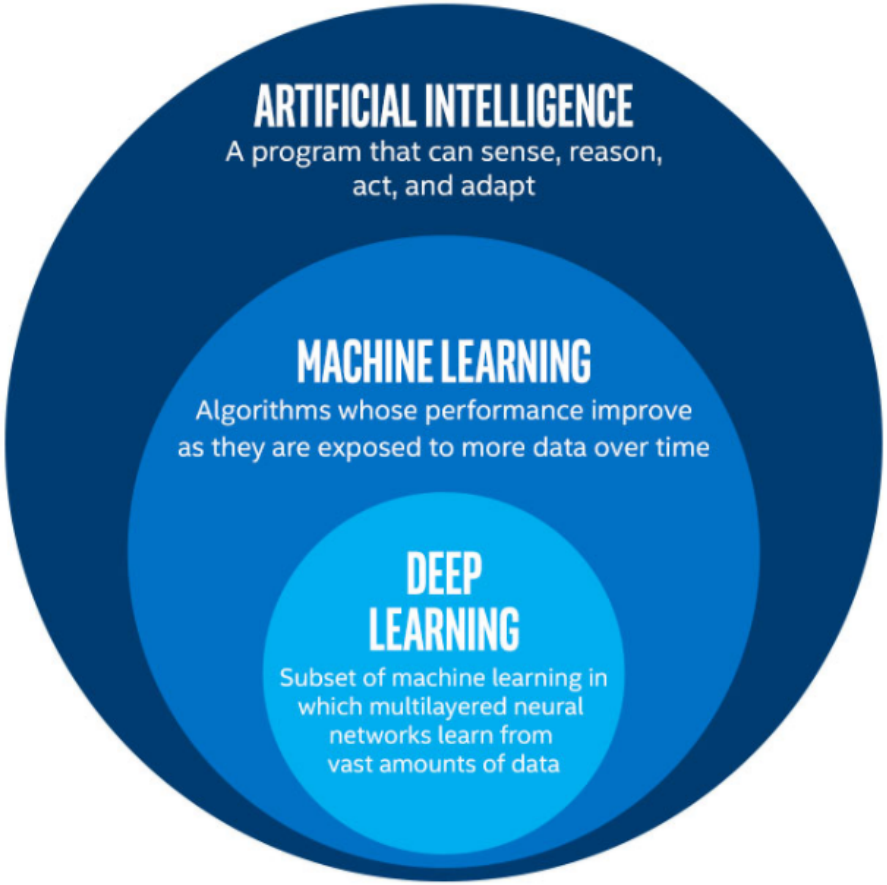
Artificial Intelligence: Introduction

Today

1. The current "AI Hype"
2. Important questions
   a) What is artificial intelligence?
   b) What is intelligence?
   c) Is there a test for intelligence?
3. What do we do in AI?
4. History of AI
5. An example: Eliza

The current "AI Hype"

- Major breakthroughs in many AI topics
- Thanks to a technique called Deep Learning



https://towardsdatascience.com/cousins-of-artificial-intelligence-dda4edc27b55

Recent Breakthroughs

- Speech Recognition & Machine Translation (2010+)

- *Google now*

- *Google Translate*

- *Skype Translator*

- Image Recognition & Computer Vision (2012+)
- Natural Language Processing (2014+)
- ...

Figures from Yoshua Bengio, 2015

Recent Breakthroughs

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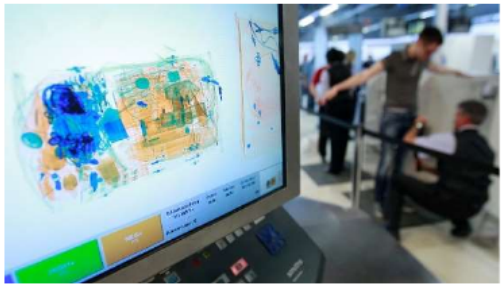
- Image Recognition & Computer Vision (2012+)



- *Object recognition*
- *Self driving cars*
- *Airport Screening*

- Natural Language Processing (2014+)
- …

Figures from Yoshua Bengio, 2015 and https://qz.com/1371531/deep-learning-algorithms-are-being-used-to-detect-lithium-ion-batteries-in-airport-luggage/

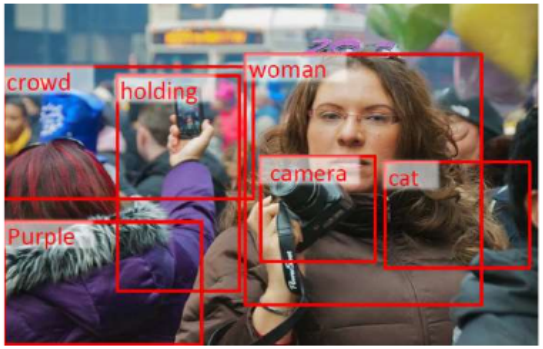
Recent Breakthroughs

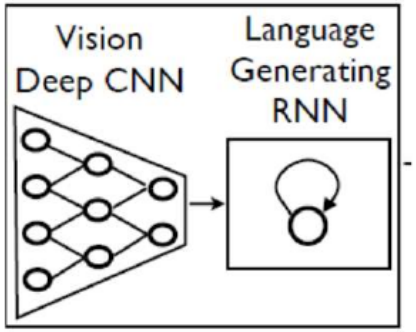
- Speech Recognition & Machine Translation (2010+)
- Image Recognition & Computer Vision (2012+)
- Natural Language Processing (2014+)

Joe went to the kitchen. Fred went to the kitchen. Joe picked up the milk.
Joe travelled to the office. Joe left the milk. Joe went to the bathroom.
Where is the milk now? A: office
Where is Joe? A: bathroom
Where was Joe before the office? A: kitchen

http://blog.csdn.net/qfnu_cjt_wl

- *Question Answering*





Machine-generated (but turker prefered)	a bicycle is parked next to a river
Human-annotated (but turker not prefered)	a bike sits parked next to a body of water

- *Image Captioning (deep vision + deep NLP)*

Figures from Yoshua Bengio, 2015

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1. What is artificial intelligence?

- No standard definition of AI among those working in the field
- AI has even been defined as:

"… the collection of problems and methodologies studied by artificial intelligence researchers."
- Luger and StubbleField

Approaches to AI: Engineering VS Cognitive Approach

- Engineering Approach:
  - Tries to find optimal solutions
  - No matter how (not necessarily what human do)
- Cognitive Approach:
  - Tries to understand the process
  - Tries to reproduce human behavior (even if wrong result)

- 4 points of view: Systems that can…

	Cognitive approach	**Engineering / Rational approach**
Behavior	act like humans	act intelligently
Reasoning	think like humans	think intelligently

Other Definitions

Machines that **think like humans**

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

Machines that **act like humans**

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

Machines that **think intelligently**

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

Machines that **act intelligently**

- *A field of study that seeks to explain and emulate intelligent behavior in terms in terms of computational processes (Schalkoff, 1990)*
- *The branch of computer science that is concerned with the automation of intelligent behavior* (Luger & Stubblefield, 1993)

Approaches to AI: Weak VS Strong AI

- Weak AI :
  - A system whose capabilities are **not** intended to match or exceed the capabilities of human beings.
  - A system *can* demonstrate intelligence, but does not necessarily have a mind, mental states or consciousness.
  - Usually, a small application with a single purpose

- Strong AI:
  - typically used in science fiction
  - A system that matches or exceeds human intelligence.
  - A system that could have: consciousness, self-awareness, the ability to *feel* sentiments, …
  - Usually, a "general purpose" application capable of several tasks

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What is Intelligence, Anyways?

- are you intelligent if you:
  - can do complex arithmetic quickly?
    - humans are bad at it
    - … but computers are good at it
  - can recognize a face in a picture?
    - humans are good at it
    - … but hard to automate in a computer
  - hold a 15 min. conversation?
    - humans are good at it
    - … but really hard to automate in a computer

What is Intelligence?

- intellectual vs physical capabilities
  - a dog has a more acute sense of smell…
  - a bat can see at night…
- reflex vs planned/reasoned action
  - when the female wasp returns to her burrow with food, she first deposits it on the threshold, checks for intruders inside, and only then, if the coast is clear, carries her food inside.
  - but that's **instinctual** behavior
  - if the food is moved a few inches away while she is inside: on emerging, she will repeat the whole procedure as often as the food is displaced.
- awareness of existence (consciousness of itself)
  - if a system passes a test for intelligence but is not aware of it, is it intelligent?
  - but the only way to *really* know if a machine is thinking is to *be* the machine…

source of picture http://upload.wikimedia.org/wikipedia/en/8/85/Cicada_Killer_Wasp.jpg

Is Deep Blue Intelligent?

- In 1996 and 1997 IBM's Deep Blue beat the human chess champion Kasparov in a six-games match.
- But Deep Blue uses:
  - plain brute force technique
  - on a massively parallel supercomputer
  - can explore 200,000,000 positions per second (Kasparov can examine 3/sec)
- Today, emphasis on more *intelligent* chess programs
- in Nov. 2006, Deep Fritz vs. Kramnik, ran on an ordinary Intel Core 2 Duo CPUs

source of image:
http://upload.wikimedia.org/wikipedia/en/c/c6/P11_kasparov_breakout.jpg

Is Chess Playing Intelligent?

"Chess is far easier than innumerable tasks performed by an infant, such as understanding a simple story, recognizing objects and their relationships, understanding speech, and so forth. For these and nearly all realistic AI problems, the brute force methods in Deep Blue are hopelessly inadequate."

– David Stork

Is Watson Intelligent?

- In 2011, IBM's Watson competed on *Jeopardy!*
- Watson beat Brad Rutter, the biggest all-time money winner on *Jeopardy!*, and Ken Jennings, the record holder for the longest championship streak
- Watson received the first prize of $1 million
- Watson is a question answering system... "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"

source: http://en.wikipedia.org/wiki/Watson_%28artificial_intelligence_software%29

Is AlphaGo Intelligent?

- GO was always considered a much harder game to automate than chess because of its very o high a branching factor (35 for chess vs 250 for Go!)
- In 2016, AlphaGo beat Lee Sedol in a five-game match of GO.
- In 2017 AlphaGo beat Ke Jie, the world No.1 ranked player at the time

- AlphaGo uses a Monte Carlo tree search algorithm to find its moves based on knowledge previously "learned" by deep learning

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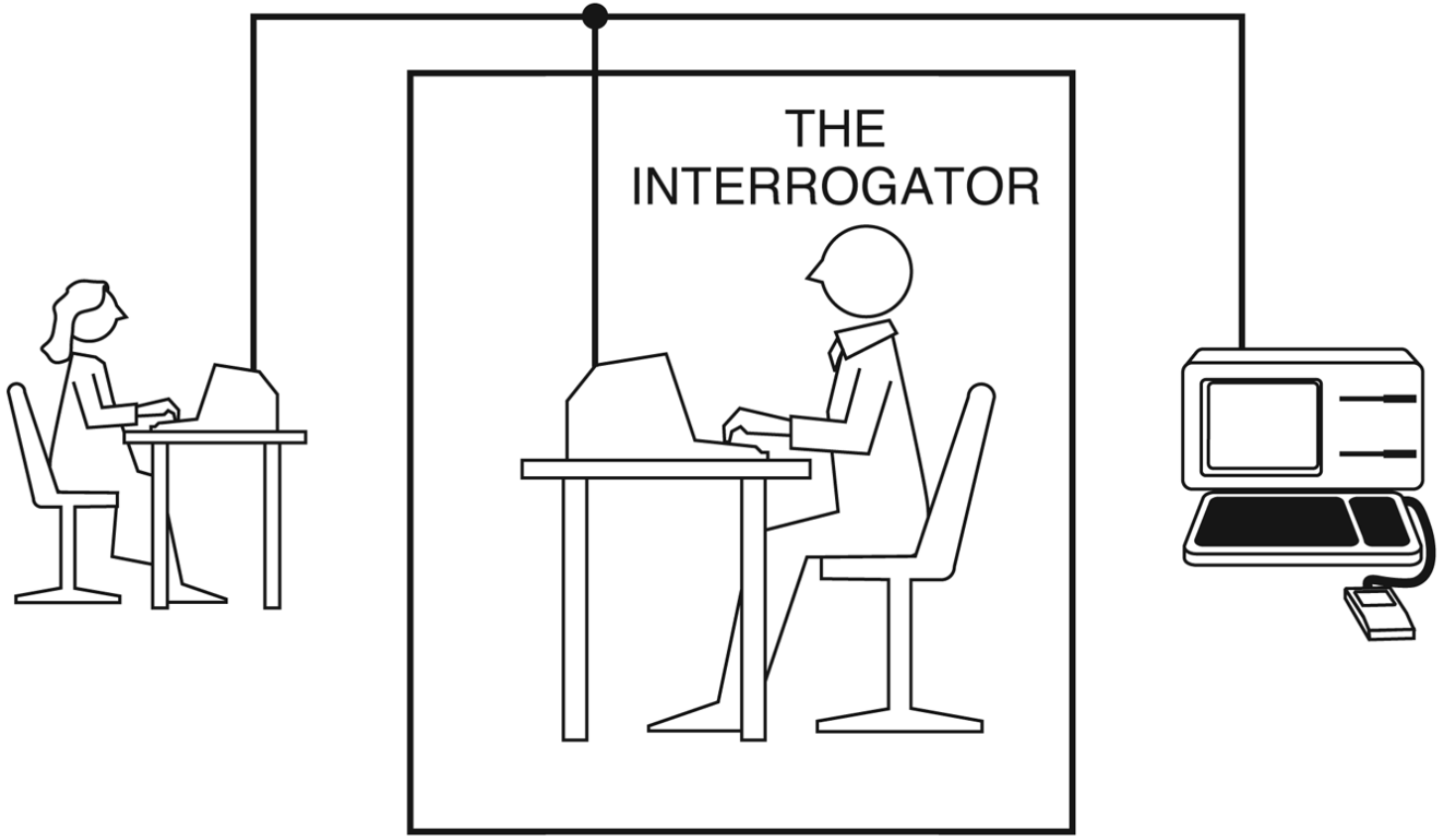
A Test for Intelligence…

- The Turing Test
  - The "imitation game"
  - Proposed by Alan Turing in 1950
  - If a human interrogator cannot tell the computer and human apart, then the computer is intelligent
  - Measures the intelligence of a computer vs. a human
  - Turing predicted that by 2000, a machine might have a 30% chance of fooling a person for 5 minutes

The Turing Test



- A human mediates between the interrogator and the machine

The Turing Test

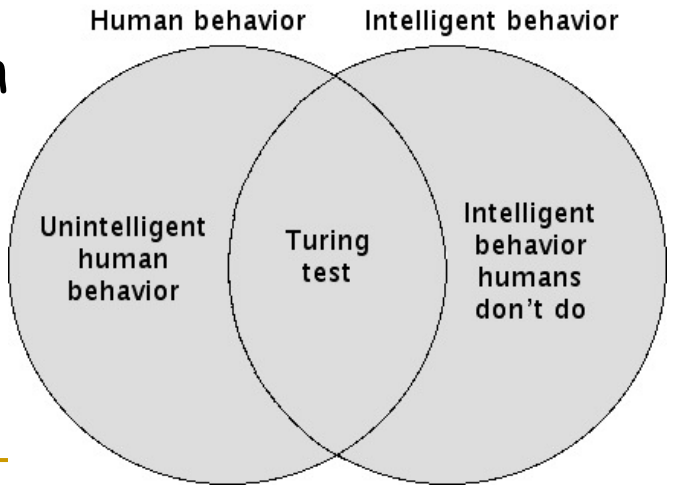
- Some capabilities required to pass the Turing test:
  - Natural Language Processing (NLP) to communicate
  - Knowledge Representation to store knowledge
  - Automated Reasoning to infer new knowledge
  - Machine Learning
  - …

Arguments For the Turing Test

- Objective notion of intelligence
- Prevents us from arguments about the computer's consciousness
- Eliminates bias in favor of humans
- …

Arguments Against Turing Test

- Not reproducible
- Not constructive
- Machine intelligence designed w.r.t. humans
  - test is anthropomorphic. It only tests if the subject *resembles* a human being.
  - unnecessarily restrict machines
  - ex: x-ray vision, fast computation



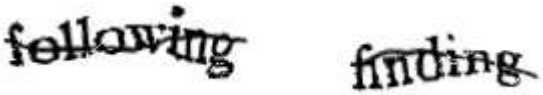
source of image:
http://en.wikipedia.org/wiki/Image:Weakness_of_Turing_test_1.jpg

Did anyone pass the Turing Test yet?

- The Long Bets Foundation has $20,000 bet between
  - Mitchell Kapor, founder of Lotus Development, and
  - Ray Kurzweil, inventor
  - Kapor bets that "By 2029 no computer - or "machine intelligence" - will have passed the Turing Test. "
- After more than 60 year ... <drum roll please> ... In 2014, the news reported that a chatbot passed the Turing Test!
- But, Kurzweil himself is not convinced... because the test had restrictions...
  - the chatbot claimed to be a 13-year-old, and
  - one for whom English is not a first language

https://longbets.org/1

Current Turing Tests



CAPTCHA:

- **C**ompletely **A**utomated **P**ublic **T**uring test to tell **C**omputers and **H**umans **A**part
- the system asks a user to complete a test which the computer is able to generate and grade, but not able to solve.
- Because computers are unable to solve the CAPTCHA, any user entering a correct solution is presumed to be human.
- also known as **reverse Turing test**, because it is:
  - given by a machine and targeted to a human
  - in contrast to the Turing test that is given by a human and targeted to a machine.

source of image:
http://upload.wikimedia.org/wikipedia/commons/b/b6/Modern-captcha.jpg

Turing Test not so smart anymore?

Limitations of the Turing Test

- **Superficiality:** It focuses on deception, not intelligence.
- **Lack of Scalability:** Not practical for evaluating the vast array of AI capabilities.
- **Human Imitation vs. AI Innovation:** Prioritizes mimicking human behavior over unique AI strengths.
- **Not Comprehensive:** Fails to assess the wide range of abilities that modern AI possesses.
- **Advanced Interactions:** AI now handles nuanced and context-rich interactions, which the Turing Test doesn't fully capture.
- **Ethical AI Considerations:** Ensuring AI systems are fair, unbiased, and safe.
- **Automated Testing:** Evaluate AI on a much larger scale and more efficiently than the Turing Test.

Modern Bot Evaluation Frameworks

What is being evaluated? Concrete Tasks Examples

- **Natural Language Understanding (NLU):** Understanding and processing human language (e.g., sentiment analysis, question answering).
- **Creative Tasks:** AI's ability to generate creative content (e.g., writing poems, creating artwork).
- **Decision-Making Skills:** AI's effectiveness in scenarios requiring complex decision-making (e.g., strategic game playing, business forecasting).

How do we evaluate? Metrics Examples:

- **Accuracy and Precision:** Measure of correctness in AI's outputs (e.g., percentage of correct answers in NLU tasks).
- **Response Time:** Speed at which AI provides responses, important in real-time applications.
- **Robustness and Generalization:** AI's ability to handle unexpected inputs or scenarios.

How to Evaluate a Large Language Model (LLM)?

Framework Name	Factors Considered for Evaluation	Url Link
Big Bench	Generalization abilities	https://github.com/google/BIG-bench
GLUE Benchmark	Grammar, Paraphrasing, Text Similarity, Inference, Textual Entailment, Resolving Pronoun References	https://gluebenchmark.com/
SuperGLUE Benchmark	Natural Language Understanding, Reasoning, Understanding complex sentences beyond training data, Coherent and Well-Formed Natural Language Generation, Dialogue with Human Beings, Common Sense Reasoning (Everyday Scenarios and Social Norms and Conventions), Information Retrieval, Reading Comprehension	https://super.gluebenchmark.com/
OpenAI Moderation API	Filter out harmful or unsafe content	https://platform.openai.com/docs/api-reference/moderations
MMLU	Language understanding across various tasks and domains	https://github.com/hendrycks/test
EleutherAI LM Eval	few-shot evaluation and performance in a wide range of tasks with minimal fine-tuning	https://github.com/EleutherAI/lm-evaluation-harness

https://www.analyticsvidhya.com/blog/2023/05/how-to-evaluate-a-large-language-model-llm/

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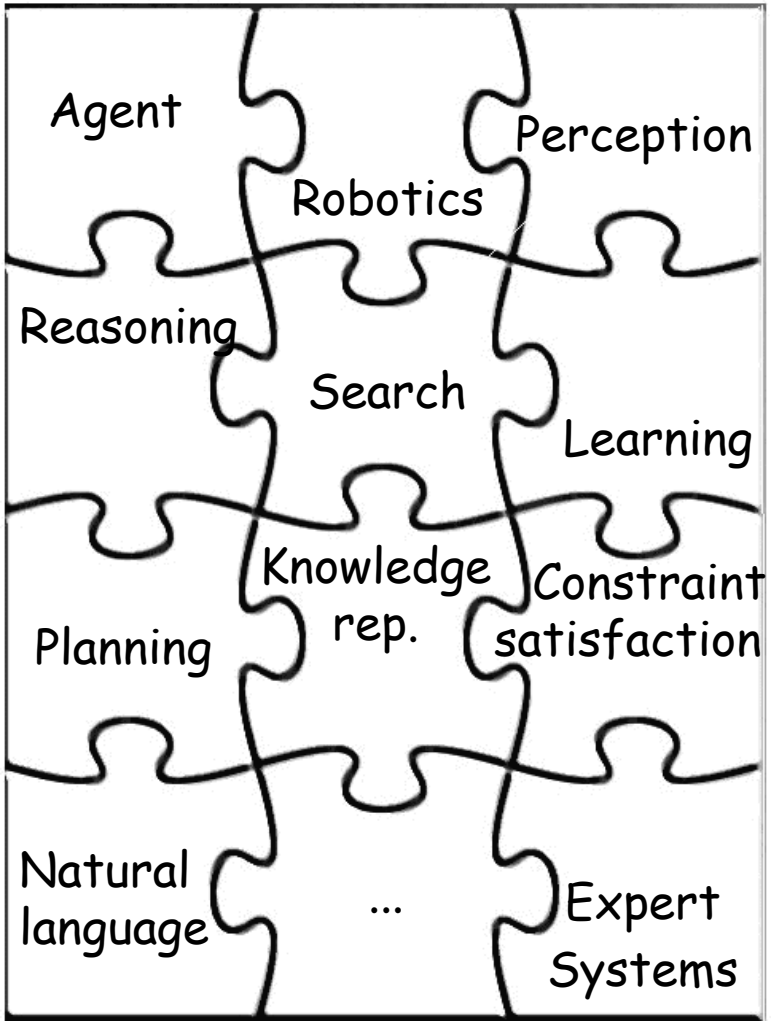
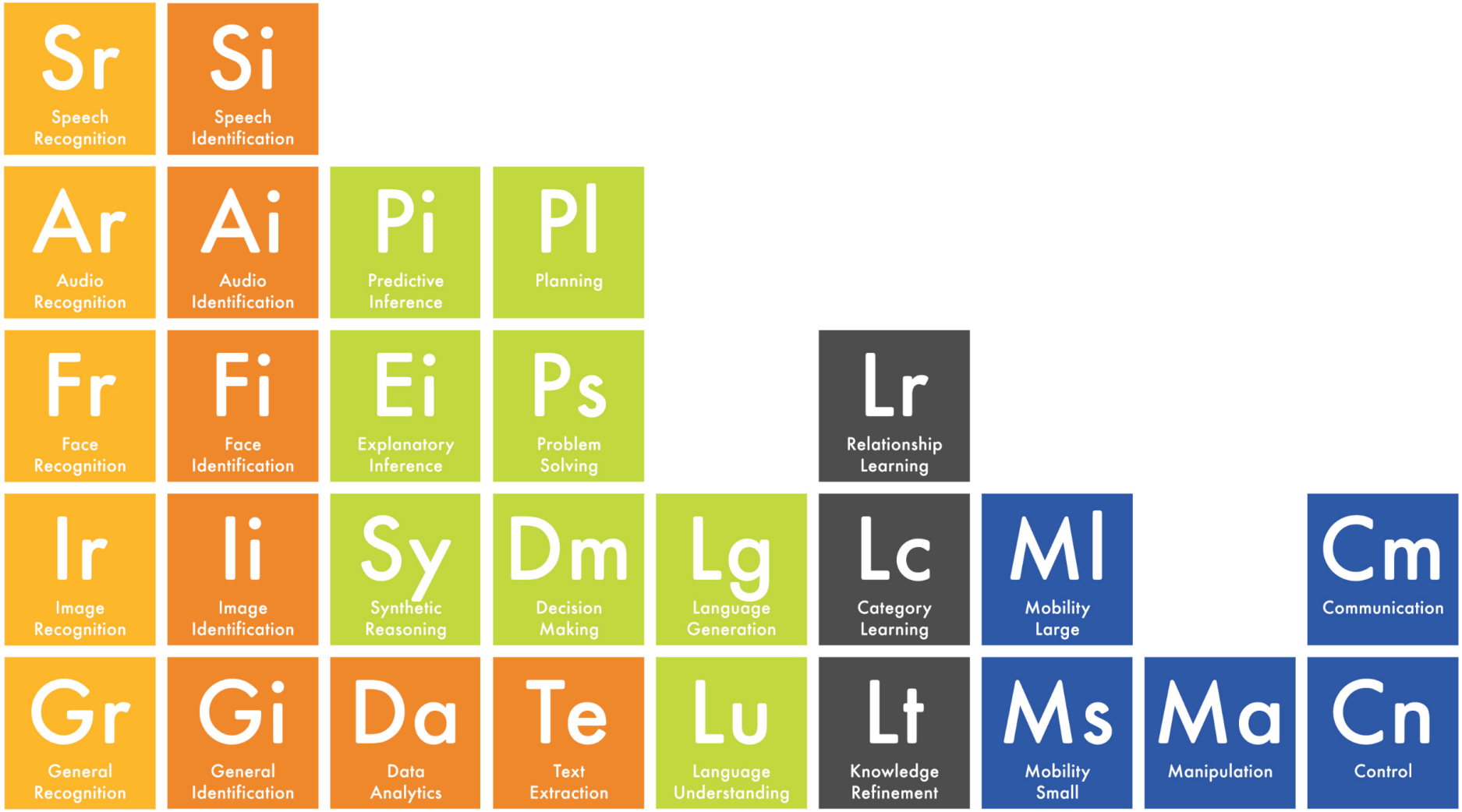
What do we do in AI?

- Knowledge representation (including formal logic)
- Search, especially heuristic search (puzzles, games)
- Planning
- Reasoning under uncertainty, including probabilistic reasoning
- Learning
- Agent architectures
- Robotics and perception
- Natural language processing
- ...



The Periodic Table Of AI



https://www.datasciencecentral.com/profiles/blogs/the-periodic-table-of-ai

Successes of AI…

- A few years ago, all these were considered AI problems… now, no one thinks of them as AI
  - OCR – Optical Character Recognition
  - Speech Recognition
  - Information Retrieval
  - Spell checker and Grammar checker
  - Expert Systems
  - Data Mining
  - Word Prediction
  - …

Some Successes of AI…

- A more pragmatic definition of AI today :

"AI research is that which computing scientists do not know how to do cost-effectively today."

AI is like …

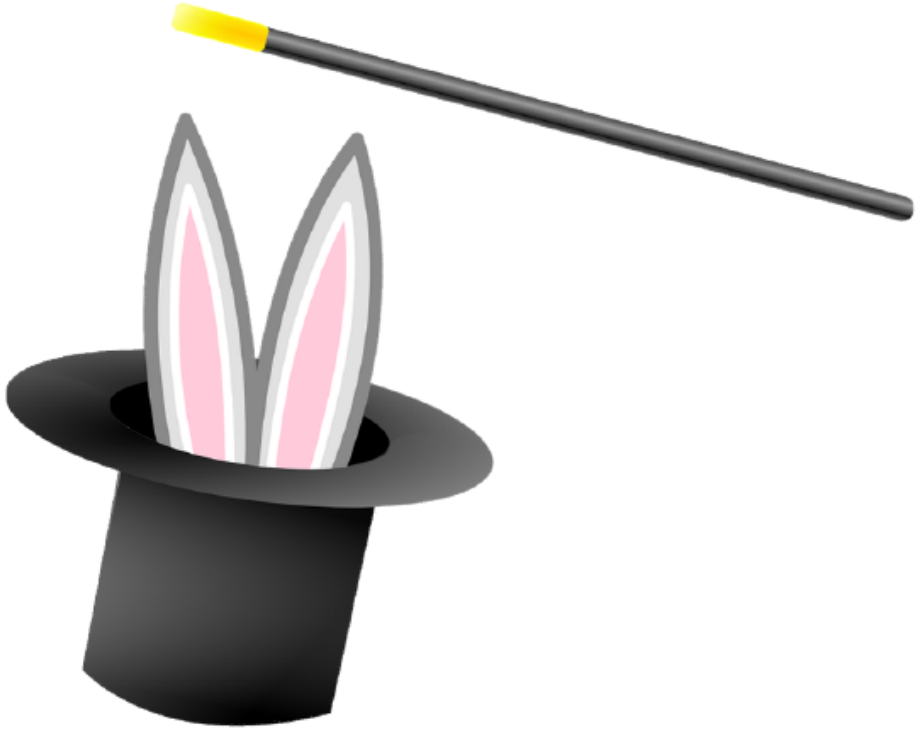


Image from: https://pixabay.com/p-25490/?no_redirect

What do we do in AI?

Topics at the Canadian AI Conference 2024

Canadian AI 2024, the 37th Canadian Conference on Artificial Intelligence, invites papers that present original work in all areas of Artificial Intelligence, either theoretical or applied. Topics of interest include, but are not limited to:

- Agent Systems
- AI Applications
- Automated Reasoning
- Case-based Reasoning
- Cognitive Models
- Constraint Satisfaction
- Data Mining
- Deep Learning and Neural Models
- E-Commerce
- Ethics in AI, AI for social good
- Evolutionary Computation
- Explainable AI
- Games
- Information Retrieval and Search
- Information and Knowledge Management
- Knowledge Representation
- Machine Learning
- Multimedia Processing
- Natural Language Processing
- Planning
- Robotics
- Swarm Intelligence
- Unbiased, safe and trusted AI
- Uncertainty
- User Modeling
- Web Mining and Applications

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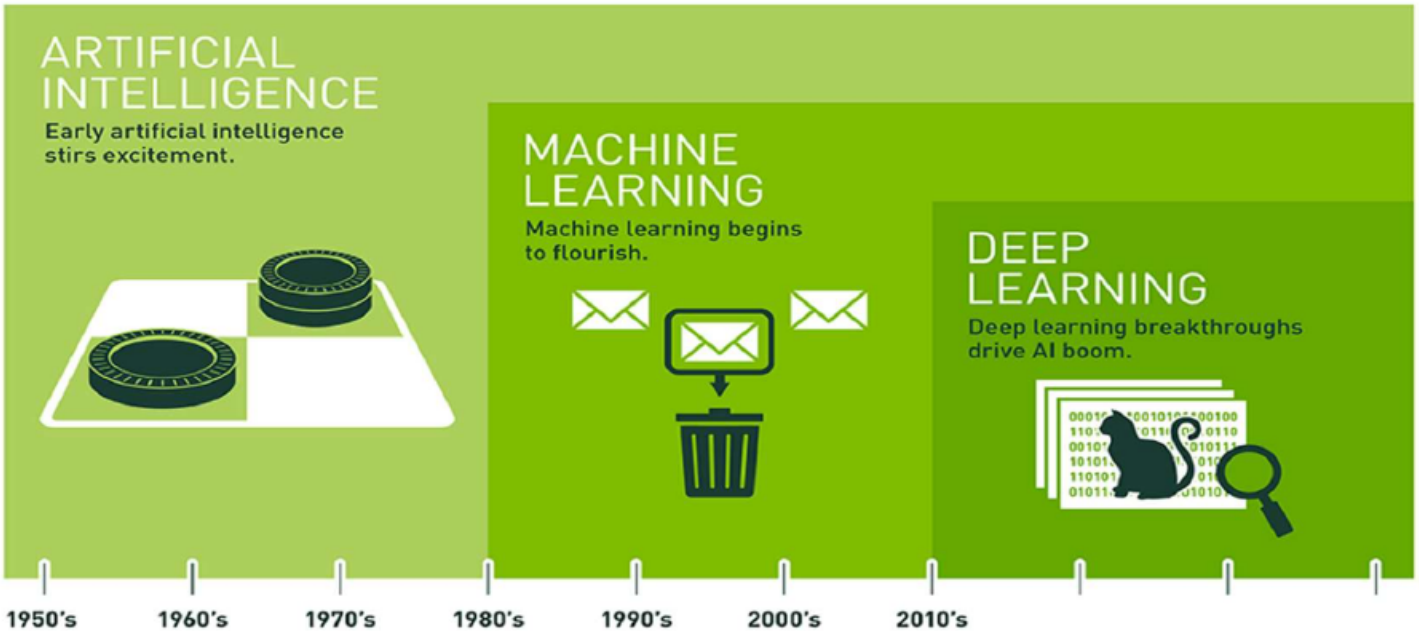
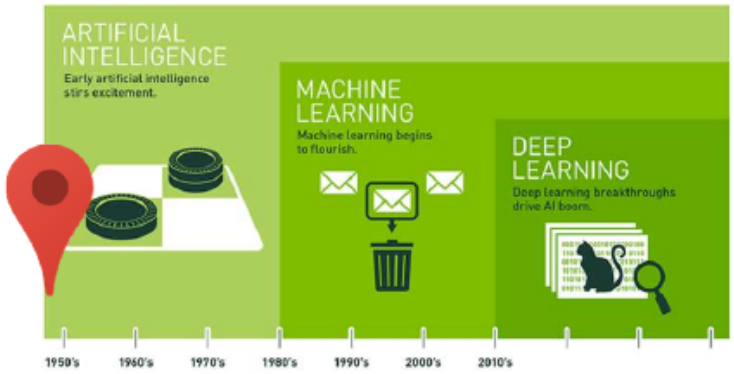
History of AI



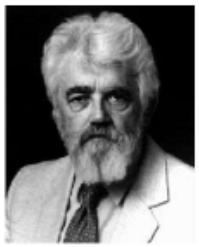
https://medium.com/machine-learning-for-humans/neural-networks-deep-learning-cdad8aeae49b

History of AI



- 1940-1956
  - 1943: early work in neural networks… but just a theory, no real implementation
  - 1950: Alan Turing describes the Turing test
  - 1956: The Darmouth workshop
    - get-together of the big guys: McCarthy, Minsky, Shannon & others
    - the term "Artificial Intelligence" is first adopted

Dartmouth Conference: The Founding Fathers of AI


John McCarthy


Marvin Minsky


Claude Shannon


Ray Solomonoff

Alan Newell

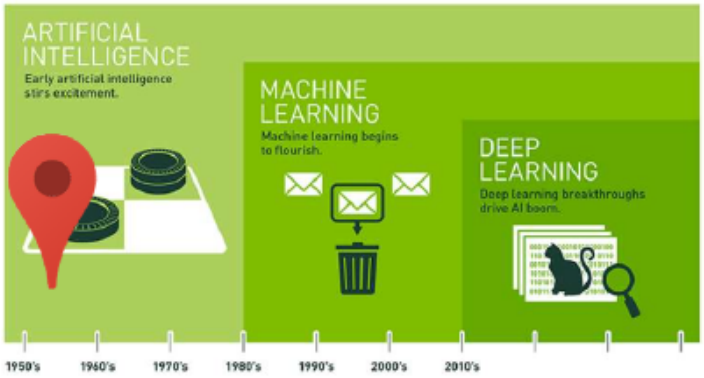
Herbert Simon

Arthur Samuel

And three others…
Oliver Selfridge (Pandemonium theory)
Nathaniel Rochester (IBM, designed 701)
Trenchard More (Natural Deduction)

- https://www.linkedin.com/pulse/goedels-incompleteness-theorem-emergence-ai-eberhard-schoeneburg/

History of AI



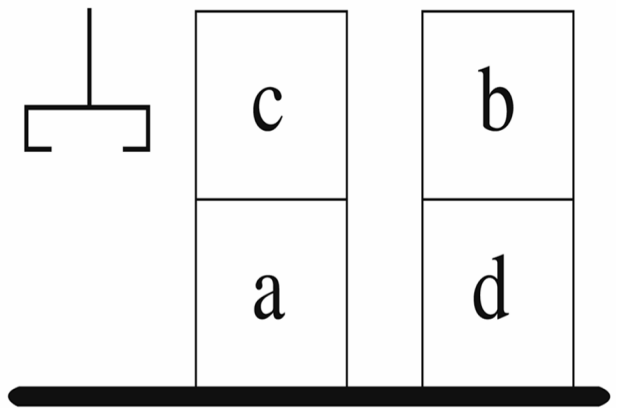
- The rise of AI (~1956 - 70s)
  - The era of GOFAI: Good Old Fashioned AI
  - Symbolic computation rather then numeric computation
    - `cold`, `hot` rather than `25.5°C`
    - `onTop(red)` rather than `position[1,0,0] = 50cm`
  - Development of AI-specific programming languages:
    - 1958: John McCarthy develops LISP
    - 1972: Colmeraurer develops Prolog

Unrealistic Predictions

- In 1950, Turing predicted that 50 years later (in 2000)
  - it will be possible to program a computer with ~100 Mb memory to pass the Turing Test 30% of the time, with 5 minute conversations.
  - It will be natural to speak of computers 'thinking'.
  - --> we still can't do that
- Machine Translation:
  - In the 1950s, after World War II, we could translate automatically a few sentences from Russian to English.
  - Prediction: "Within three to five years, machine translation will be a solved problem."
  - --> we still can't do that
- All this, lead to the First AI Winter…

Example of a Toy-World

- toy-world = micro-word
- 1973: Winograd developed SHRDLU to understand English sentences in a restricted world and carried out instructions typed in English with a robot arm.



History of AI

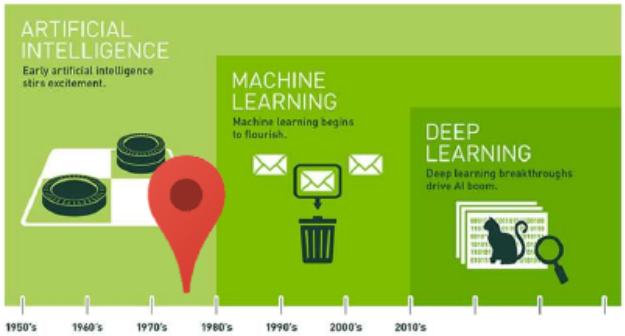
- Reality hits (late 60s - early 70s)
  - 1966: the ALPAC report kills work in machine translation (and NLP in general)
  - People realized that scaling up from micro-worlds (toy-worlds) to reality is not just a manner of faster machines and larger memories…
  - Minsky & Papert's paper on the limits of perceptrons (cannot learn just any function…) kills work in neural networks
  - in 1971, the British government stops funding research in AI due to no significant results
  - it's the first major *AI Winter…*

https://www.vectorstock.com/royalty-free-vector/freezing-snowman-vector-689086

History of AI

- 1970s - 1980s
- A big "hype" … Expert Systems
  - knowledge-intensive, rule-based techniques
  - Commercial expert systems
  - Decision-support systems

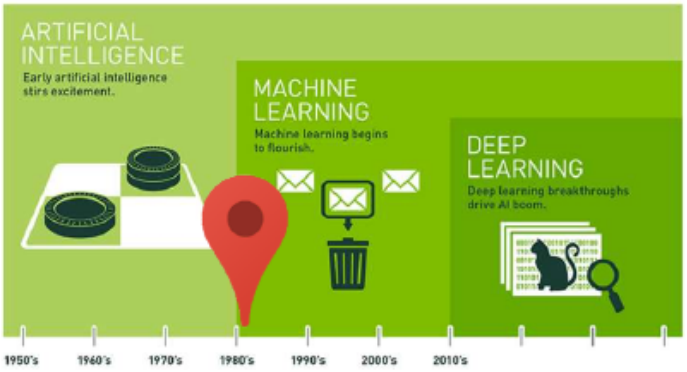
HUMANS need to write the rules by hand…



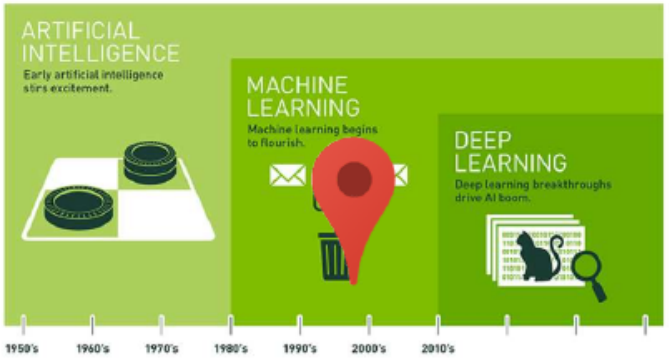
1972: MYCIN diagnoses blood infections as well as doctors.

History of AI

- mid 80s – mid 90s
- Another AI Winter
  - The end of Expert Systems
    - Too tedious to write rules by hand
    - Too expensive to maintain



History of AI



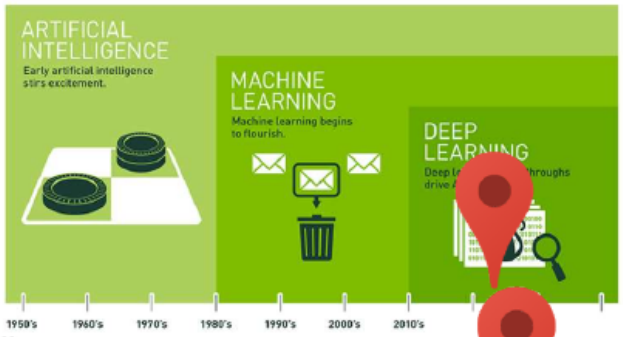
- 1980s-2010
- The rise of Machine Learning
  - More powerful CPUs-> usable implementation of neural networks
  - Big data -> Huge data sets are available
    - document repositories for NLP (e.g. emails)
    - billions on images for image retrieval
    - billions of genomic sequences, …

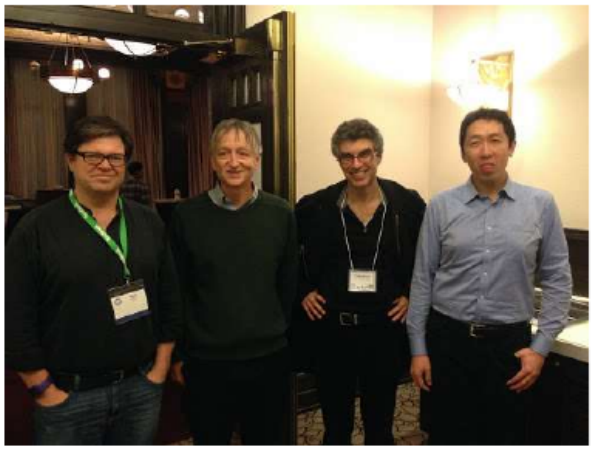
😃 Rules are now learned automatically !

2011: Watson wins at Jeapardy!

History of AI

- 2010-today
- Deep Learning
  - Development of "deep neural networks"
  - Trained on massive data sets
  - Use of GPU for computations
  - Use of "generic networks" for many applications
    - Image recognition
    - Self driving cars
    - Machine translation
    - Speech recognition & synthesis
    - Chatbots
    - Game playing
    - …





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Eliza

- Developed by Joseph Weizenbaum
- In the 1960's
- Simulation of a dialogue with a psychotherapist
- Great success at the time
  - Led at least one psychologist to seriously suggest that computers might help alleviate the shortage of trained psychotherapists (!)
- Weizenbaum later questioned his own work and became one of the field's biggest critics

Eliza is...

- An example of a simple production system
  (see later for a discussion of this type of systems)

- Example dialogs with our new psychotherapist...

Session with Eliza

- I am the psychotherapist. Please, describe your problems. Each time you are finished talking, type RET twice.
- *I am very unhappy these days*
- Are you unhappy often?
- *Always after the new classes start*
- Tell me about your classes.
- *I am registered for artificial intelligence*
- Why do you say you are registered for artificial intelligence?
- *I feel I should understand more about AI*
- Earlier you said you felt unhappy?
- *I am unhappy because of the examinations*
- Are you sure that is the real reason?
- *Not really*
- Maybe the examinations have something to do with this.
- *This could be one of the reasons*
- Is it because of your plans that you say this could be one of the reasons?

How does Eliza work?

- See Weizenbaum's paper at:
  http://www.universelle-automation.de/1966_Boston.pdf

"Input sentences are analyzed on the basis of decomposition rules which are triggered by key words appearing in the input text. Responses are generated by reassembly rules associated with selected decomposition rules."

Algorithm

1. Identify Keywords:
    1. Scan the input sentence to look for words in a dictionary of keywords.
    2. Keywords are given a rank, and the highest ranking keyword is considered first
2. Get Decomposition Patterns
    1. For each keyword, there is an associated list of decomposition patterns
    2. The first decomposition pattern that matches the input sentence is selected.
    3. If the decomposition rule does not match, then the next best ranking keyword is selected (and go back to step 2.1).
3. Apply Reassembly Pattern
    1. For each decomposition rule, there is a set of associated reassembly patterns to generate a response.
    2. If a subsequent sentence selects the same decomposition pattern, the next reassembly pattern is used (so the output is not repetitive)
4. If there is no keywords in the input sentence, then generate a canned response

Example

- If the input sentence is:
  - I am very unhappy these days.
- Eliza's response will be:
  - How long have you been very unhappy these days?

- Keyword:
  - I am
- Decomposition pattern:
  - I am <whatever>
- Reassembly Pattern:
  - How long have you been <whatever>?

A More Complex Example

- Input sentence:
  "It seems that you hate me".

- Keywords: "you" and "me"
- Decomposition pattern:
  - <whatever1> you <whatever2> me
  - It seems that you hate me
- Reassembly pattern
  - What makes you think I hate you?

notice the pronoun
(you from the user --> I for Eliza)

notice the pronoun
(me from the user --> you for Eliza)

Eliza (1966) vs. ChatGPT (2023)

- **User Experience Matters**
  Eliza was able to engage users deeply, even though its "understanding" of conversation was quite shallow. This reveals the importance of the user interface and user experience in the effectiveness of conversational agents.
- **The Illusion of Understanding**
  Eliza showed that it's easy for users to anthropomorphize machines and assume that they "understand" the conversation, even when they don't. This has ethical implications for the deployment of more advanced systems like ChatGPT, particularly in applications like mental health.
- **Ethical Concerns**
  The strong reactions that people had to ELIZA highlighted potential ethical concerns that still exist today. For instance, should chatbots be used for sensitive tasks like therapy? If they are used in such contexts, what safeguards should exist?

Eliza (1966) vs. ChatGPT (2023)

- **Simplicity Can Be Effective**
  Eliza operated using very simple pattern-matching techniques but was surprisingly effective at mimicking certain types of human interaction. This highlights that often a simple model can be very effective for specific tasks and encourages us to think about the balance between model complexity and utility.
- **Interdisciplinary Insights**
  The reactions to ELIZA also brought attention to the importance of insights from psychology, sociology, and other disciplines when designing and evaluating conversational agents.
- **Data Security and Privacy**
  The personal and sometimes sensitive nature of the data that people are willing to share with conversational agents like Eliza raises important questions about data security and privacy.

Today

- Important questions
  1. What is artificial intelligence?
  2. What is intelligence?
  3. Is there a test for intelligence?
- What do we do in AI?
- History of AI
- An example: Eliza