



"How Companies Learn Your Secrets"

"Should Target Tell Your Loved Ones You Are Pregnant, Or Should You?"

"How Target Knew a High School Girl Was Pregnant Before Her Parents Did"

"Target Figures Out Teen Girl Is Pregnant Before Her Father Does, Sends Helpful Coupons"

Information Security and Privacy

- Information Security
  - Ensure stored/transmitted information is confidential (prevent eavesdropping), authentic (comes from who it's supposed to), in its original form, etc…
- Privacy
  - Ensure only authorized entities can access data/information
  - Prevent accidental/malicious disclosure

Computer security

- It can involve the creation of malicious software (‘malware’)
- Purpose: learn about how malicious software is created and distributed.
- Goal: develop countermeasures to protect computer systems

Computer security

- Understanding ‘how things work’ is one key component to designing more secure systems.
  - e.g., Creating viruses and other malware in order to create better defenses against them.
- But also the ‘human’ factor must be considered: some security experts think that many security breaches are due to user actions not technical flaws (social engineering)
  - Sometimes the “weakest line of defense” is not the technology but the person.

Computer security

- A sub-area
  - Cryptography
    - Is involved in the transmitting and storing sensitive information.
    - The development of new and better approaches for encoding sensitive data (to make unauthorized access harder).

Theory of Computation

- Two primary subfields
  - Complexity Theory
    - How efficiently can the problem be solved
      - Time
      - Memory Space
    - How is the efficiency impacted by the (size of) input that is supplied?
  - Computability Theory
    - Can the problem be solved with a computer?
    - Some things are not computable (eg. Halting Problem)!

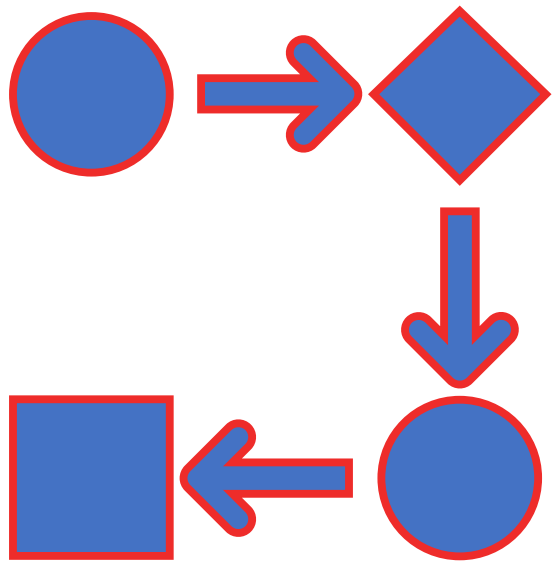
Networks

- Deals with networks surrounding one computer to networks that span the planet
  - How do we transfer data quickly?
    - Do we need a consistent level of service?
  - How do we transfer data reliably? Wirelessly?
  - How do we get the data where it needs to go?
  - Should network providers be allowed to inspect, filter or manipulate data?

  - From the hardware level (fourier transforms, to intermediate layers like TCP/IP, to software layer like torrents)

Distributed Systems

- How can we get multiple computers to work together to solve a problem?
  - Representing the problem in a way that allows it to be solved in parallel
  - Coordinating actions
    - Dealing with race conditions / deadlock
    - Avoiding duplicate work

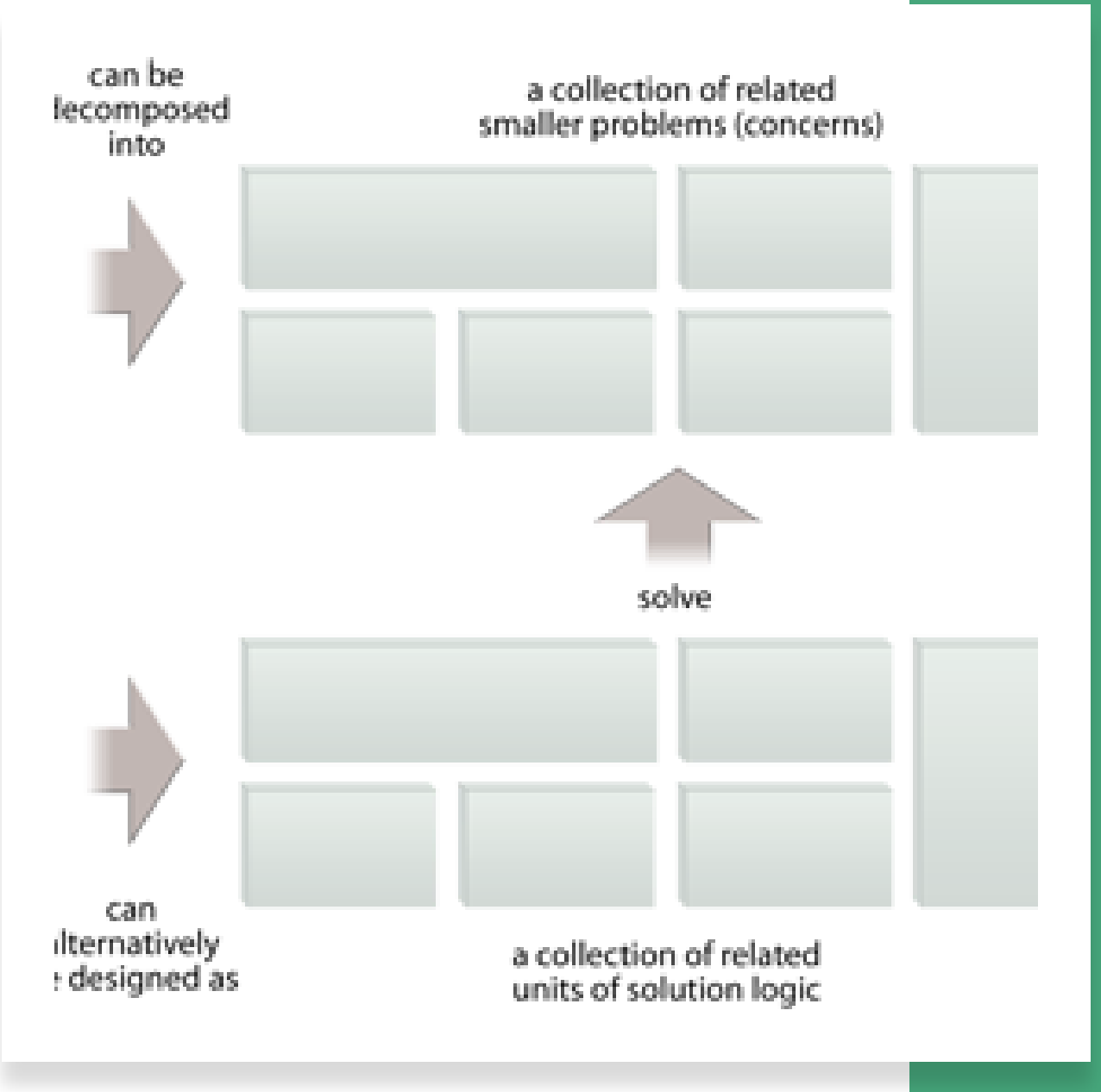


Software Engineering

- How do we develop large software projects?
  - How do we model the problem so that many people can work on it at once?
  - How do we ensure that the software does what it is supposed to?
  - How do we find and fix bugs in a large application?
  - What design decisions can we make to ease future expansion?

Software engineering

- Employing systematic ways of producing good software on time and within budget.
- A typical person can only hold ~7 concepts in their mind at a time.
- A typical computer program consists of more than 7 ‘parts’.
- Consequently mechanisms for dealing with this complexity are needed. → Functional decomposition



Game Development

- Brings many areas together
  - Graphics, HCI,
  - Networks, Distributed Systems,
  - Artificial Intelligence, Software Engineering,
  - …
  - Frequently pushes the limits of these areas
- What makes a game fun?
  - How do we define fun?
  - How do we measure fun?

The Brown Box (1967)

The first character select screen built by Aaron Keller. Originally World of Warcraft had only six races. Trolls and gnomes were added later in development.

Artificial intelligence (AI)

- Building a technology that is ‘smart’ or ‘intelligent’
- Issue: what is intelligence?
  - …There is some debate even among people in the field as to what constitutes ‘intelligence’
  - Fact retrieval
  - Creativity
  - Problem solving ability

→ Many experts in this field would tend to agree that AI is about making technology that can think and behave like a person.

Playing Games

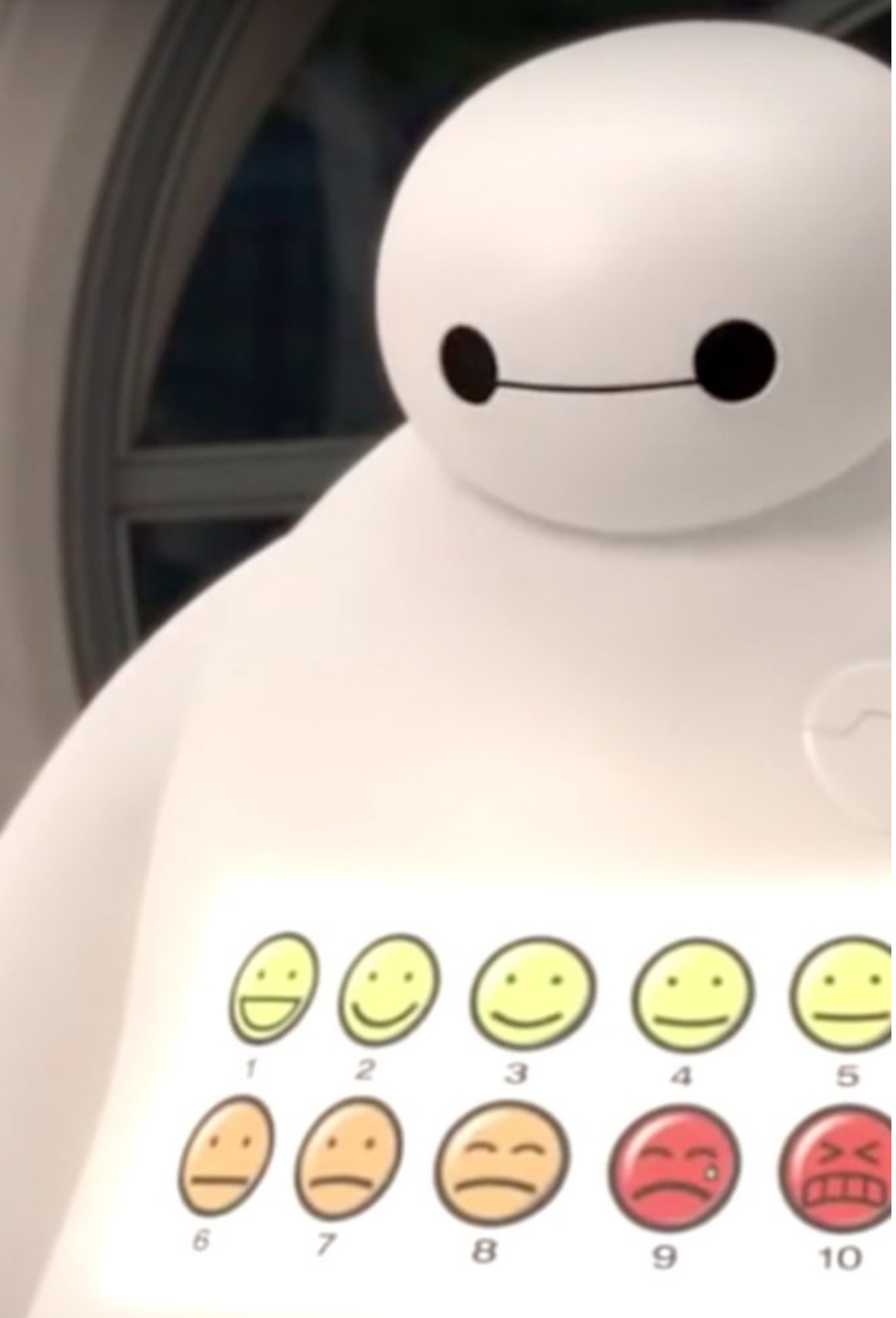
- Tic Tac Toe Strongly Solved
- Checkers -> Chinook 1994 Weakly Solved (2007)
  - http://webdocs.cs.ualberta.ca/~chinook/news/media.html
- Chess -> Deep Blue 1996 Unsolved but better than humans by far
- Poker – “”””””solved””””””” 2015
- Go -> Alpha Go 2016
- StarCraft II – AlphaStar 2019

Alpha Go

- What does alpha go do?
  - Lookahead search (just like my tictactoe minmax) (uses more complex idea of Monte Carlo Tree Search, only look along most likely paths of game)
  - It uses neural networks to match images (pattern of game board) and give a feeling of the game
  - Reinforcement learning. Played neural network trained on experts of get idea of how human players would play, and then played itself (ZeroGo skipped experts)

- Uses this neural network to determine what lookahead paths to follow

Alpha Go



Artificial intelligence (AI)

- Some sub-areas
  - Expert systems
    - Capturing the knowledge of a human expert as a set of rules stored in a database.
    - The expert system can then answer questions, diagnose problems and guide decision making.
- Example:
  - Medicine
  - IBM's Watson
    - Natural language processing
    - Won jeopardy including against Canadian Ken Jennings who had record of games own in a row
    - Also being applied to medicine
  - Computer or automotive repair

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Artificial intelligence (AI)

- The Turing Test
  - One test for determining if an artificial intelligence has been successfully created
  - It includes: test participants as well as a candidate artificial intelligence, a person who can also answer the same questions as the candidate intelligence

  - Test participants ask a series of questions (e.g., scientific problems, questions about popular culture etc.) of another person and a candidate artificial intelligence. If the test participants cannot tell the difference between the two, then an artificial intelligence has been successfully created.

Artificial intelligence (AI)

- ELIZA is an early natural language processing computer program created from 1964 to 1966 mat the
- Created to demonstrate the superficiality of communication between humans and machines, Eliza simulated conversation by using a 'pattern matching' and substitution methodology that gave users an illusion of understanding on the part of the program, but had no built in framework for contextualizing events.
- The most famous script, DOCTOR, simulated a Rogerian psychotherapist and used rules, dictated in the script, to respond with non-directional questions to user inputs
- http://www.masswerk.at/elizabot/

Artificial intelligence (AI)

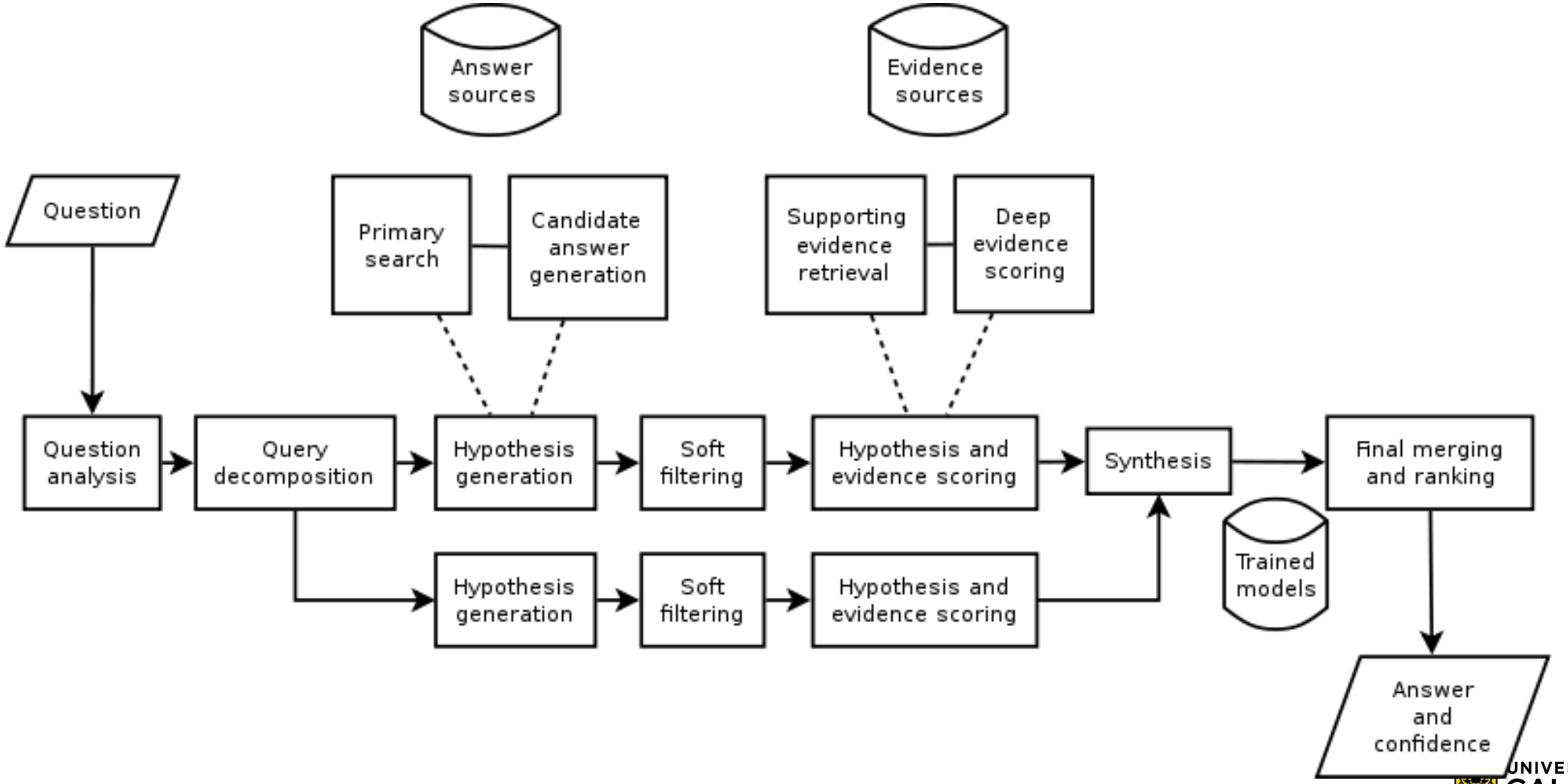
- http://www.cleverbot.com/ Eugene Goostman

- Natural Language processing in Alexa, Siri, Cortana, Google Assistant, Bixby

Watson

- Natural language processing
- Won jeopardy including against Canadian Ken Jennings who had record of games own in a row
- Also being applied to medicine

Watson

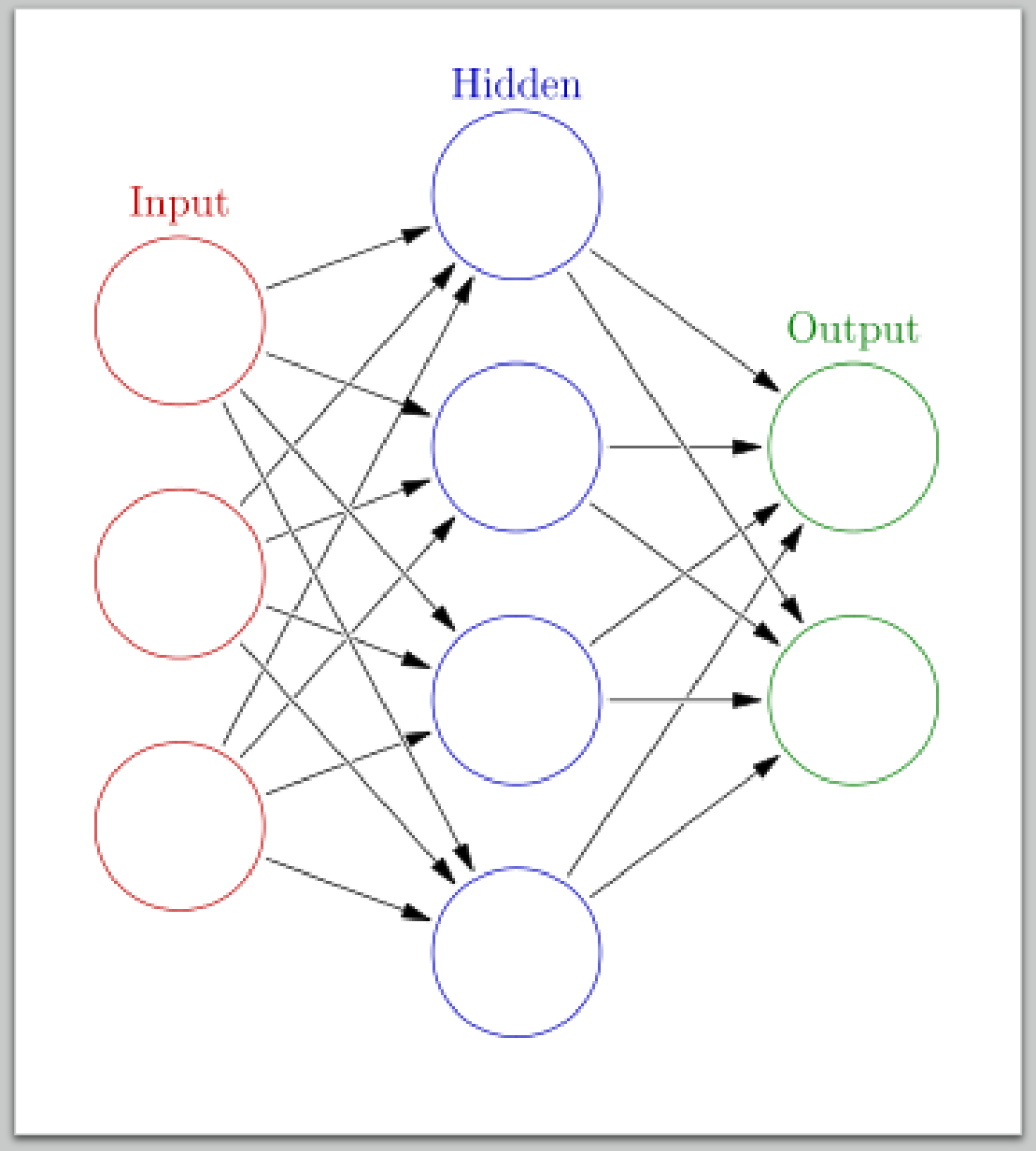


Neural networks

- Neural networks
  - Building structures that function the way that neurons and their connections in the brain function.
  - Neurons take electrical pulses as input and send electrical pulses as output.
  - A required level of input is required before the output is ‘fired’.

  → This approach has been applied to problems which involve pattern recognition
    - e.g., visual, voice

  - Effectively like reducing the problem to some hidden function



```
class: 793
label: n04209133 shower cap
certainty: 99.7%
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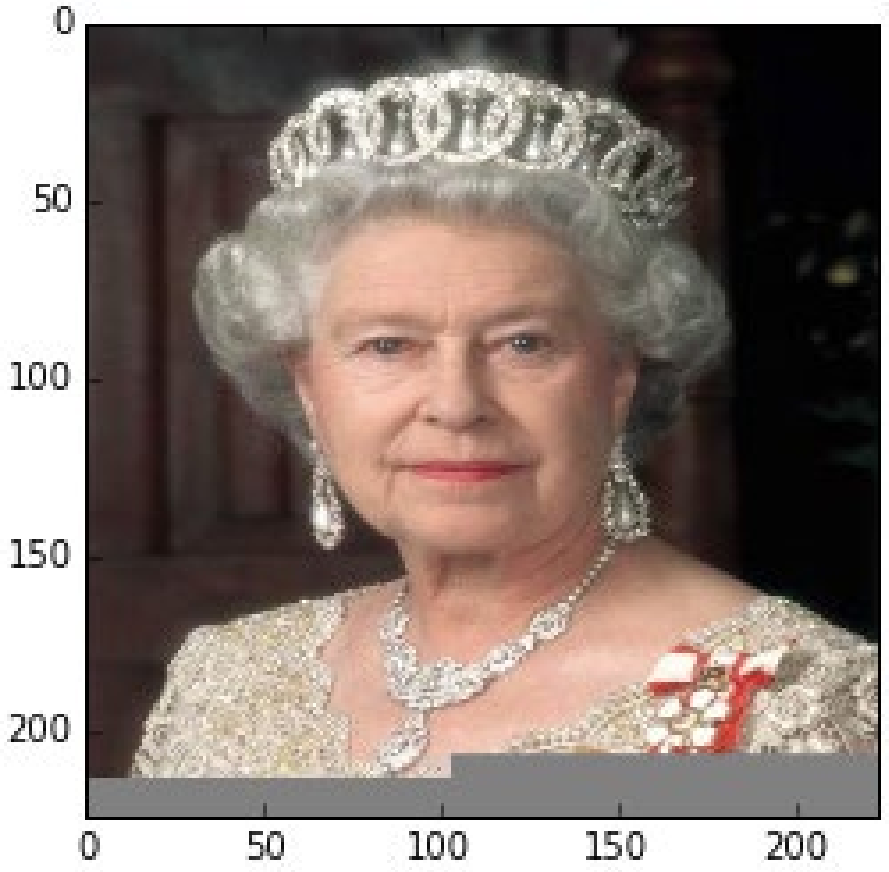
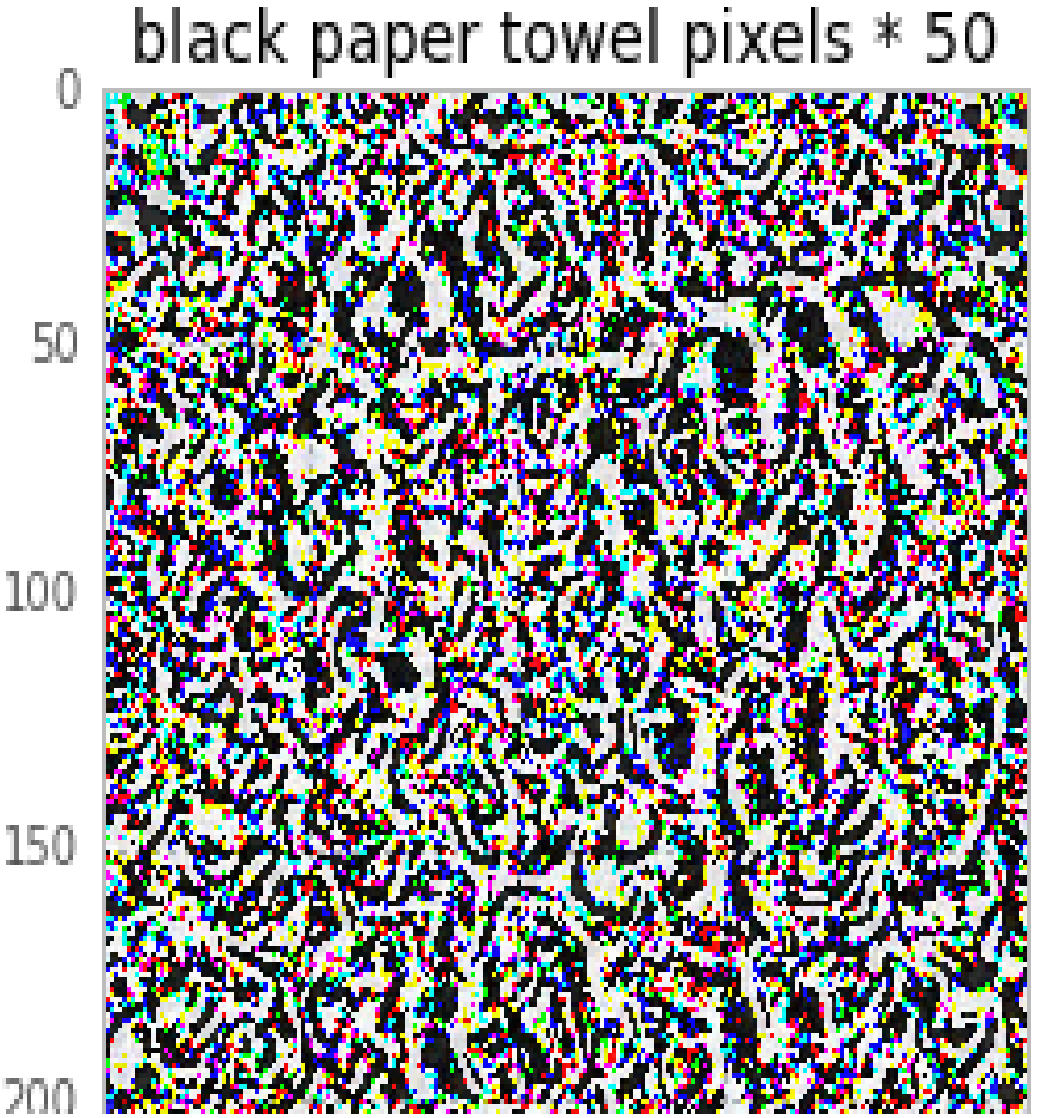
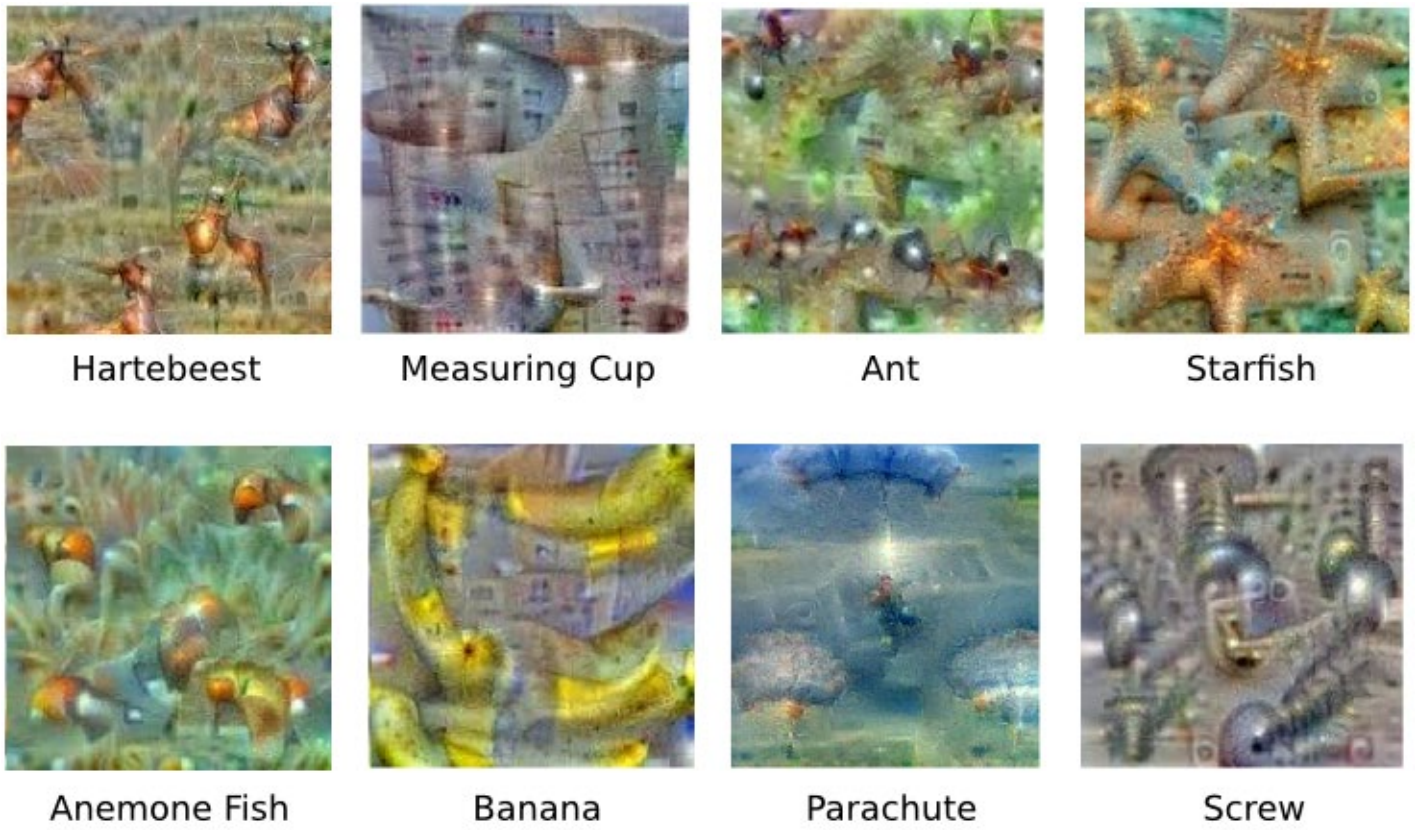




Tricking A Neural Network

Reverse Neural Network



Usage of Computer Science in other Fields

- Civil and mechanical engineering (II)
  - Use their Computational power to solve analytical problems faster
  - Asking a computer to design a building
  - The process was very time consuming and hard in the past when it had to be done manually
  - They weren’t able to design complex structures because it was not possible to solve the analytical equations manually

By 2020

Onward to … a brief history!

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