

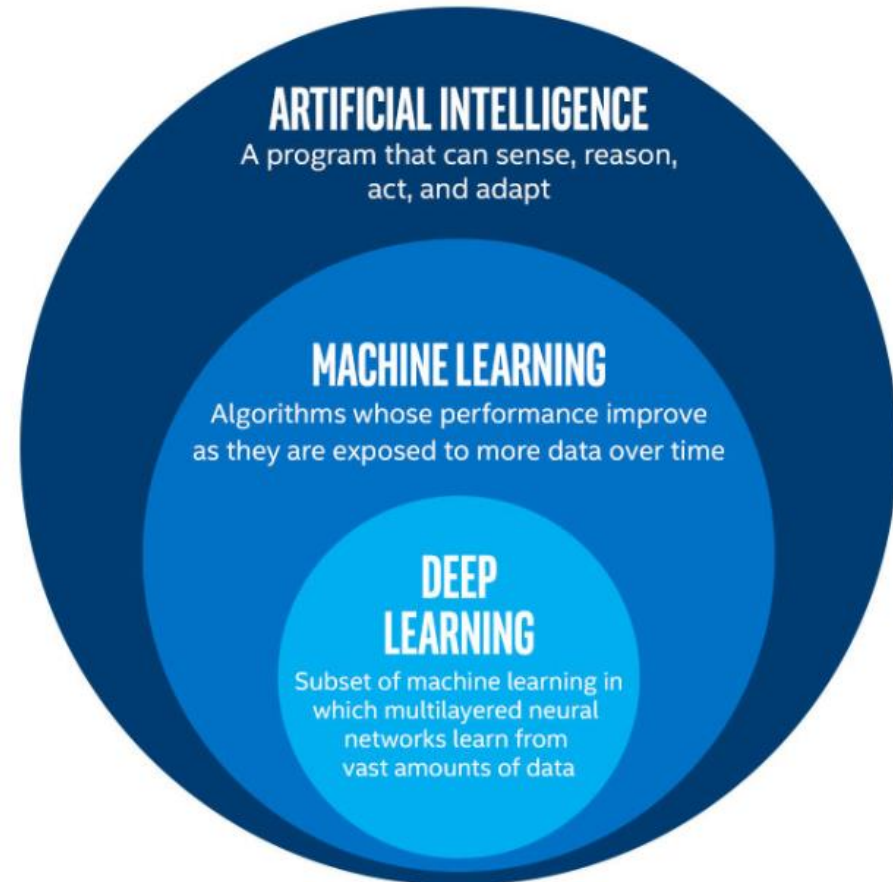
Artificial Intelligence: Introduction

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**



Recent Breakthroughs

- Speech Recognition & Machine Translation (2010+)



■ *Google now*



■ *Google Translate*

Skype to get 'real-time' translator



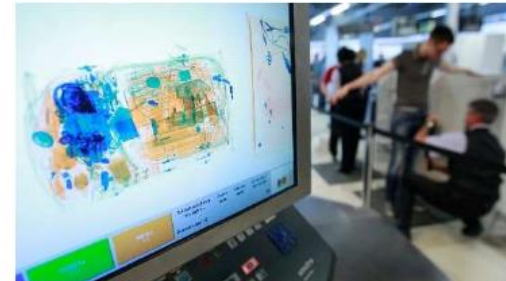
Analysts say the translation feature could have wide ranging applications.

■ *Skype Translator*

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

Recent Breakthroughs

- Speech Recognition & Machine Translation (2010+)
- Image Recognition & Computer Vision (2012+)



■ *Object recognition* ■ *Self driving cars*

■ *Airport Screening*

- Natural Language Processing (2014+)
- ...

Recent Breakthroughs

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- Natural Language Processing (2014+)

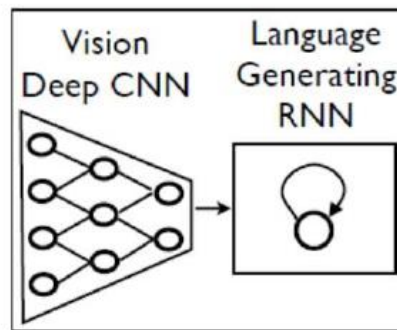
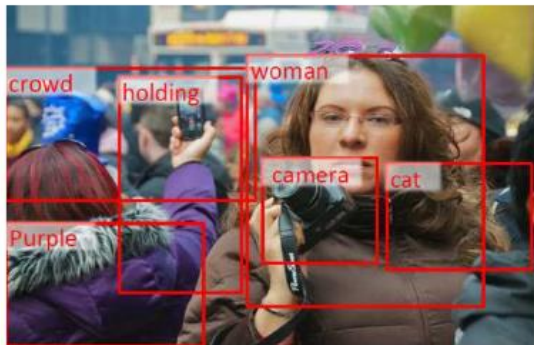
Joe went to the kitchen. Fred went to the kitchen. Joe picked up the milk.
Joe travelled to the office. Joe left the milk. Joe went to the bathroom.

Where is the milk now? A: office

Where is Joe? A: bathroom

Where was Joe before the office? A: kitchen http://blog.csdn.net/qfmu_cjt_wl

■ Question Answering



Machine-generated (but turker preferred)


a bicycle is parked next to a river

Human-annotated (but turker not preferred)

a bike sits parked next to a body of water

■ Image Captioning (deep vision + deep NLP)

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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

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:

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 (Human-Based)	Engineering / Rational approach (Ideal Rationality)
Behavior	act like humans	act intelligently
Reasoning	think like humans	think intelligently

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

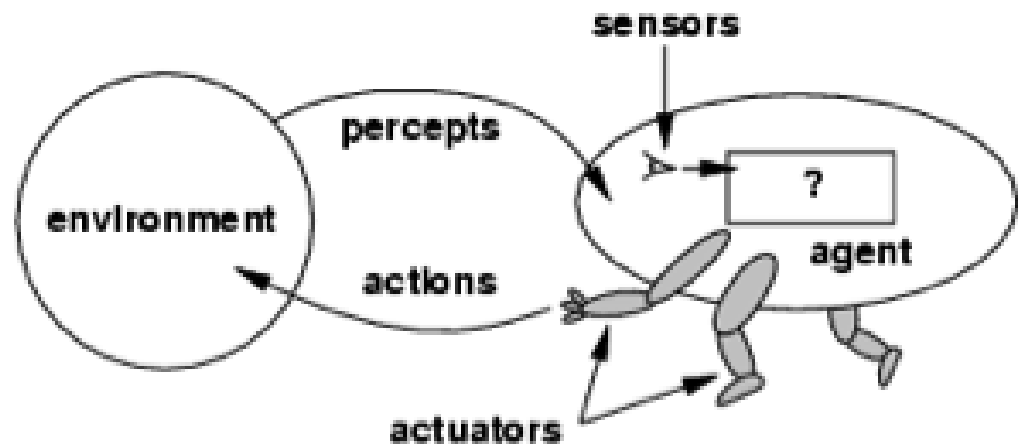
What is Intelligence?

- 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...



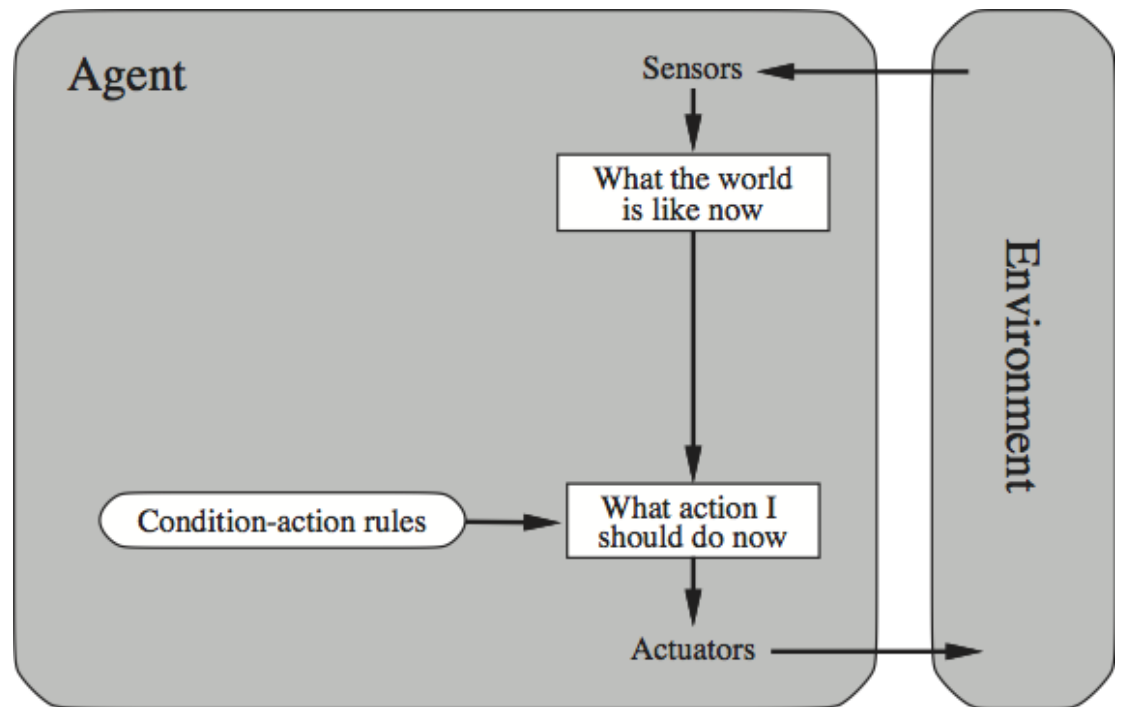
Intelligent Agent Continuum

- Agents receive percepts from environment
- Agent perform actions
- Each agent performs a function to map percept sequences to actions



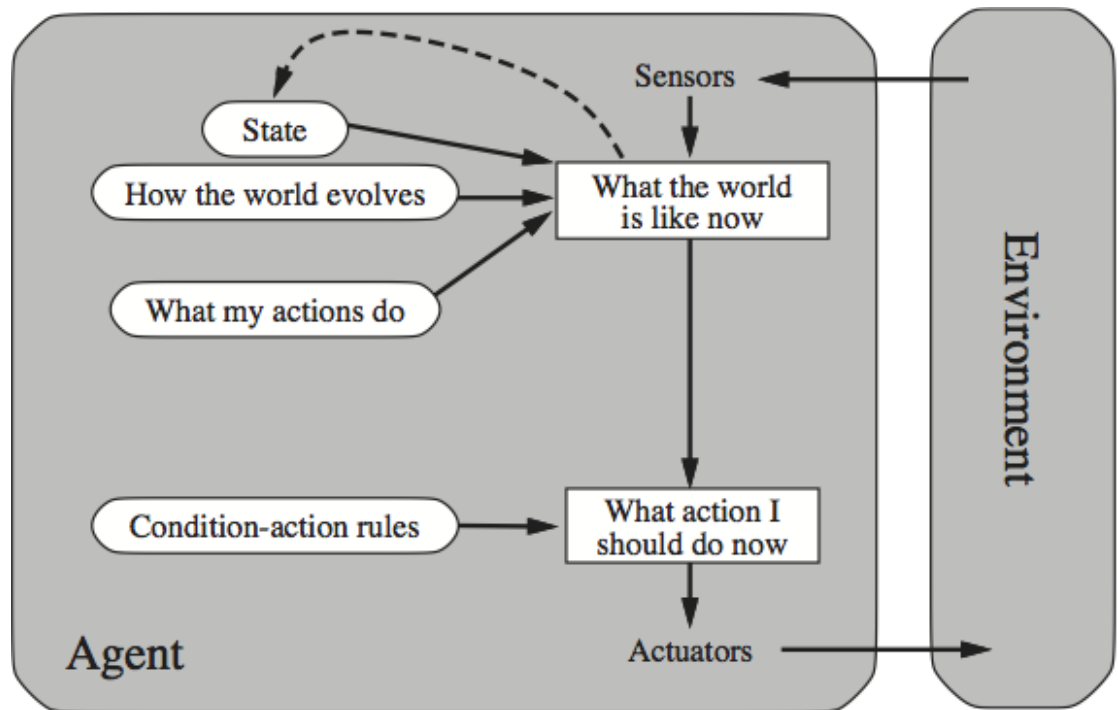
A Simple Reflex Agent

- Also known as representation-free Agent



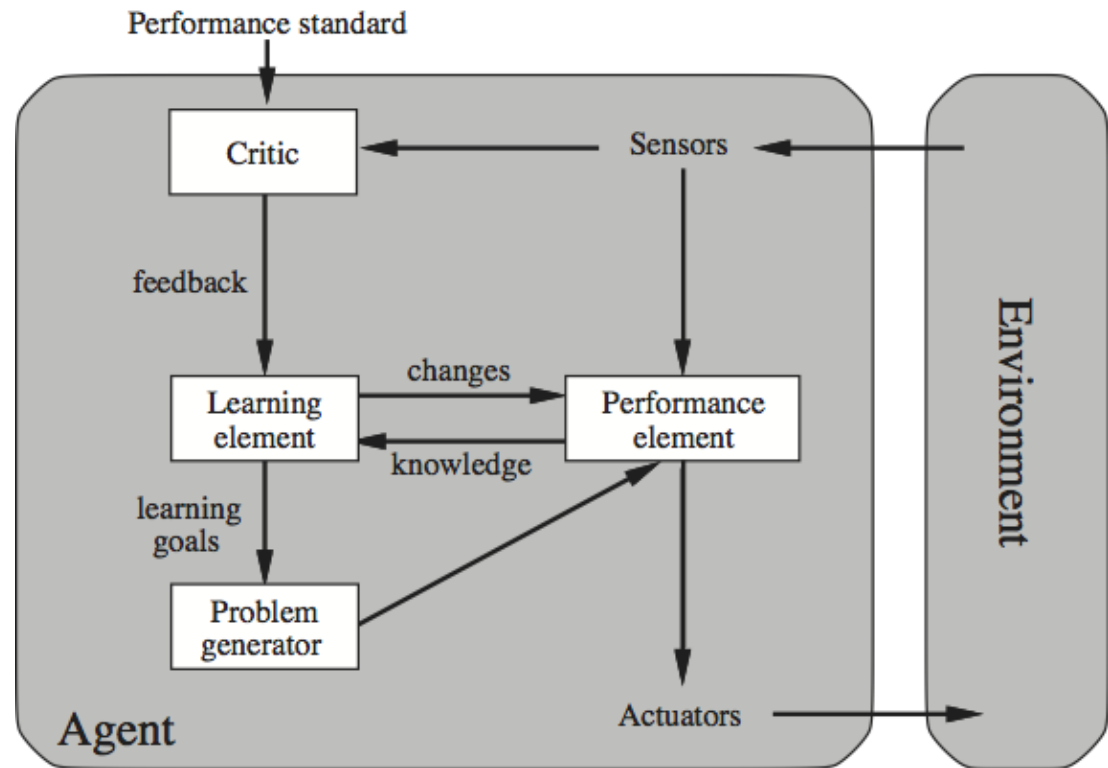
More Sophisticated Reflex Agent

- A bit smarter than a simple-reflex version
- Has the ability to internally model the outside world
- Not at the mercy of what can at the moment be directly sensed



Learning Agent

- Sense the environment
- Criticize (aka compare) with a standard in mind
- Provide feedback to update learning elements
- Etc...



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"



Is AlphaGo Intelligent?

- GO was always considered a much harder game to automate than chess because of its very high 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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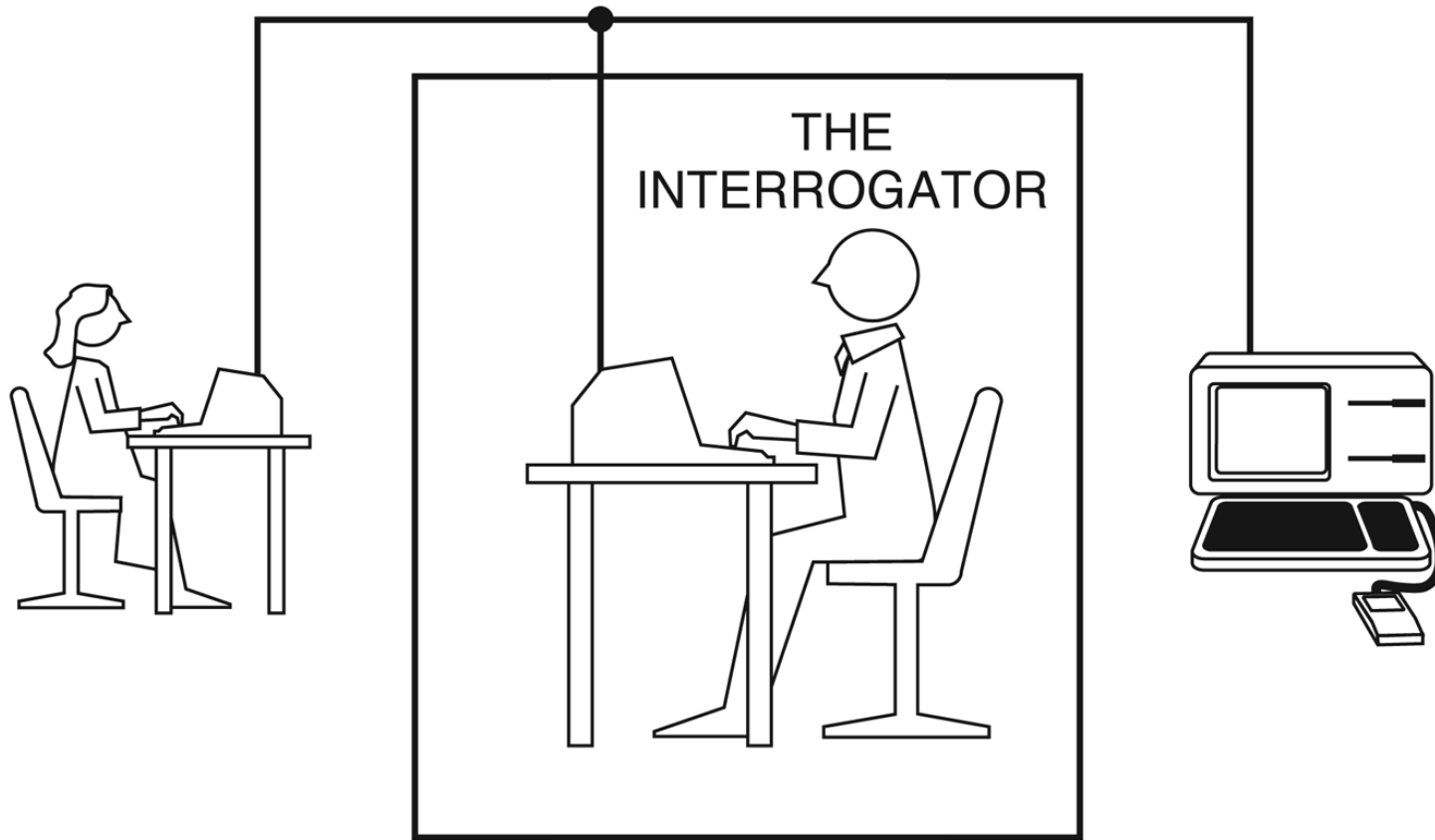
A Test for Intelligence...



■ 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

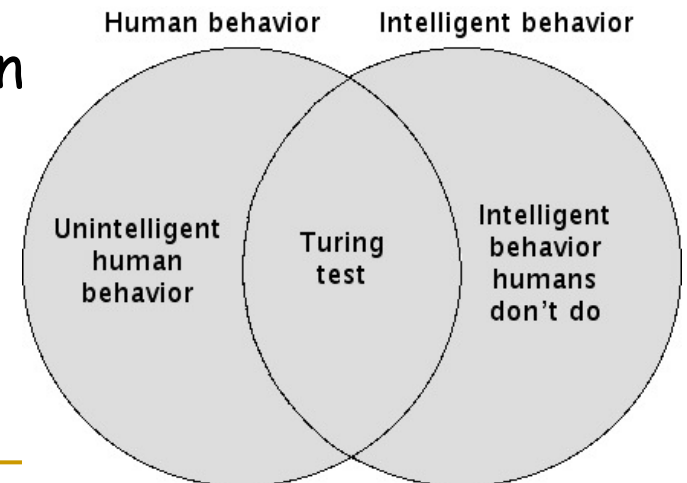
- Some capabilities required to pass the Turing test:
 - Natural Language Processing (NLP) to communicate
 - Knowledge Representation to store knowledge
 - Automated Reasoning to infer new knowledge
 - Machine Learning
 - ...

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 Kapur, founder of Lotus Development, and
 - ❑ Ray Kurzweil, inventor
 - ❑ Kapur 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

Current Turing Tests

following

finding

CAPTCHA:

- ❑ Completely Automated Public Turing test to tell Computers and Humans Apart
- ❑ 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>

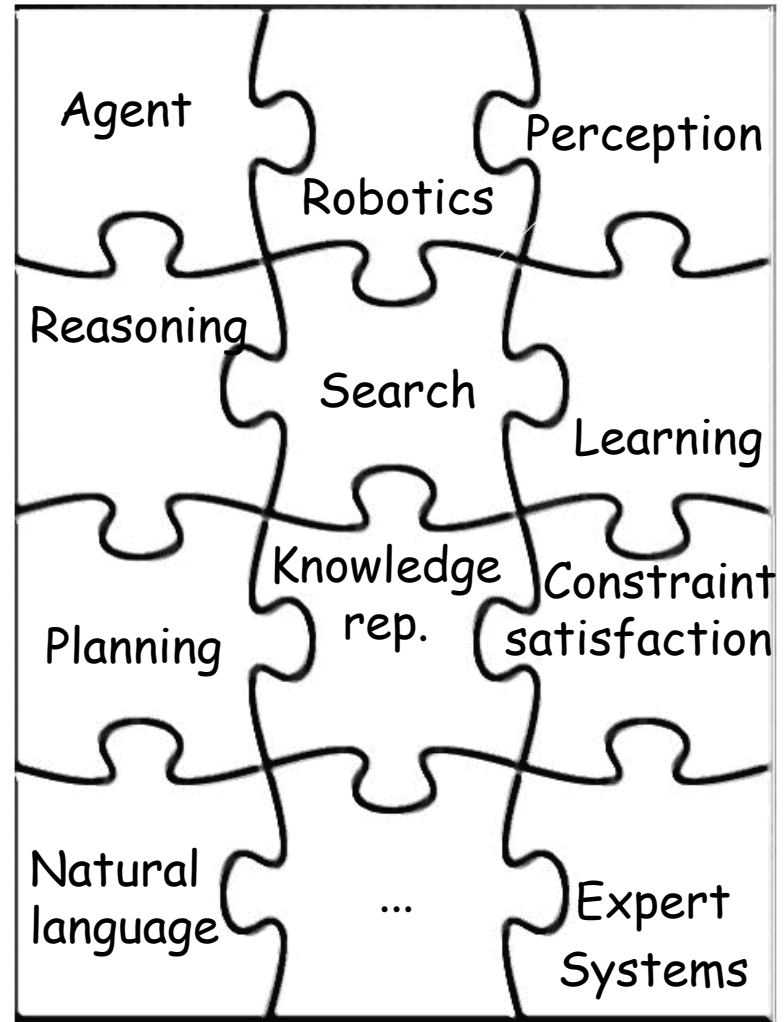
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What do we do in AI?

- 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

Sr Speech Recognition	Si Speech Identification								
Ar Audio Recognition	Ai Audio Identification	Pi Predictive Inference	Pl Planning						
Fr Face Recognition	Fi Face Identification	Ei Explanatory Inference	Ps Problem Solving		Lr Relationship Learning				
Ir Image Recognition	Ii Image Identification	Sy Synthetic Reasoning	Dm Decision Making	Lg Language Generation	Lc Category Learning	MI Mobility Large		Cm Communication	
Gr General Recognition	Gi General Identification	Da Data Analytics	Te Text Extraction	Lu Language Understanding	Lt Knowledge Refinement	Ms Mobility Small	Ma Manipulation	Cn Control	

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

Why Does AI have a Bad Reputation?

■ 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

These Problems are Harder Than we Thought...

- MT has been the target of much [false?] criticism since the 50s
- ex: a common urban legend
 - in the 60s, the Department of Defense fed the phrase:
"the spirit is willing but the flesh is weak"
 - into an English to Russian translator,
 - then fed the result back into a Russian to English system. the result came out:
"the vodka is strong but the meat is rotten".
- MT **is** hard...
 - eg: *les enfants et les femmes enceintes*
 - --> *pregnant children and women*

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
 - ...

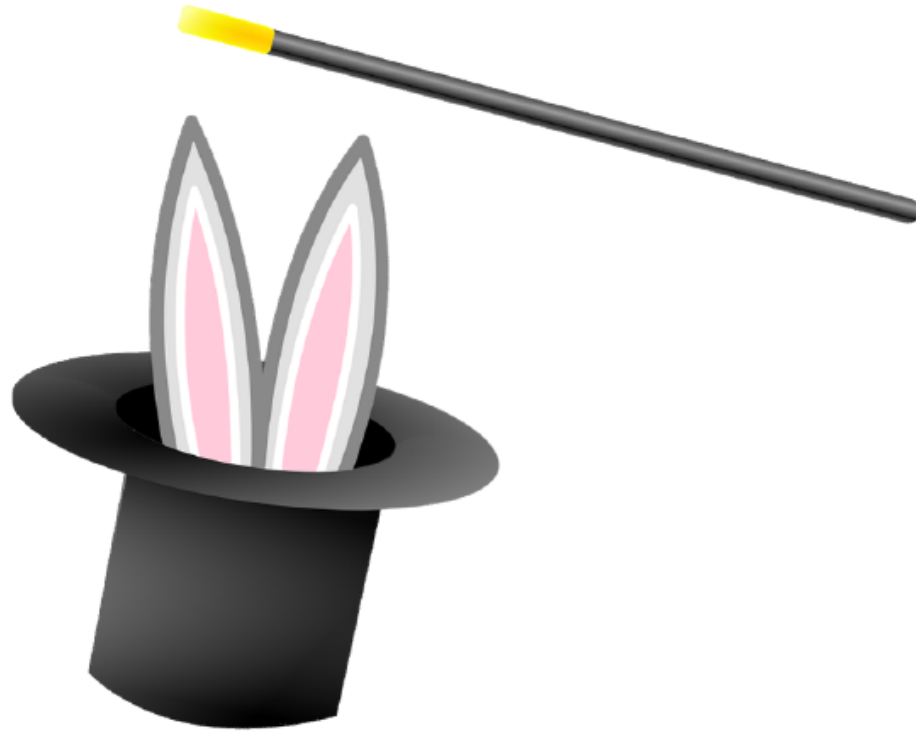
Some Successes of AI...

- A more pragmatic definition of AI today :

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



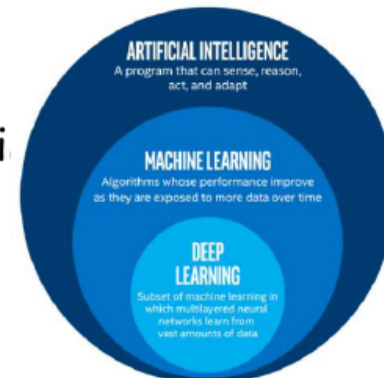
AI is like ...




What do we do in AI?

Topics at Canadian AI conference 2019

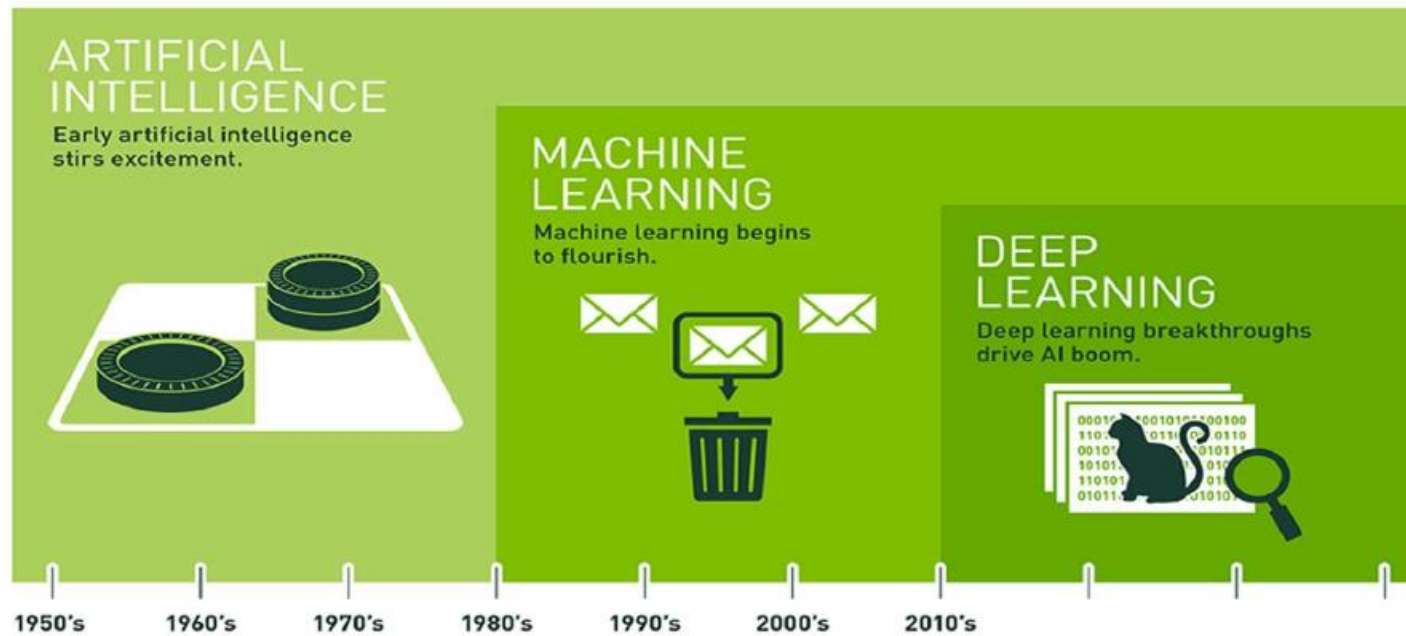
1. Automated Reasoning
2. Bioinformatics and BioNLP
3. Case-based Reasoning
4. Cognitive Models
5. Constraint Satisfaction
6. Data Mining
7. E-Commerce
8. Evolutionary Computation
9. Games
10. Information Retrieval and Search
11. Information and Knowledge Management
13. Knowledge Representation
14. Machine Learning
15. Multimedia Processing
16. Natural Language Processing
17. Neural Nets and Deep Learning
18. Planning
19. Privacy-preserving
20. Robotics
21. Uncertainty
22. User Modeling
23. Web Mining and Applications



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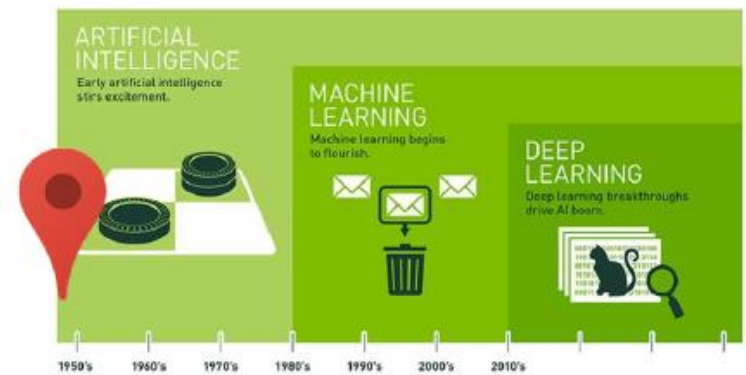
History of AI



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 Dartmouth 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...

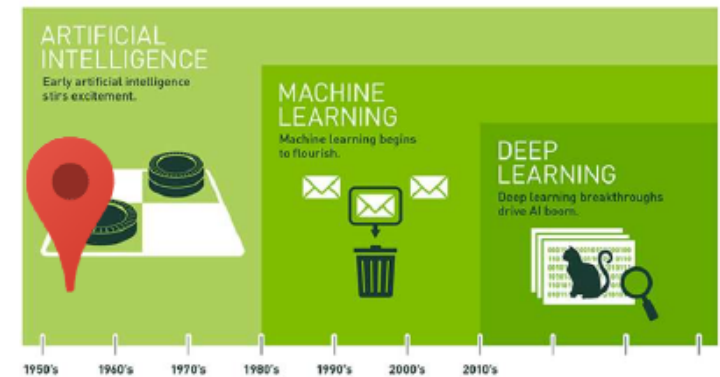
Oliver Selfridge
(Pandemonium theory)

Nathaniel Rochester
(IBM, designed 701)

Trenchard More
(Natural Deduction)

History of AI

- The rise of AI (~1956 - 70s)
 - The era of GOFAI: **Good Old Fashioned AI**
 - Symbolic computation rather than 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: Colmerauer develops Prolog

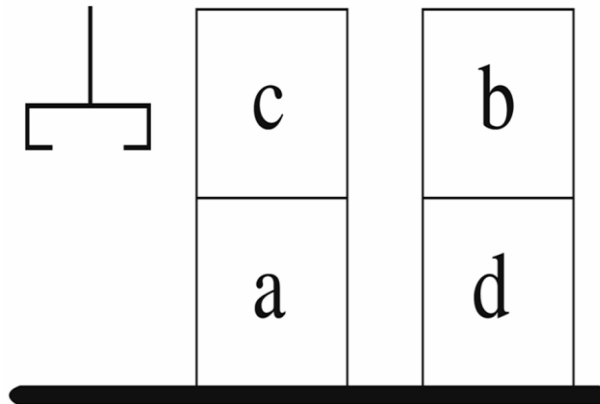


Unrealistic Predictions

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



Why did we need AI Programming Languages?

- GOFAI was characterized by a
 - Symbolic computation rather than numeric computation
 - cold, hot rather than 25.5°C
 - `onTop(red)` rather than `position[1,0,0] = 50cm`
 - Higher level of abstraction
- Lisp
 - Functional language (based on recursive functions)
 - McCarthy in the 1950's
 - Gave rise to SCHEME, ML, ...
- Prolog
 - Logical Language (based on first-order predicate logic)
 - Colmerauer in the 1970's for NL understanding
 - Based on Robinson's resolution method for theorem proving

AI Programming Languages today

- Today:
 - because of the decline in symbolic computations in AI,
 - general-purpose programming languages are typically used: C, C++, Java, ...

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 matter 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...**



History of AI

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

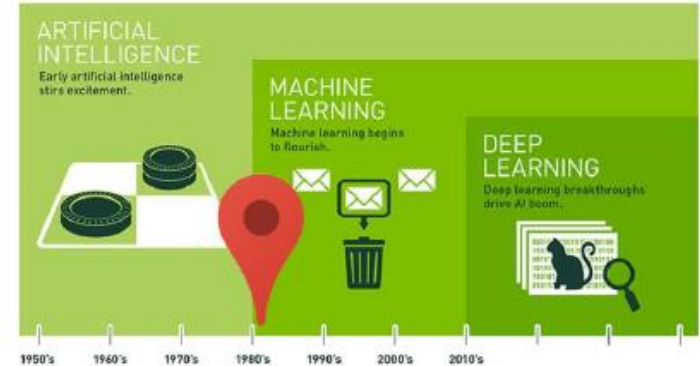
☹️ HUMANS need to write the rules by hand...



1972: MYCIN diagnoses blood infections as well as doctors.

History of AI

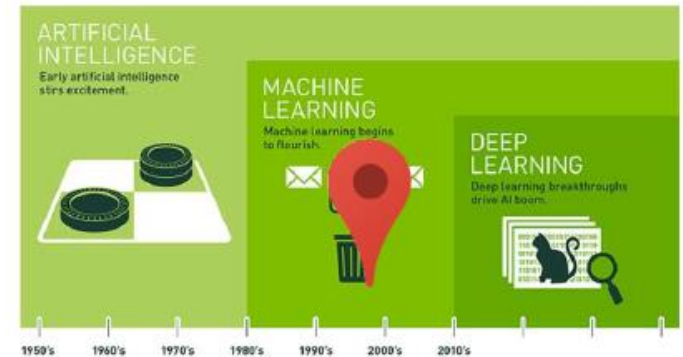
- mid 80s - mid 90s
- Another AI Winter
 - The end of Expert Systems
 - Too tedious to write rules by hand
 - Too expensive to maintain



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, ...

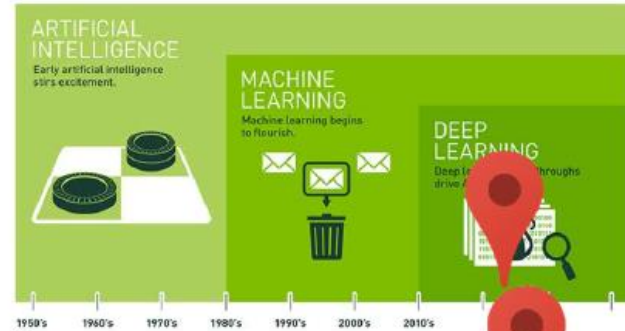
😊 Rules are now learned automatically !



2011: Watson wins at Jeopardy!

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 psychologist
- 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.csee.umbc.edu/courses/331/papers/eliza.html>

"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)

Another Session with Eliza

- I am the psychotherapist. Please, describe your problems. Each time you are finished talking, type RET twice.
- *I think I have a problem*
- Why do you say you think you have a problem?
- *I am teaching COMP472*
- Is it because of your plans that you say you are teaching comp472?
- *Yes, I do not know anything about AI*
- Maybe your life has something to do with this.
- *Yes, teaching is very time consuming*
- What makes you believe **yes teaching** is very time consuming?
- *I think this is a dumb program*
- Is it because of the people you hang around with that you say you think this is a dumb program?

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