Informatica II (Laboratorio)

Corso di laurea magistrale in Scienze pedagogiche

On Artificial Intelligence I

Andrea Bracciali – a.a. 2024/2025

These slides have been developed by the contribution of prof. Giovanni Quattrone

Argomenti trattati

- Problemi, algoritmi programmi
  - Scratch
- AI
  - Chat-gpt
- …

Past, present and future of AI

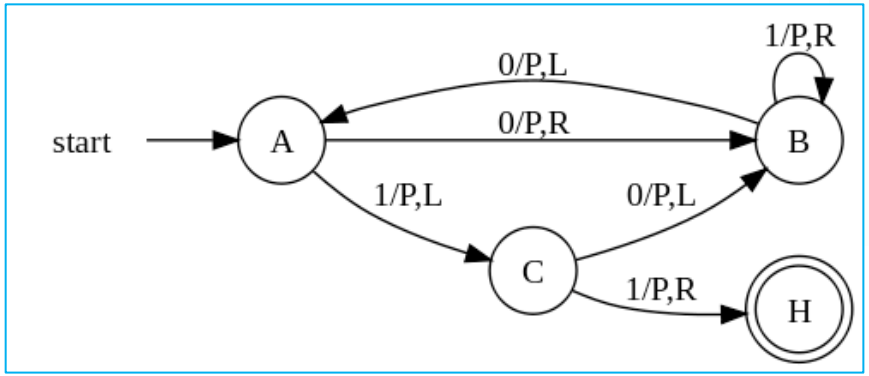
History

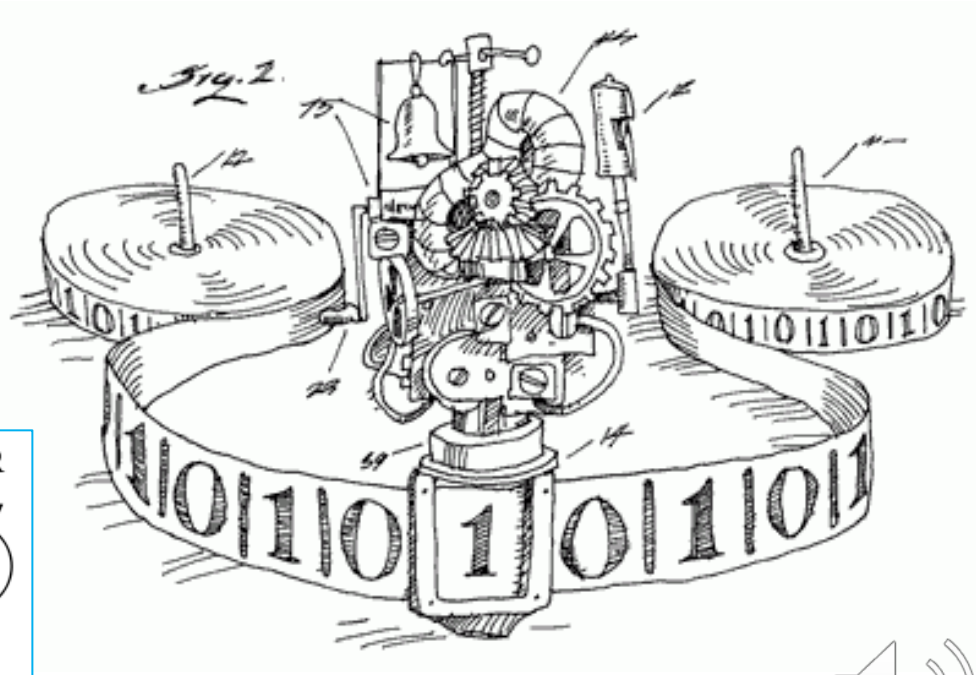
- Thought-capable artificial beings appeared as storytelling devices in antiquity
- The study of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity
  - Studied by ancient Greeks
  - Studied in the modern era by Alan Turing (Church–Turing thesis)

Silver didrachma from Crete depicting *Talos*, an ancient mythical automaton with artificial intelligence (source Wikipedia)

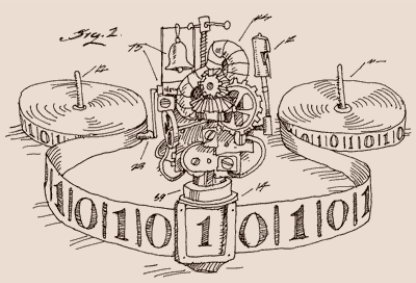
Turing machine

Deterministic rules



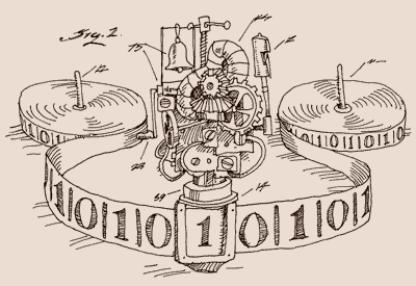


Algorithms to solve every problem

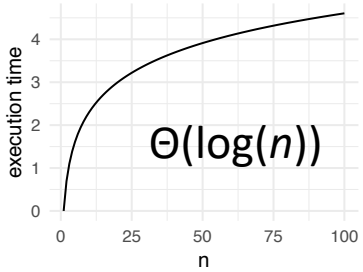


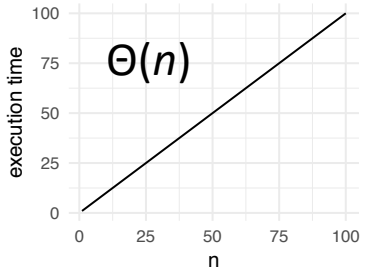
Problems solvable using deterministic Turing machines

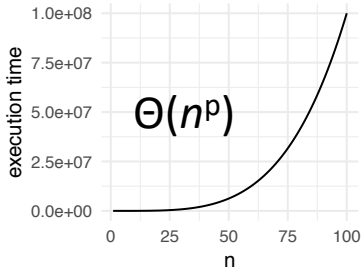
Algorithms to solve every problem

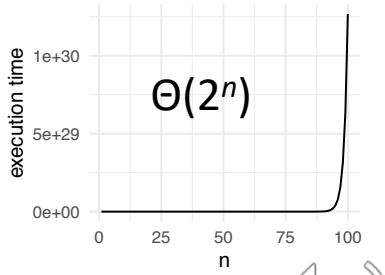


Problems solvable using deterministic Turing machines









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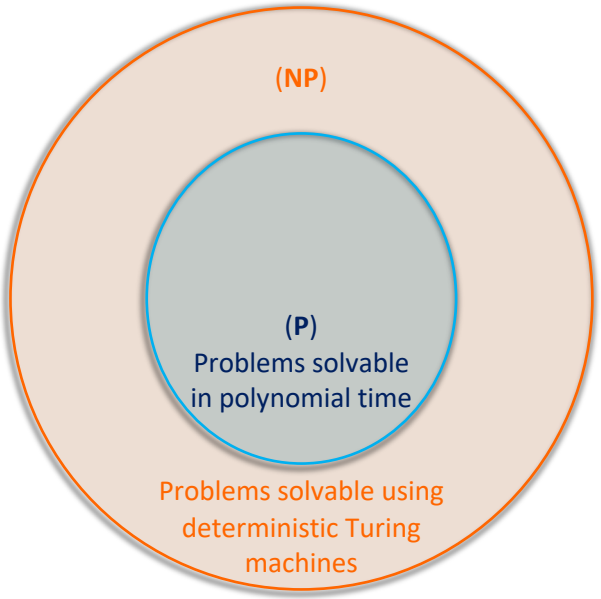
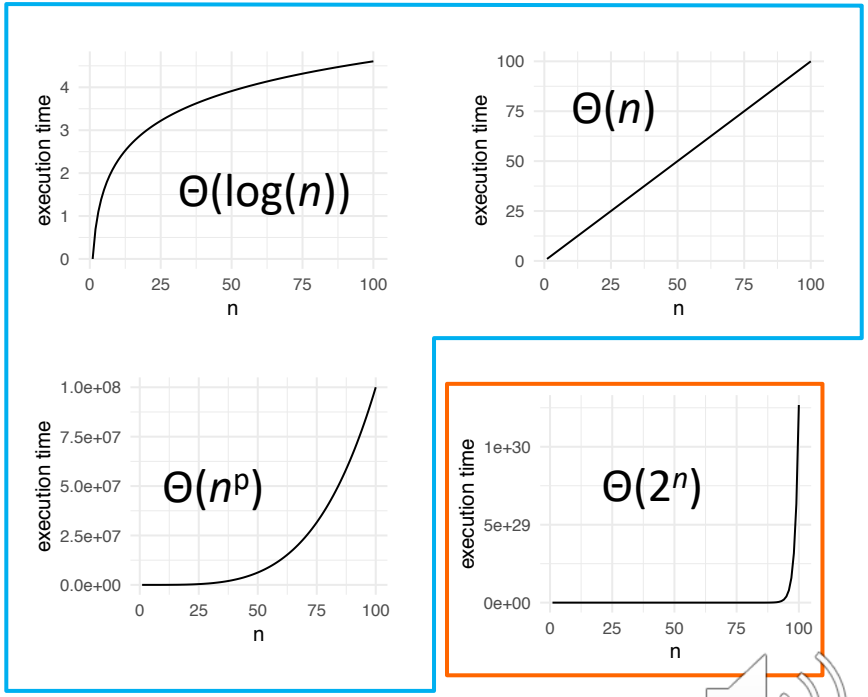


… or N-non deterministic P-olinomial (NP)



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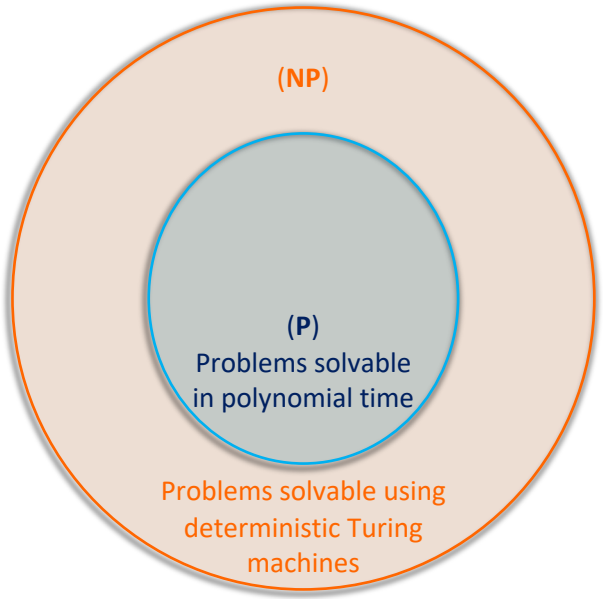

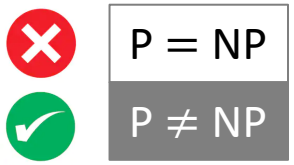

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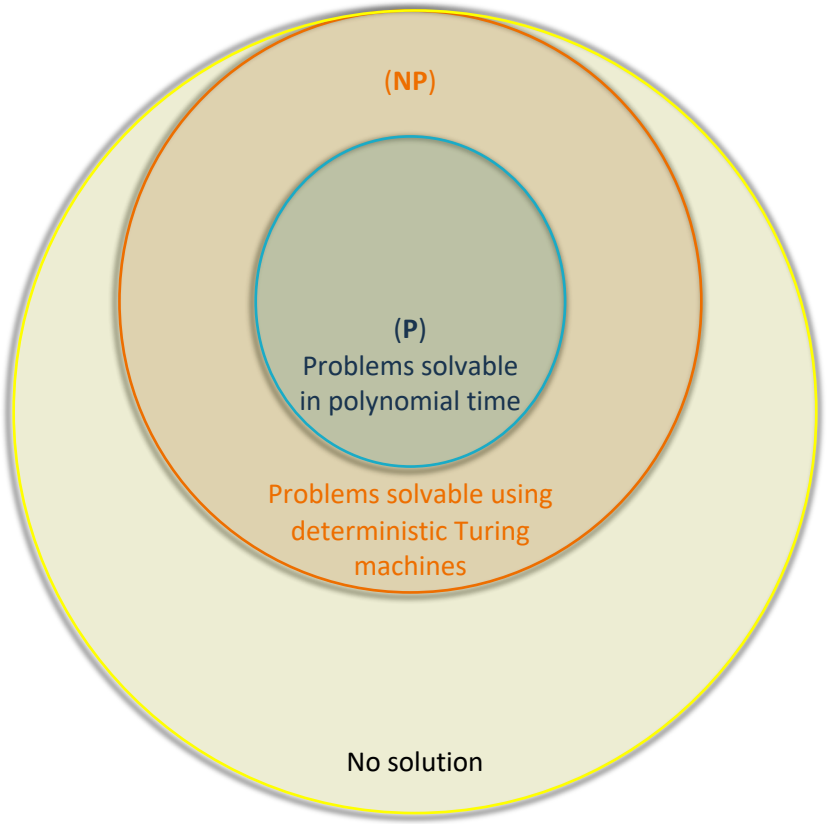
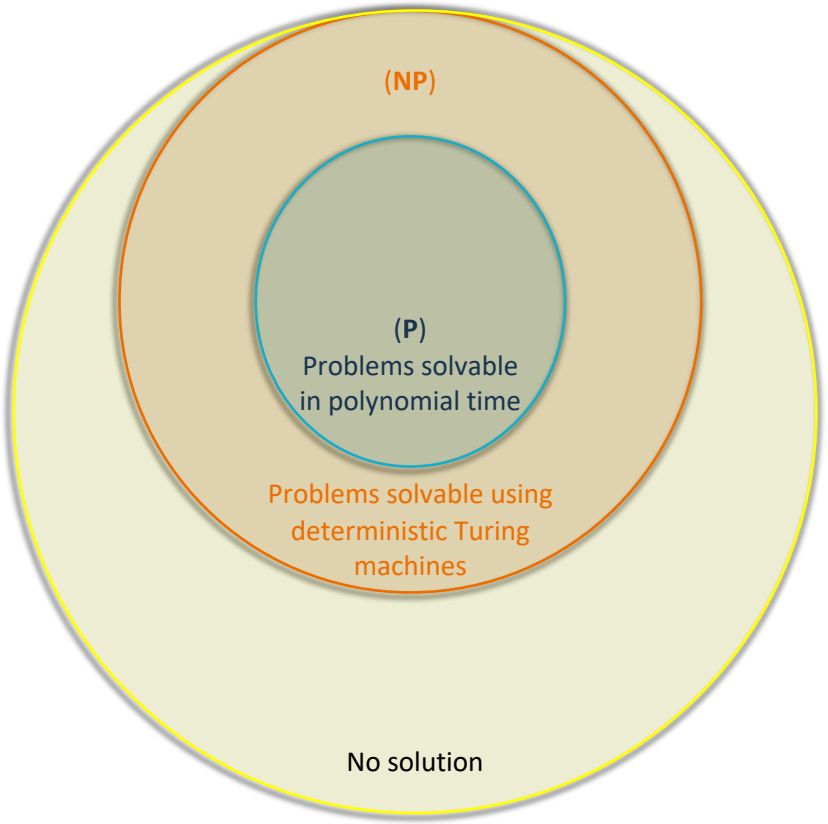


Examples

- (**P**) – *Polynomial time*
  - Find the maximum in an array
  - Find the value of `1+2+3+...+N`
- (**NP**) – *Non-polynomial time*
  - Find the best possible move in a chess match
  - Inverse of hash function
  - Brute force
- *No solution*
  - Prove the correctness of an algorithm
  - Human reasoning

Algorithms to solve every problem



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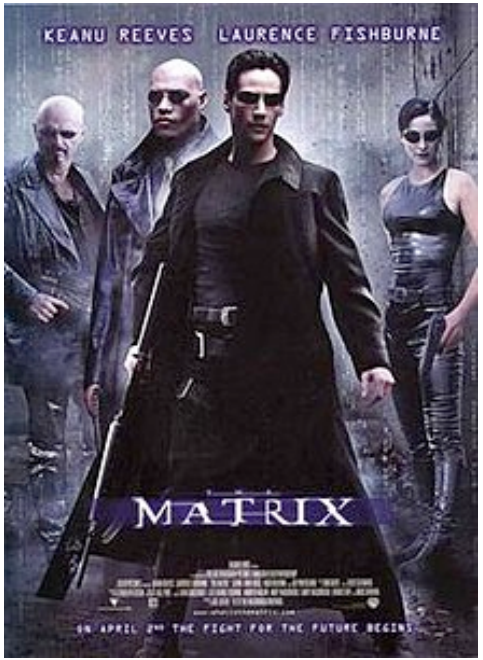
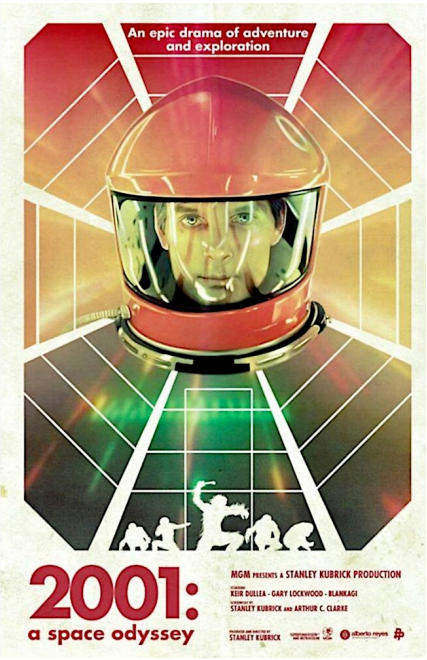
Dream or reality?





Human reasoning

Reason is the capacity of consciously making sense of things, applying logic, and adapting or justifying practices, institutions, and beliefs based on new or existing information.

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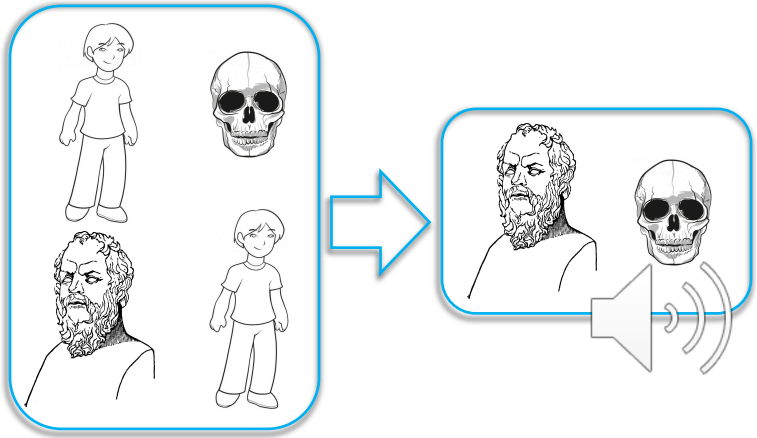
- Scientists classify reasoning in sub-groups:
  - Deductive reasoning



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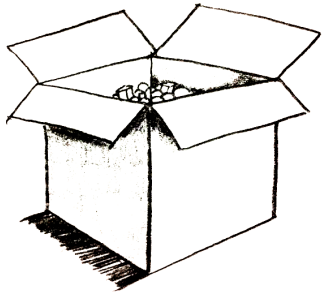

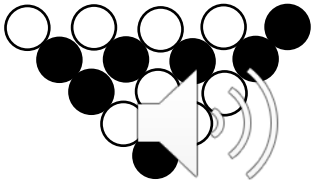

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- Scientists classify reasoning in sub-groups:
  - Deductive reasoning
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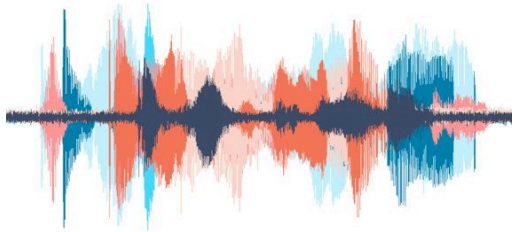
  - Intuition



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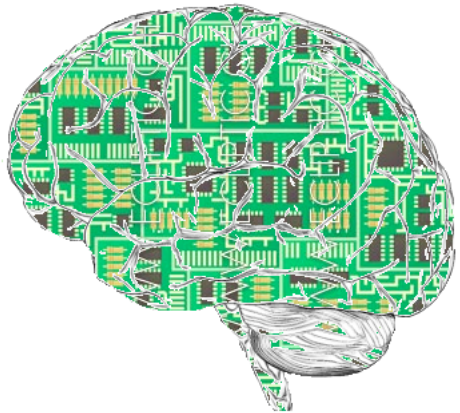
  - Intuition
  - …

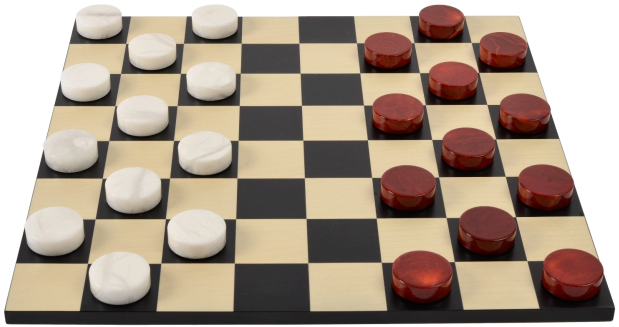
Can we automate reasoning?

- In the 40s researchers considered the possibility of building an electronic brain.
- Turing proposed changing the question from whether a machine was *intelligent*, to "whether or not it is possible for machinery to show *intelligent behaviour*".



History of AI

- AI *(Artificial Intelligence)* term coined in 1956, by John McCarth.
- 1959...
  - Astonishing results... computer can play checkers better than humans.

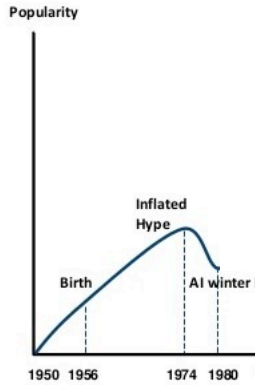


"machines will be capable, within twenty years, of doing any work a man can do"

"within a generation ... the problem of creating 'artificial intelligence' will substantially be solved"

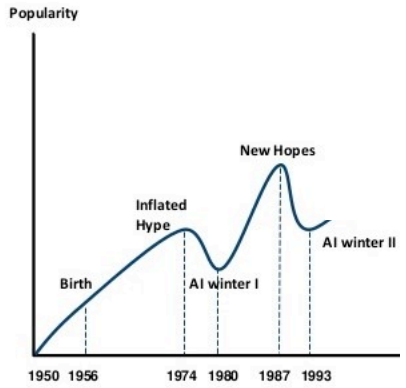
History of AI

- They failed to recognize the difficulty of some of the remaining tasks.
- AI winter



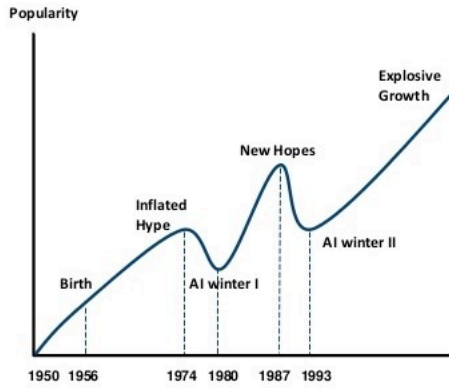
History of AI

- New hopes... followed by a new winter



History of AI

After 1993: explosive growth of AI

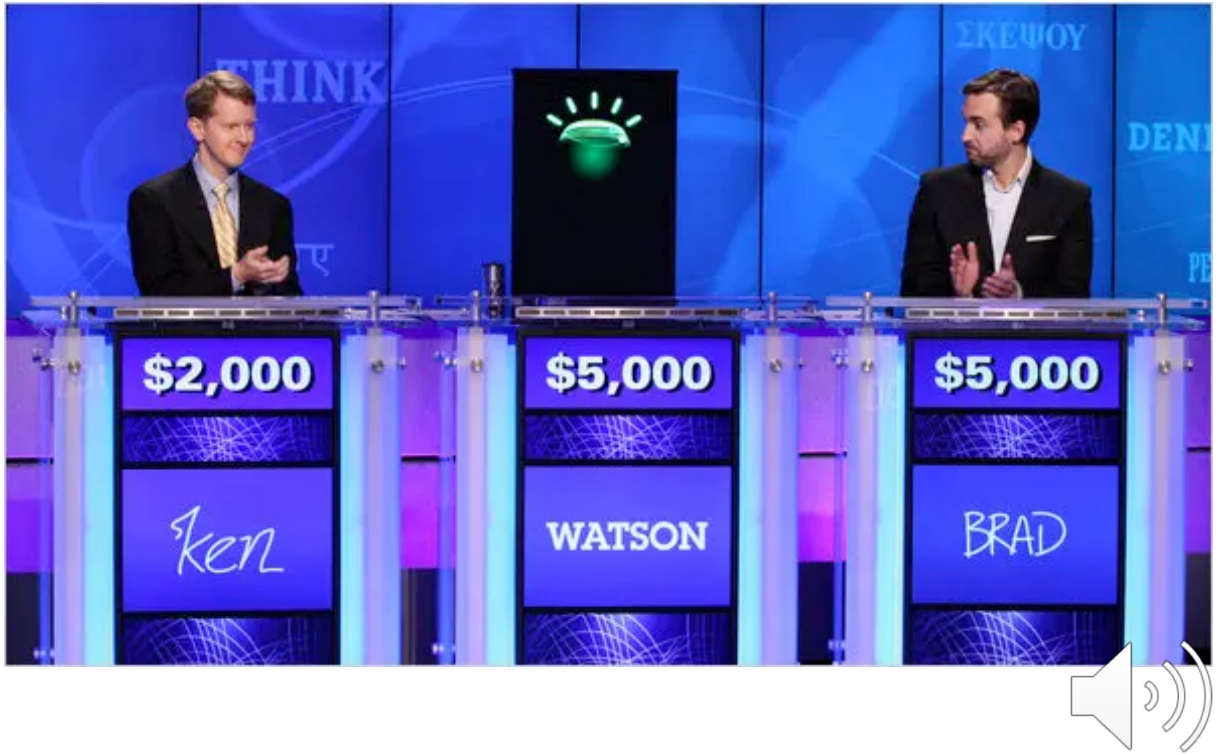


History of AI

1997: The chess-playing computer developed by IBM, *Deep Blue*, defeated Garry Kasparov.

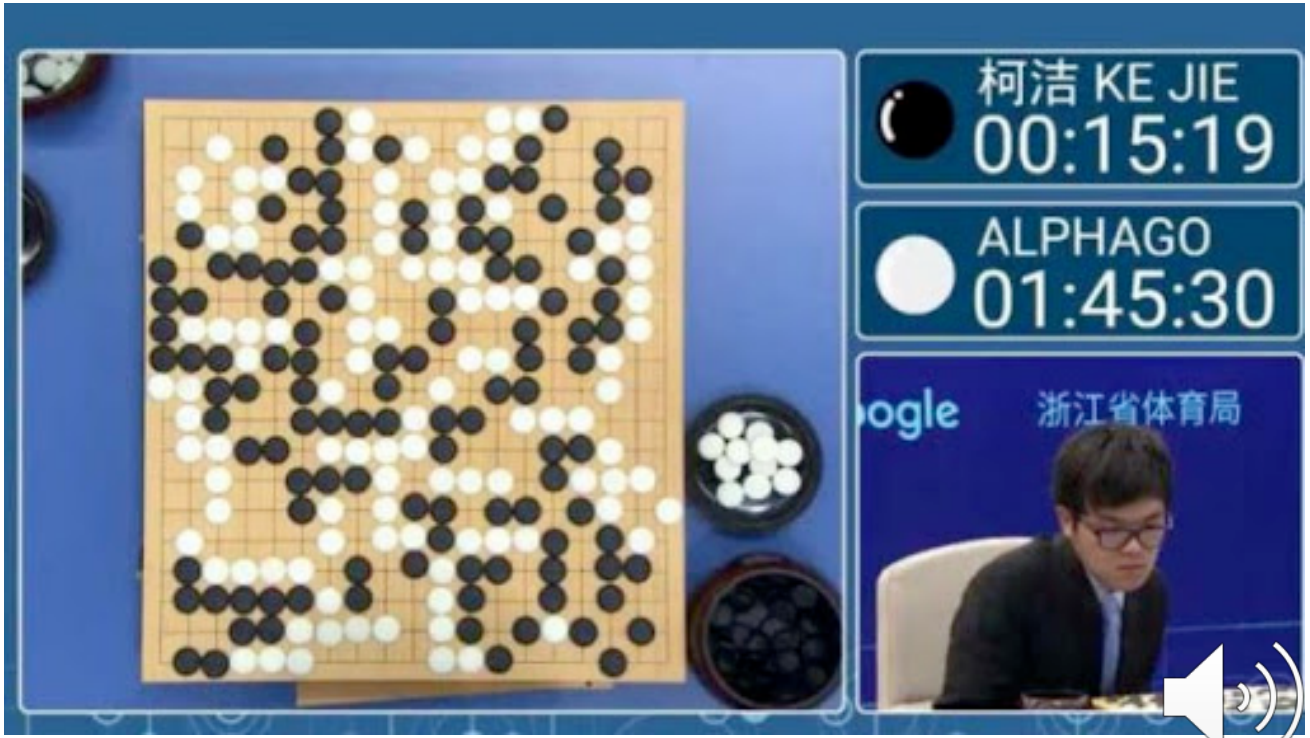
History of AI

2011: IBM's question answering system, *Watson*, defeated the two greatest Jeopardy! champions Brad Rutter and Ken Jennings, by a significant margin.



History of AI

2016: *AlphaGo* won 4 out of 5 games of Go in a match with Go champion Lee Sedol.



Homework: watch https://www.youtube.com/watch?v=WXuK6gekU1Y (it may appear in the exam!)

Go game

Two players, two kind of stones... black and white.

The stones need to be placed into a 19×19 board.

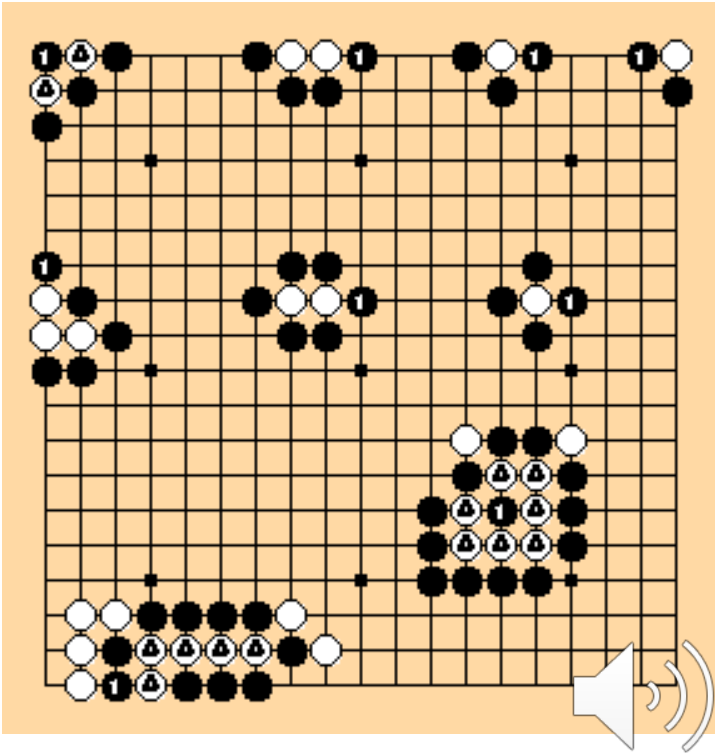
Go game

Purpose of the game... surround the opponent to capture its stones.

Go is a game of astonishing simplicity and beauty...

...and it's practically impossible to compute all the legal moves.

More than 2×10^{170} legal moves
(more than atoms in the observable universe)

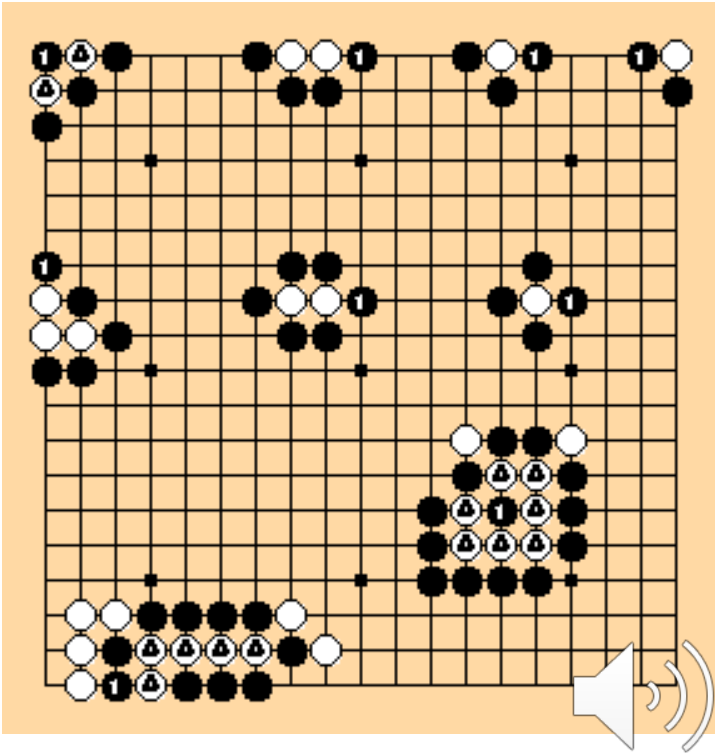


Go game

Computation power does not help!

Go game rewards *intuition* and *creativity*.

Prior to AlphaGo, researchers had claimed that computers would never defeat top humans at Go.

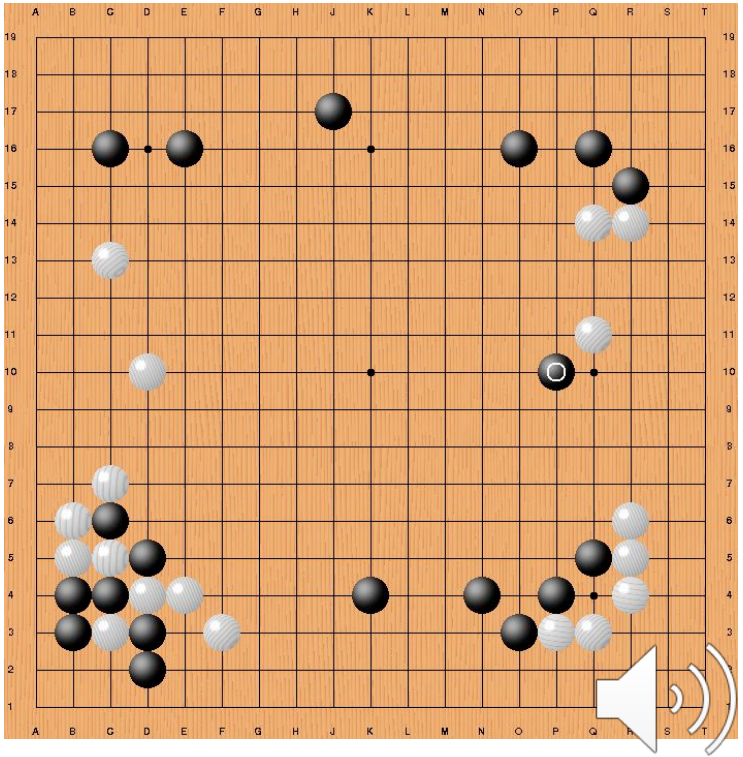


Move 37, or how AI can change the world

"*Move 37*" was unimaginable in the more than three thousand year history of the game.

By taking position on the "fifth line" AlphaGo pushed the boundaries of *human intuition*.

Can AI have intuition?
Can AI be creative?

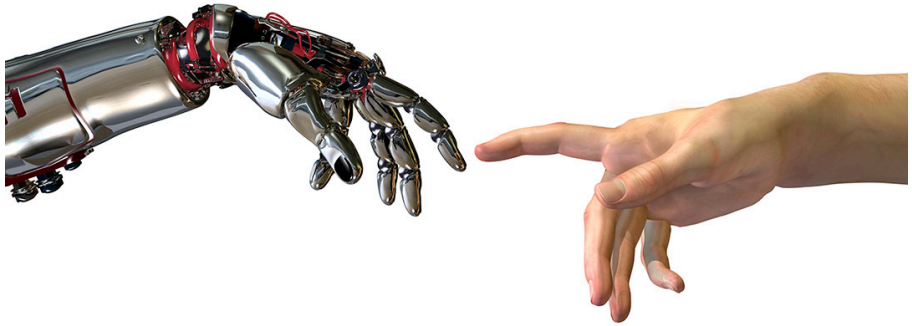


AI today

Future of AI

Artificial Intelligence

Good or bad?

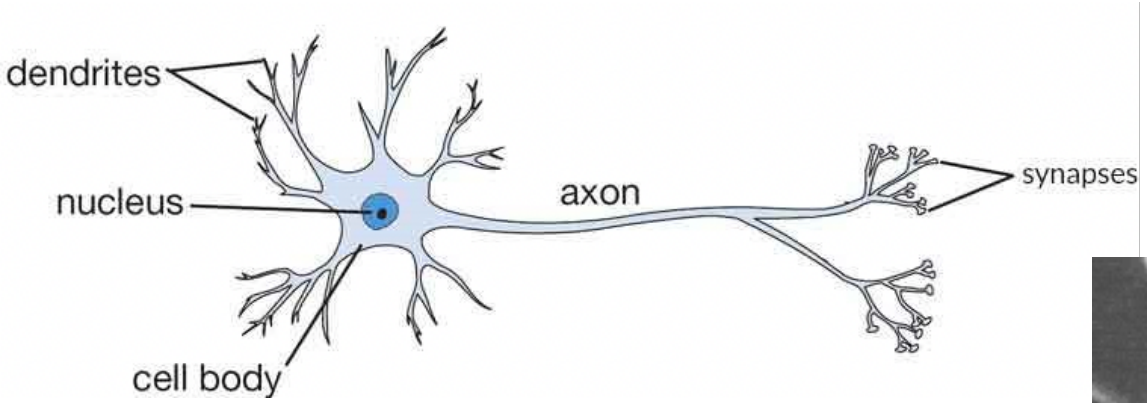


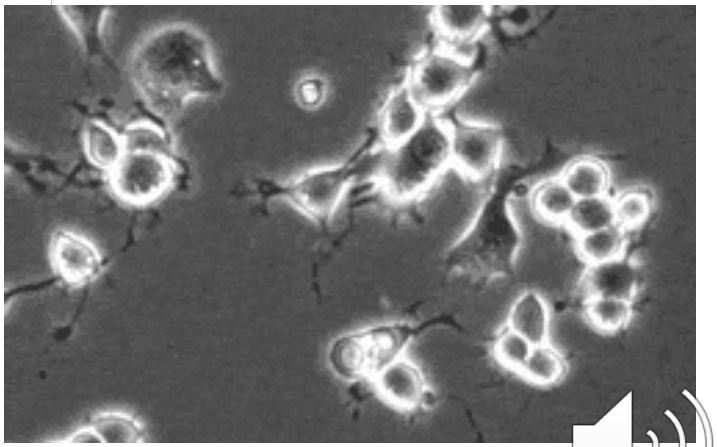
Biological Inspiration

- Perceptron

- Neuron

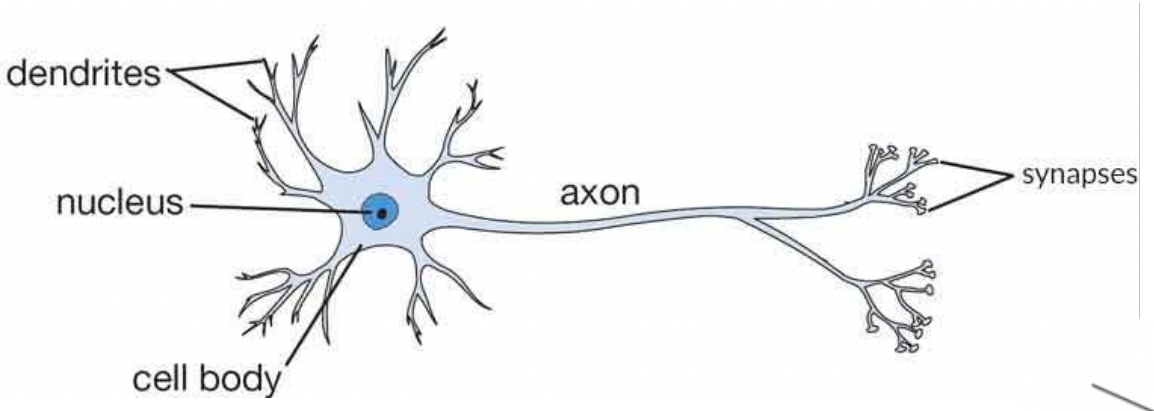
Biological Inspiration

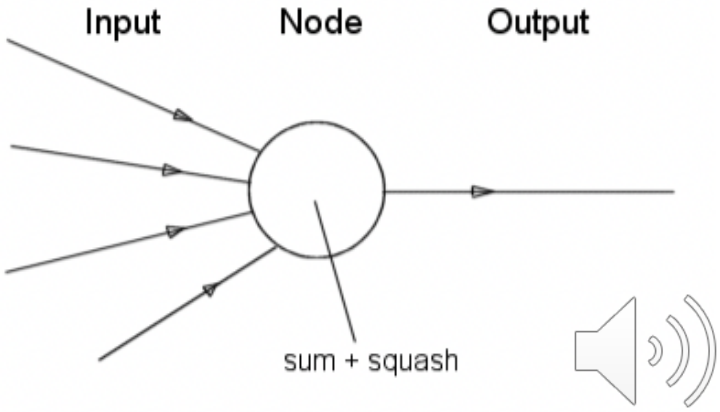




Neurons growing in culture (timelapse). University of Victoria

Biological Inspiration





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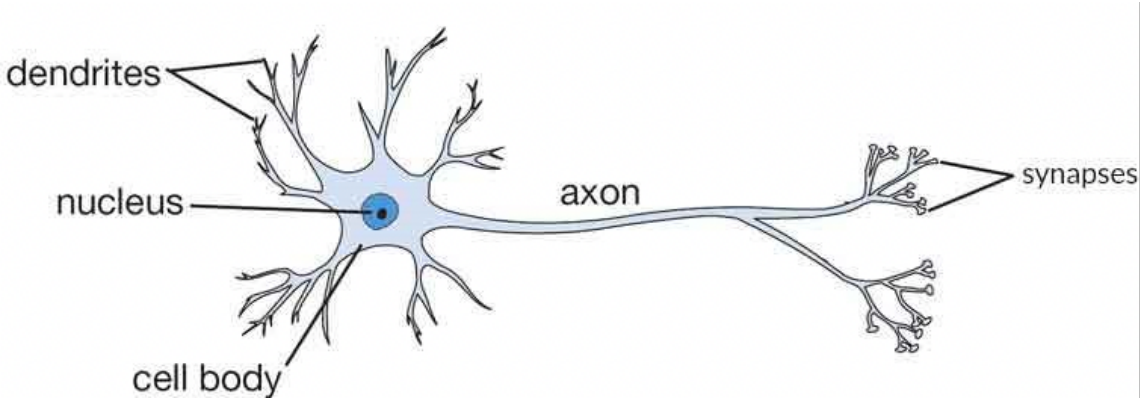
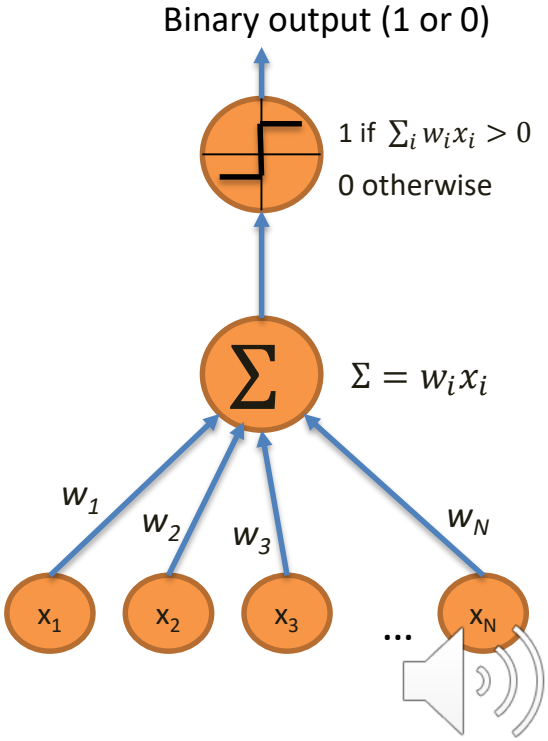
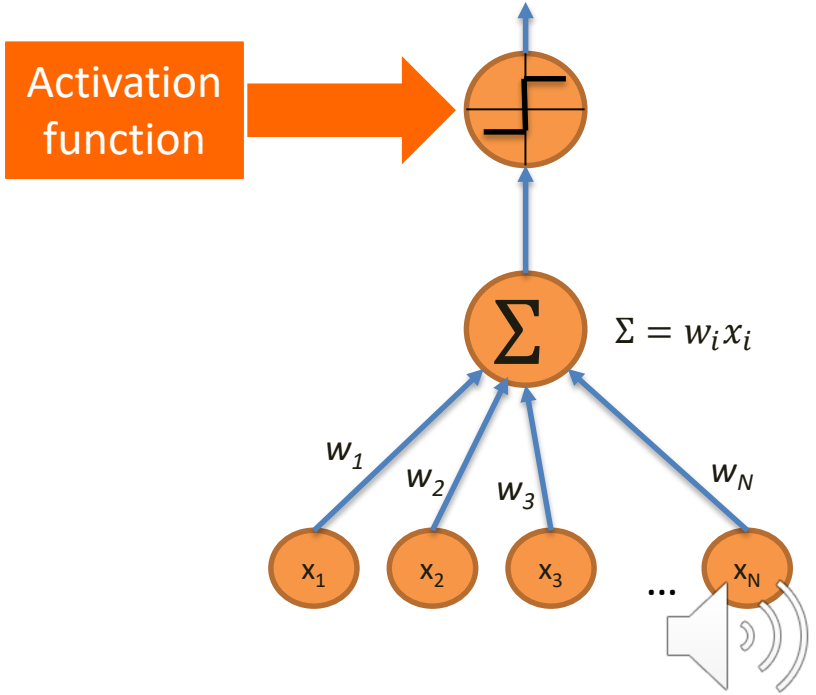




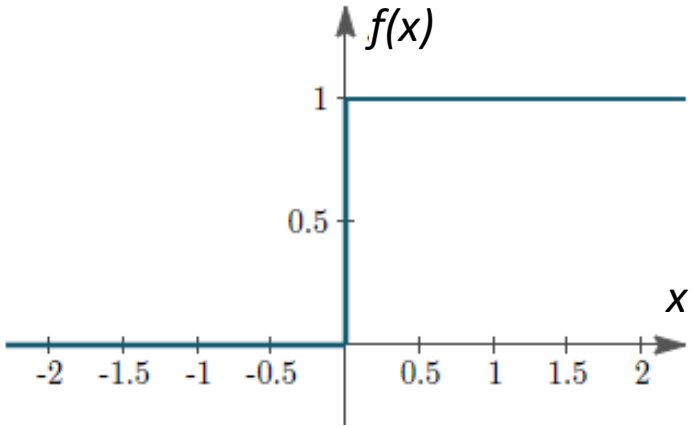
Neuron

- From Perceptron to Neuron
  - *Perceptron*: binary function as activation function
  - *Neuron*: other activation functions

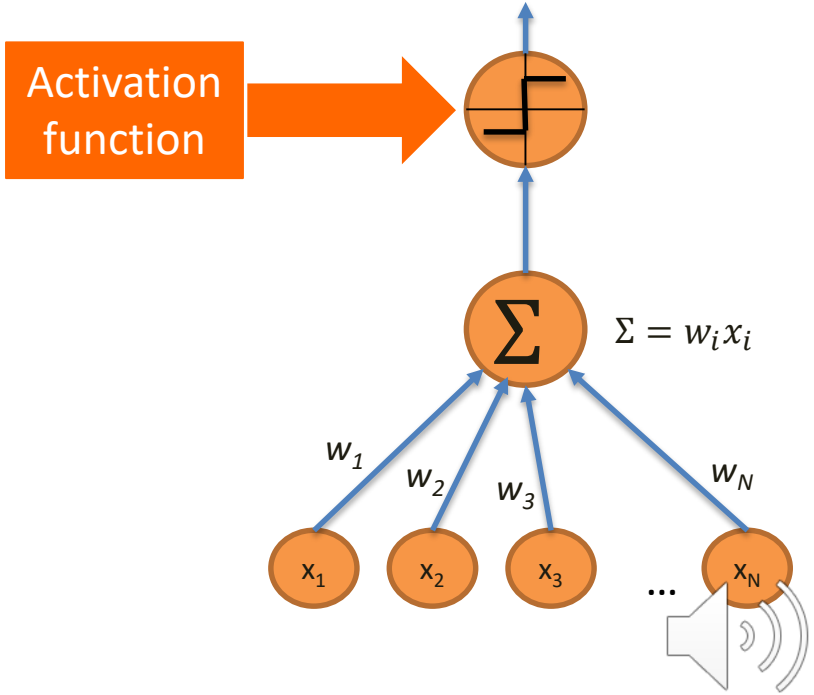


Perceptron

Binary function

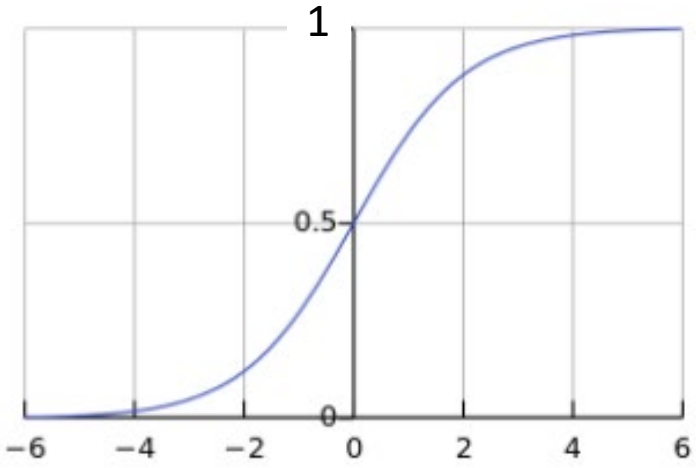


$$f(\mathbf{x}) = \begin{cases} 1 & \sum w_i\, x_i + b \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

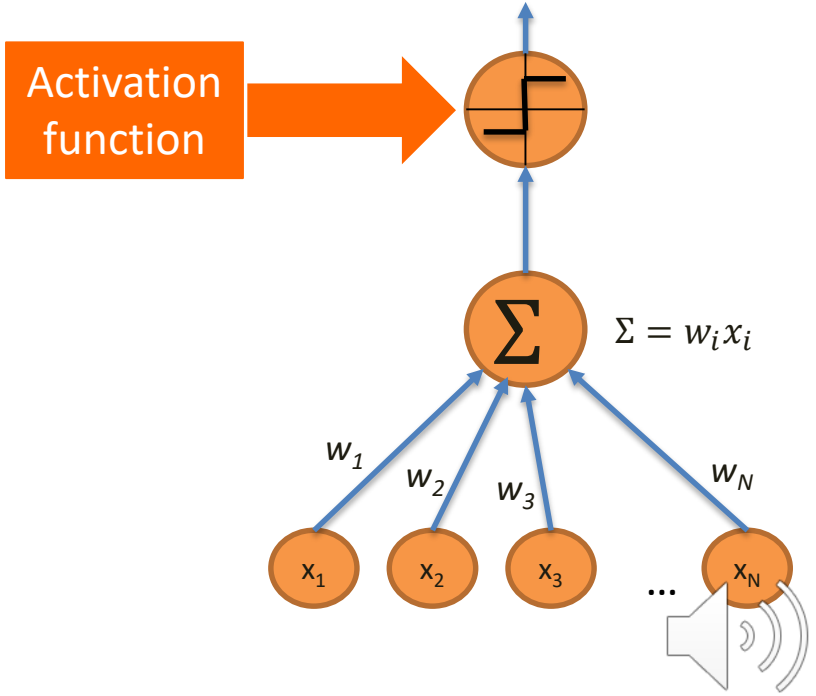


Neuron

Sigmoid function



$$f(x) = \frac{1}{1 + e^{-x}}$$

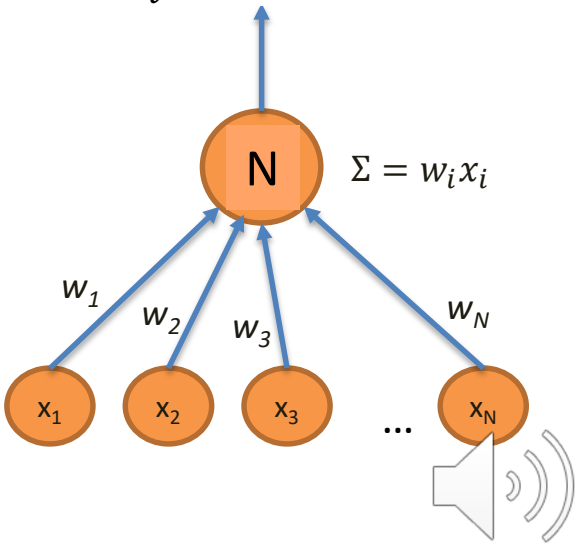


From Neurons to Artificial Neural Networks

From Neurons to Artificial Neural Networks

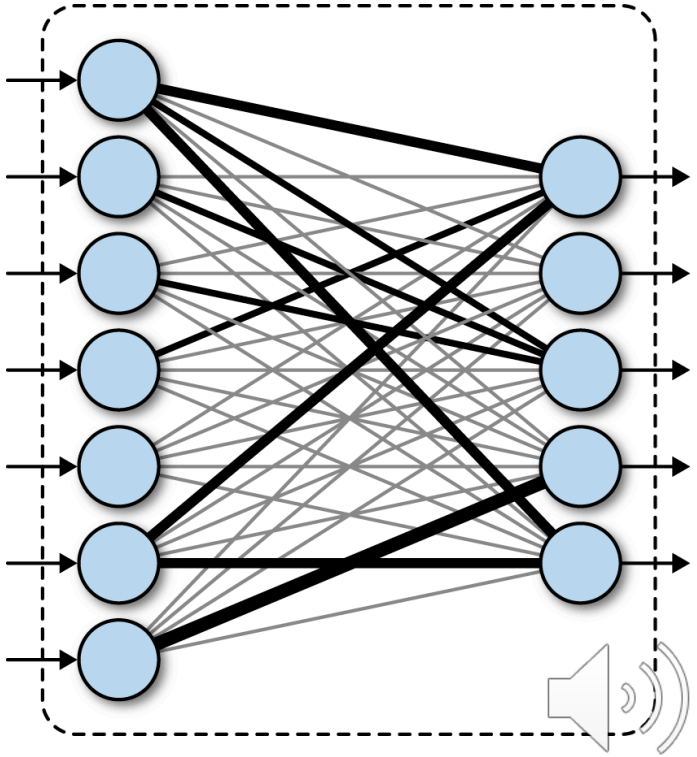
- Neuron
  - Very simple operating principles

$$\sigma\left(\sum_i w_i x_i + bias\right)$$



From Neurons to Artificial Neural Networks

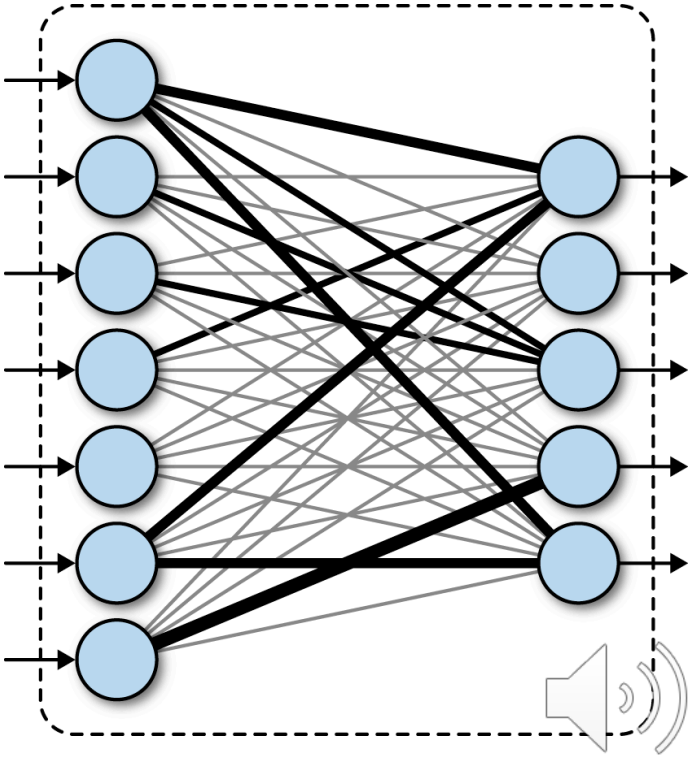
- Neuron
  - Very simple operating principles
- Artificial Neural Network
  - Many interconnected Neurons
  - Each single neuron operates on simple principles, but the network as a whole exhibiting complex behaviours



Artificial Neural Networks

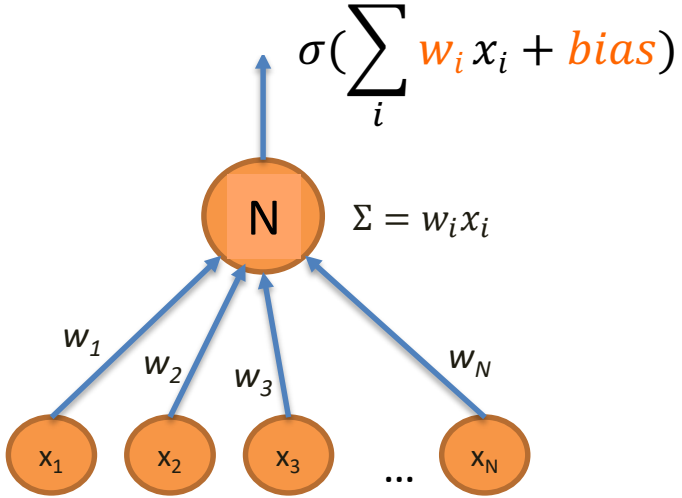
Interconnected neurons to simulate the interconnections of biological neurons

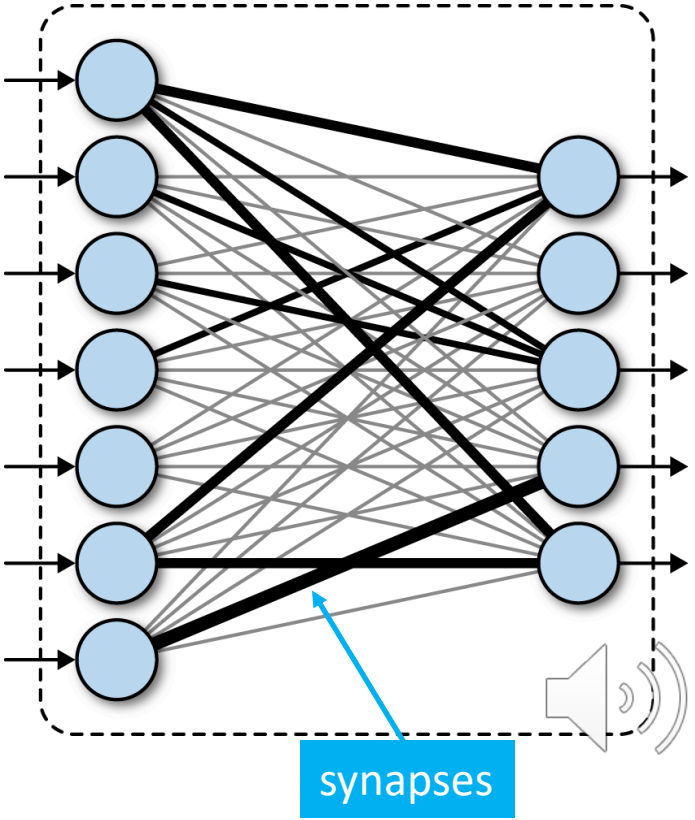
- Learning occurs in the brain primarily through the formations and *changes of synapses* linking neurons together (Donald Hebb, 1949)
  - i.e., if two neurons are active (fire) at the same time, their synaptic connection becomes stronger



Artificial Neural Networks

In the context of Artificial Neural Networks, learning means adjusting the weights and biases of all neurons.

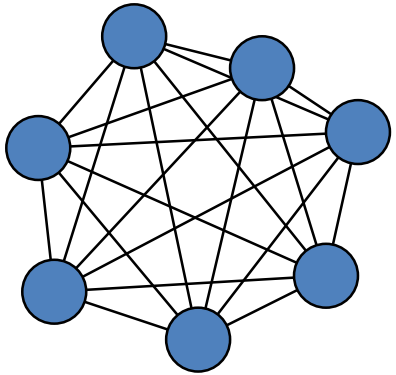




Topology of Artificial Neural Networks

Topology of Artificial Neural Networks

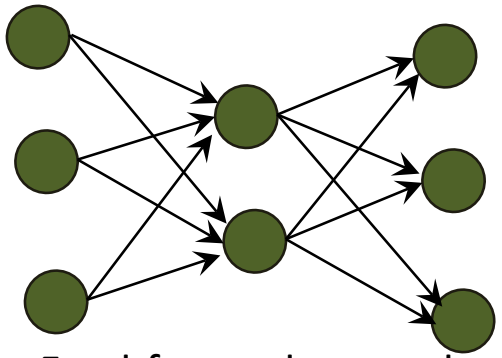
- Fully-connected



Fully connected

Topology of Artificial Neural Networks

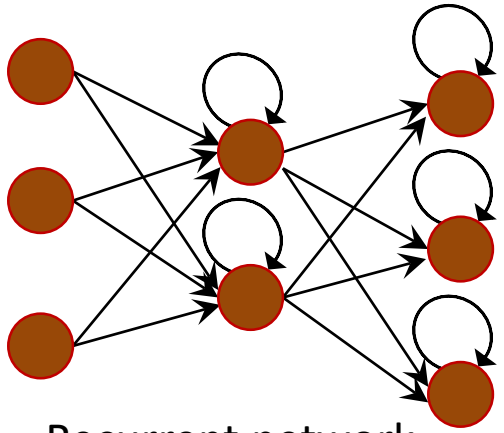
- Fully-connected
- Feed-forward networks



Feed-forward network

Topology of Artificial Neural Networks

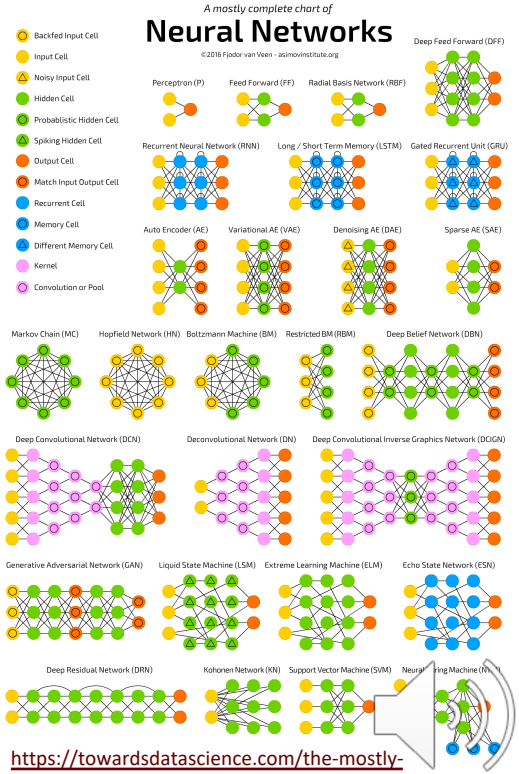
- Fully-connected
- Feed-forward networks
- Recurrent networks



Recurrent network

Topology of Artificial Neural Networks

- Fully-connected
- Feed-forward networks
- Recurrent networks
- Many others…

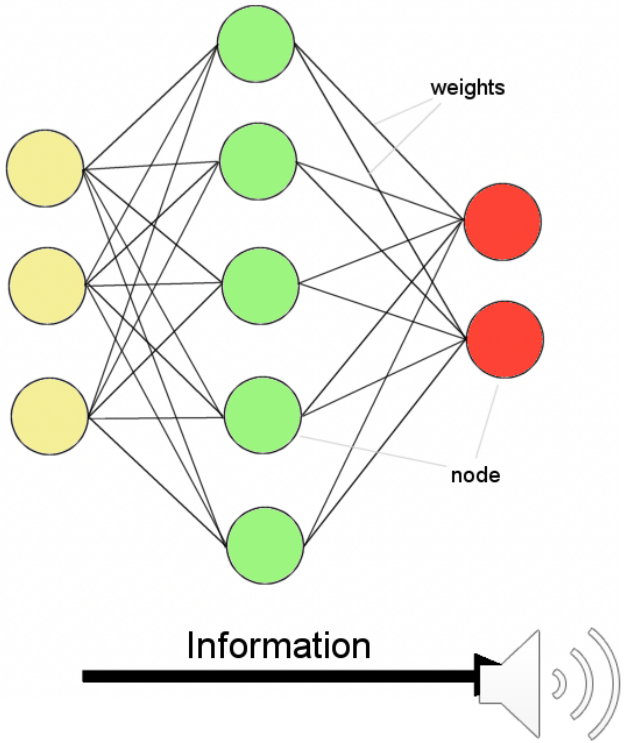


https://towardsdatascience.com/the-mostly-complete-chart-of-neural-networks-explained-3fb6f2367464

Feed-forward networks

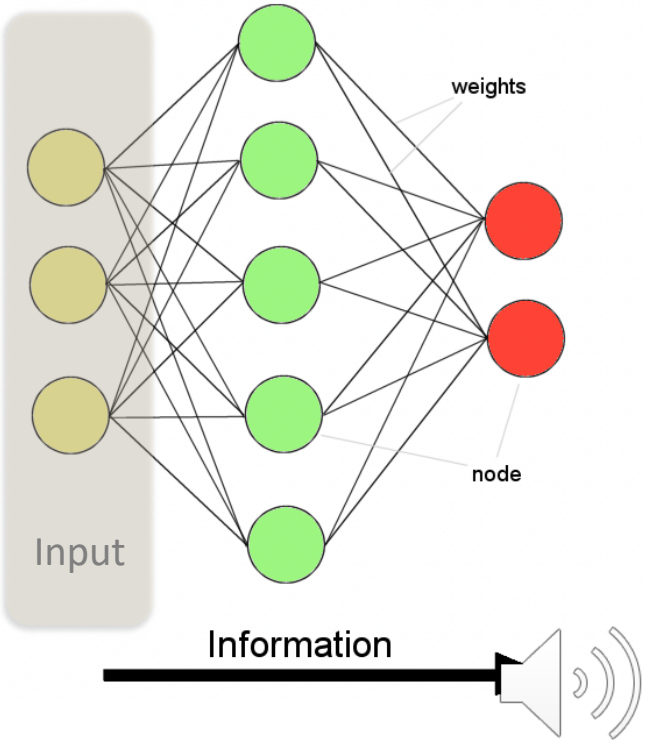
Feed-forward networks

- Layered architecture



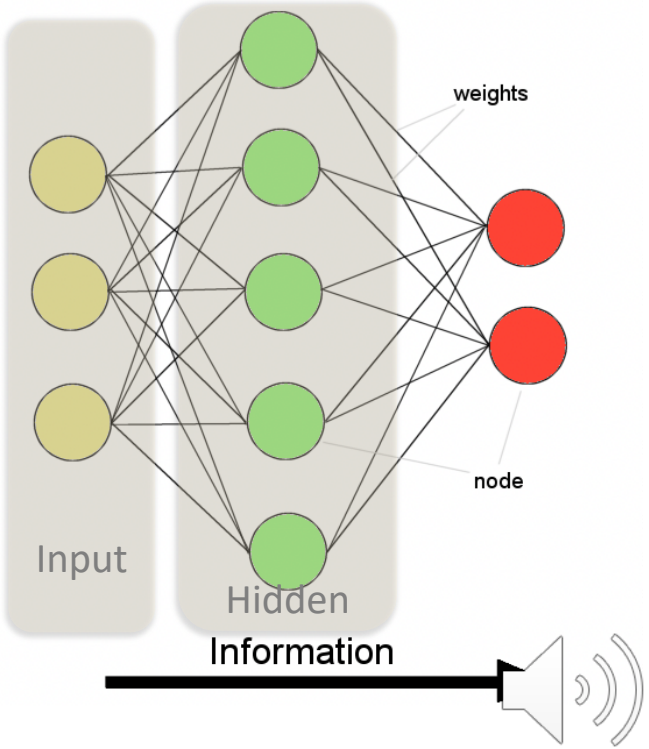
Feed-forward networks

- Layered architecture
- Information flow is unidirectional
  - Data is presented to the input layer



Feed-forward networks

- Layered architecture
- Information flow is unidirectional
  - Data is presented to the input layer
  - Passed on to the hidden layer(s)



Feed-forward networks

- Layered architecture
- Information flow is unidirectional
  - Data is presented to the input layer
  - Passed on to the hidden layer(s)
  - Passed on to the output layer