immerse
EDUCATION

# History of Artificial Intelligence

Elizabeth Savochkina | 5th June

# Shape of a Day

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|---|
| **Registration**<br>9.00am to 9.30am |
| **History of AI**<br>9.30am to 11.30am |
| **Break 11.30am to 13.30 pm** |
| **Workshop:**<br>**Identifying Opportunitis for AI**<br>13.30am to 14.30pm |
| **Workshop:**<br>**Team Poster +**<br>***Optional Installation***<br>14.30am to 15.30pm |

# What is "intelligence"?

Defined by the Oxford English Dictionary as:

(OED)

1. The faculty of understanding; intellect. Also as a count noun: a mental manifestation of this faculty, a capacity to understand.

2. The action or fact of mentally apprehending something; understanding, knowledge, comprehension (of something).

3. Understanding as a quality admitting of degree; spec. quickness or superiority of understanding, sagacity.

5a. An intelligent or rational being, esp. a spiritual one, or one alien to mankind.

5b. An embodiment of intelligence or understanding; a highly intelligent person.

# What is “intelligence”?

Consider the following formula that calculates the sum of two numbers:

```
x = 4721956294 + 9846151389
```

Consider the OED definition of artificial intelligence:

> The capacity of computers or other machines to exhibit or simulate intelligent behaviour; the field of study concerned with this.

# Machines vs. humans

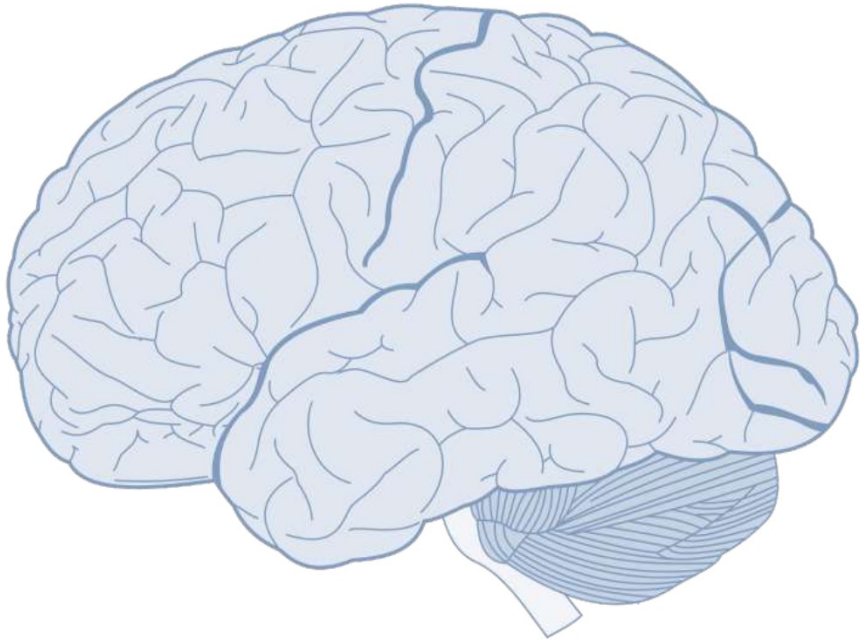
# Machines vs. humans

**Are humans more intelligent than machines?**

“AI can evoke the next world war and result in dominating the world and that robot leadership is a threat to the world.” – Elon Musk

# Machines vs. humans

The Fujitsu *Fugaku* supercomputer at RIKEN, Japan. Currently the fastest supercompter in the world.



The human brain.

- The supercomputer was used **to simulate the spread of the coronavirus through droplet dispersion**.
- It was also involved in forecasting concentrated downpours and other weather events.

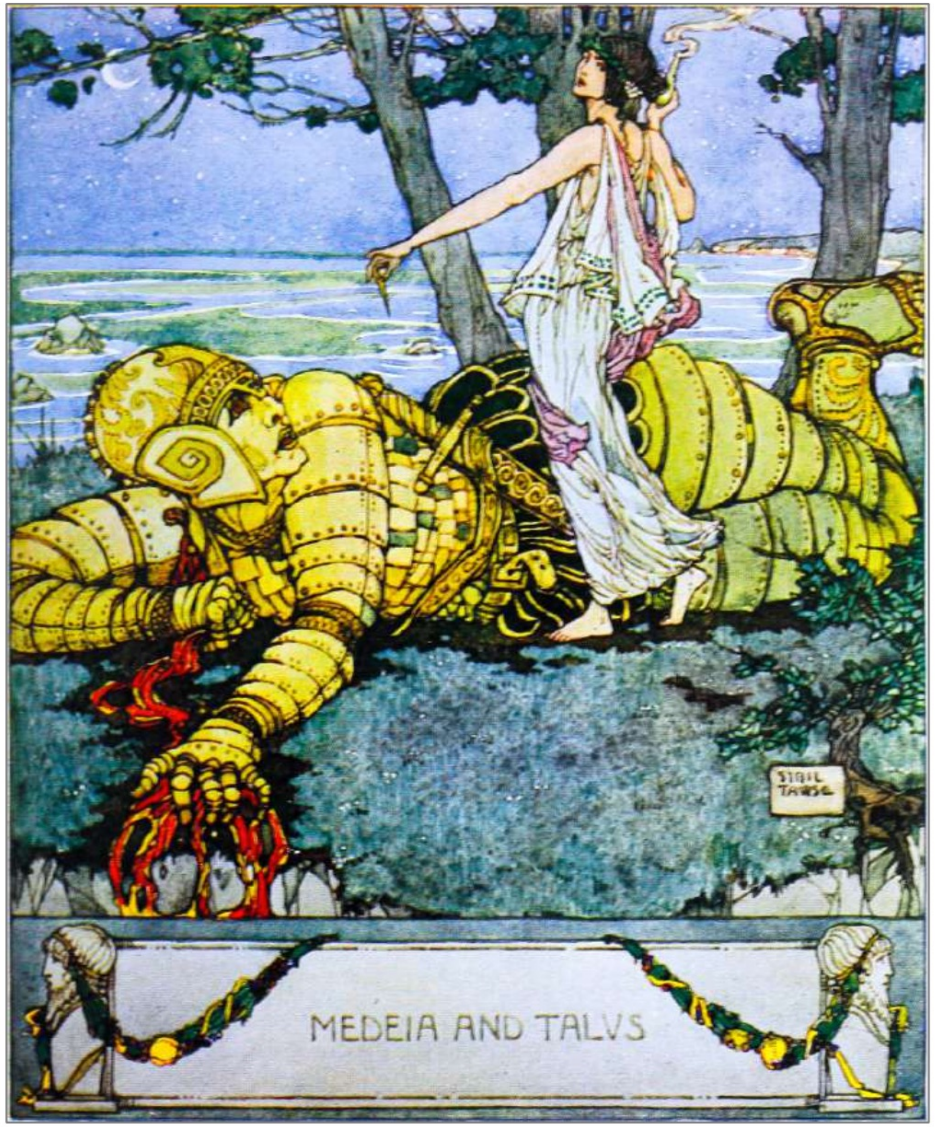
# Intelligent machines

Concept of artificial beings has been present for millennia and notably present in Greek mythology:

*Hephaestus*, a deity who forged mechanical guard dogs from gold and silver; 700 BC or earlier

*Talos* (pictured), an automaton made of bronze; 300 BC or earlier

Pygmalion's *Galatea*, a statue who was brought to life by the goddess Aphrodite, in the Latin poem "Metamorphoses"; 8 AD

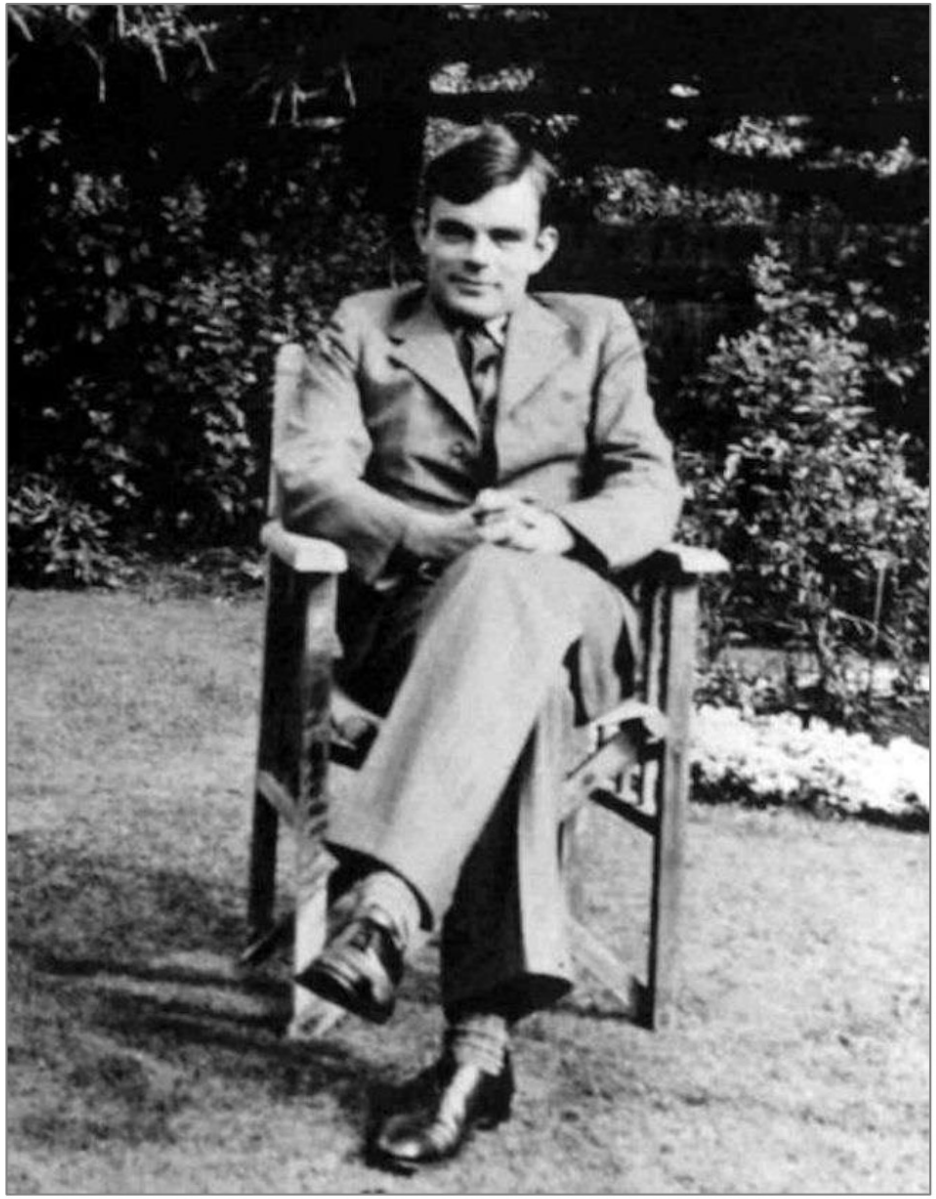


# Intelligent computers

In 1950, Alan Turing considered the philosophical question,

**Can machines think?**

in Turing, AM. "Computing Machinery and Intelligence." *Mind* 59.236 (1950): 433-460.



# Who is Alan Turing?

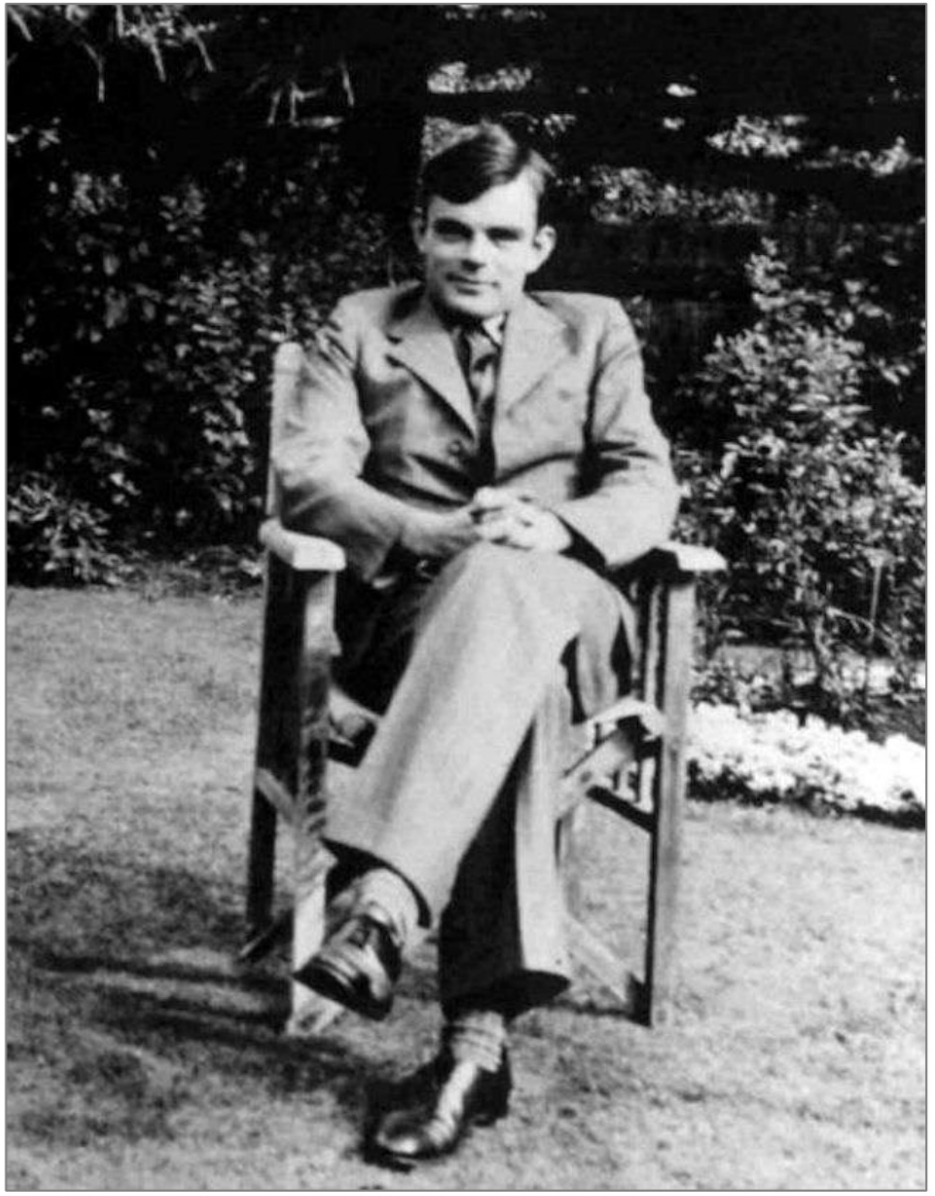
In 1936, Alan Turing published the paper,

"On Computable Numbers, with an Application to the Entscheidungsproblem"

A decision problem, of finding a way to decide whether a formula is true or provable within a given system

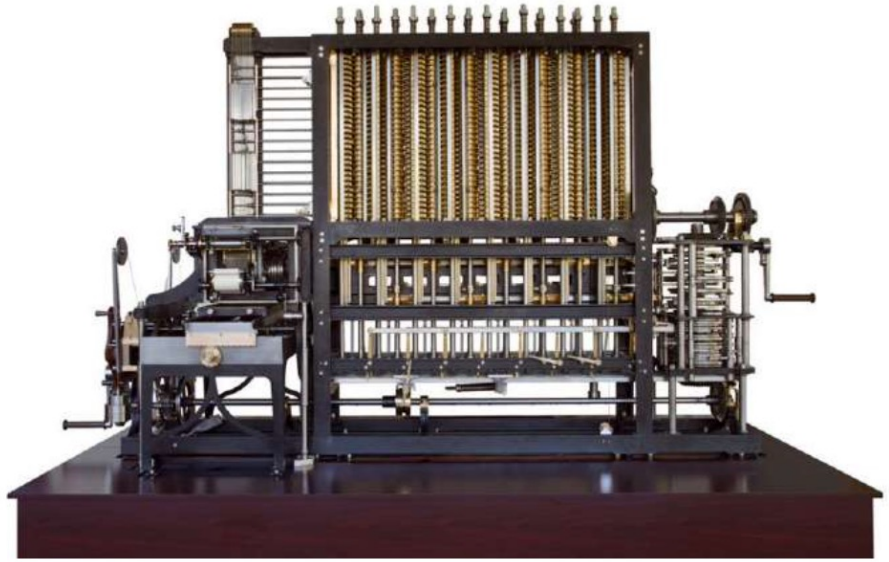
in which he proposed the universal machine, or Turing Machine – the notion that anything that is computable can be done by such a machine.

**Alan Turing is considered as having conceptualized the precursor to the modern computer.**



# A very brief history of computers

First concept of a mechanical computer: Charles Babbage's "Difference Engine" and "Analytic Engine" (late 1800s)



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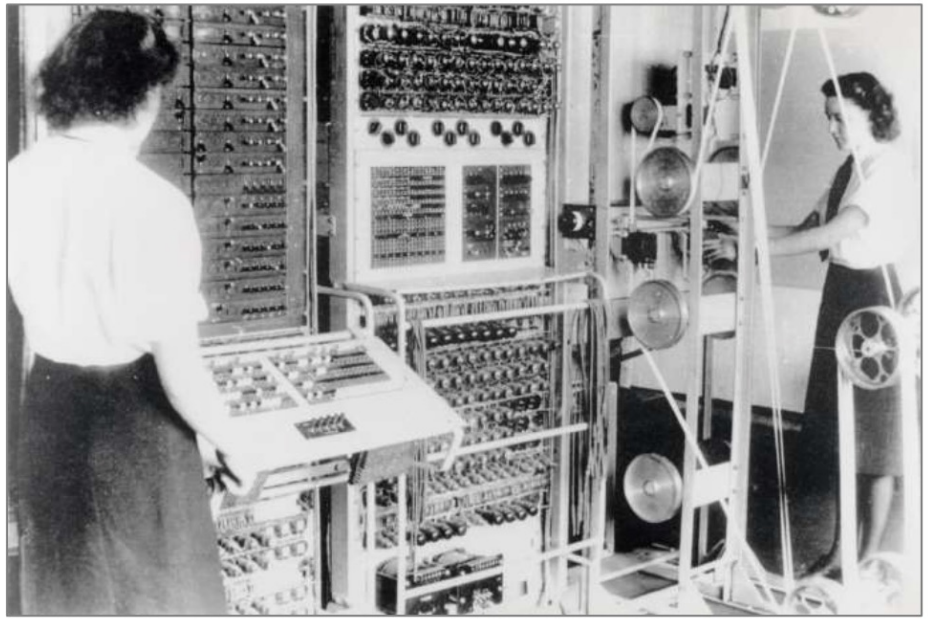
First electronic digital programmable computer: Colossus, built at Bletchley Park to break German ciphers during WW2 (1943)



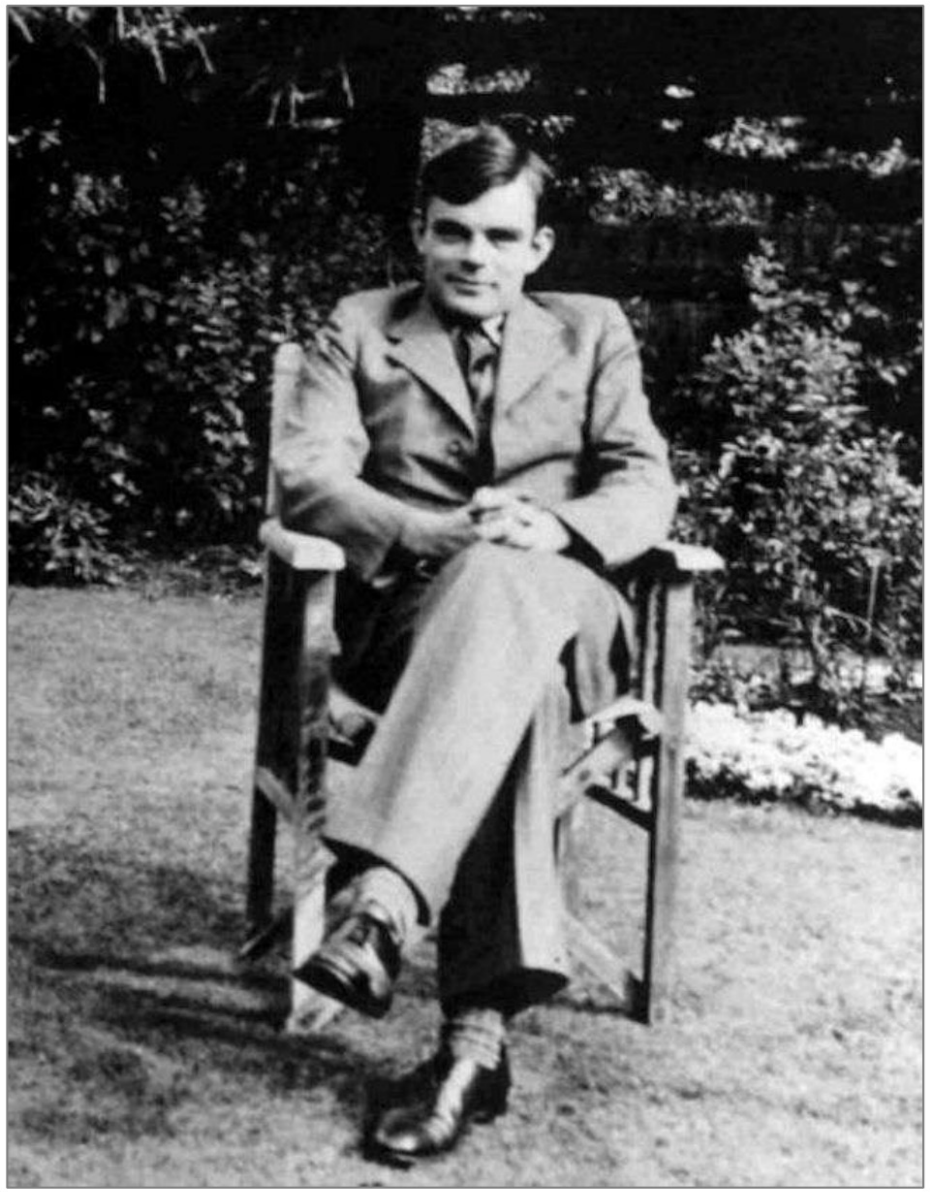
# Intelligent computers

In 1950, Alan Turing considered the philosophical question,

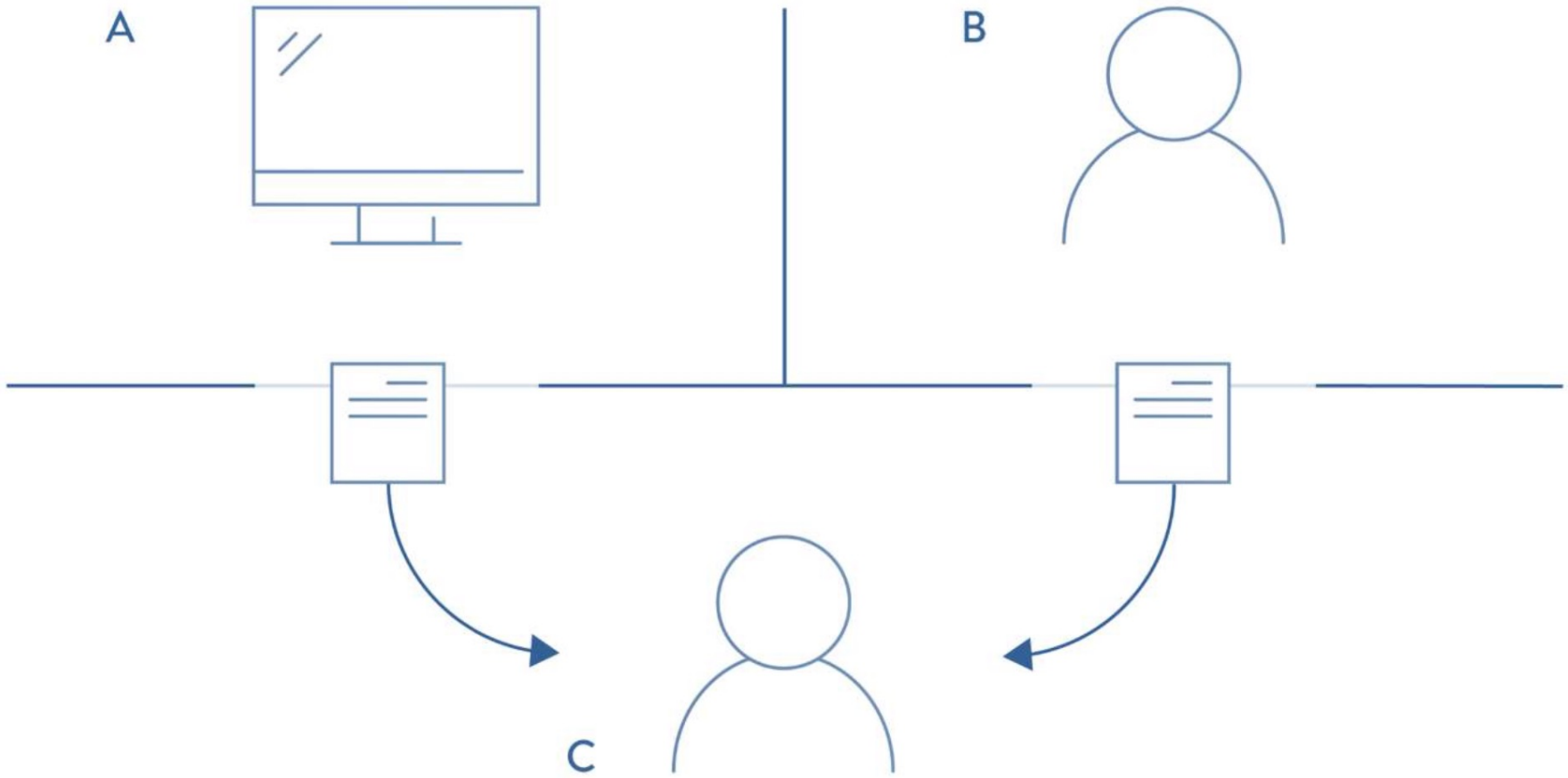
**Can machines think?**

He formalised this question by reframing it in more unambiguous terms and demonstrable as a tangible test, today referred to as:

**“The Turing Test”**



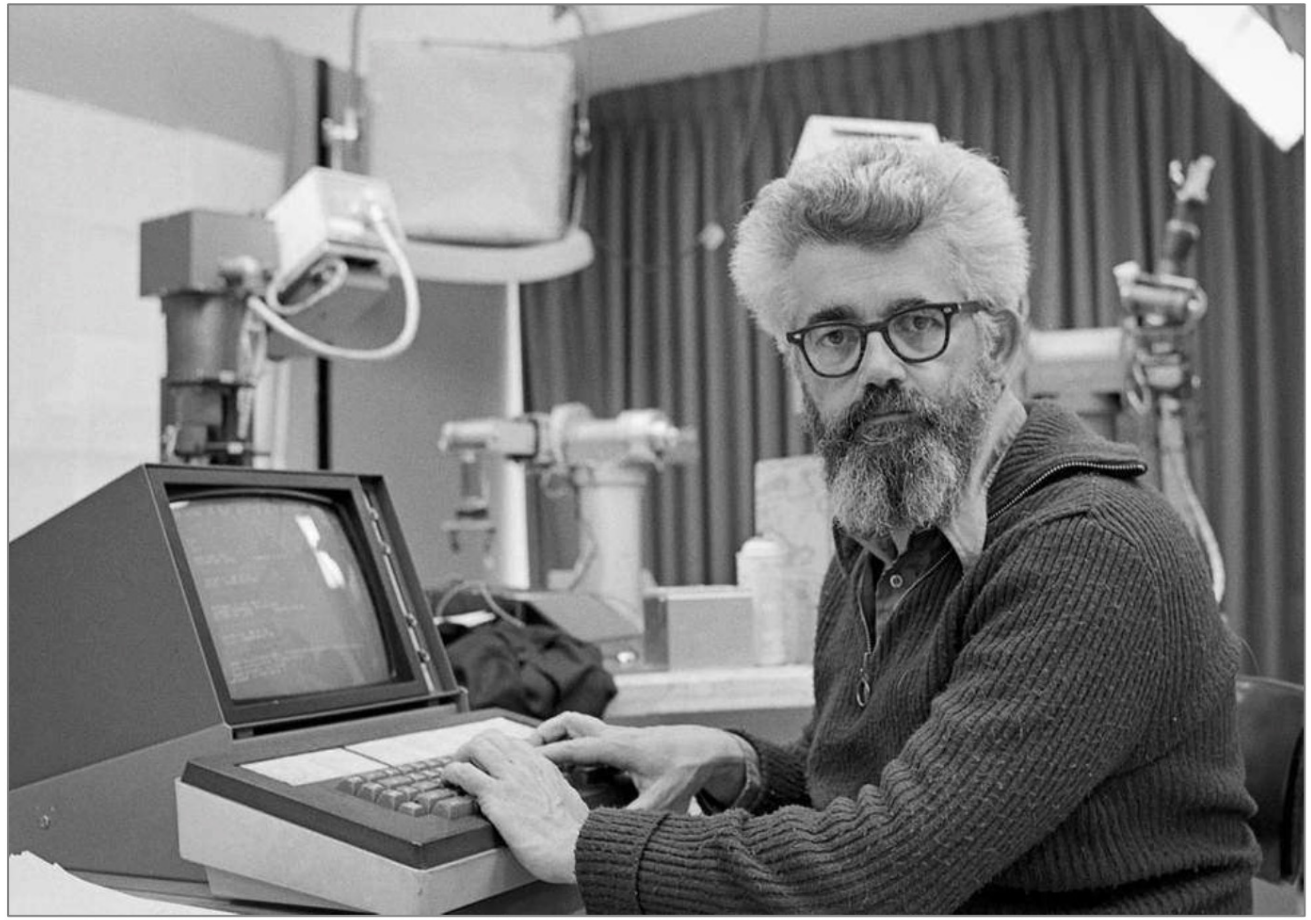
# The Imitation Game a.k.a. “The Turing Test”



# The birth of AI

Dartmouth workshop on "Artificial Intelligence" in 1956:

- Brought together mathematicians and scientists to discuss how machines could simulate learning and intelligence.
- Organised by John McCarthy who is widely credited as coining the term "Artificial Intelligence".
- Interestingly, workshop participants dismissed what was later considered the first AI computer program, the Logic Theorist.



# Logic Theorist

Considered as the first AI computer program, proposed by Newell and Simon in 1955.

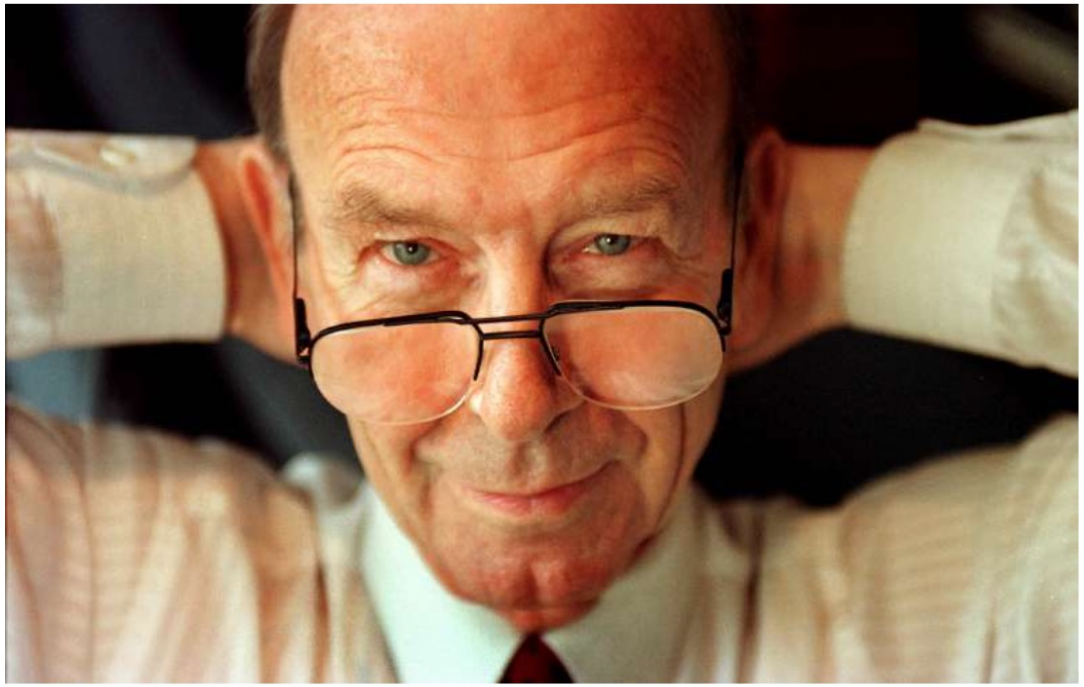
Introduced key concepts in AI:

- Logical reasoning as search (finding an optimal solution out of all possible solutions),
- Heuristics (criteria to finding practical, not optimal solutions), and
- List processing (an efficient way of representing and searching over data)

# Game playing AI and learning machines

In 1960, Donald Michie invented **MENACE** (Matchbox Educable Noughts And Crosses Engine):

- An automated system that learns to play tic-tac-toe (noughts and crosses) by playing against itself.
- Built out of matchboxes, pieces of paper, and coloured sugar drops.



# MENACE

MENACE was entirely mechanical (not a computer program) but demonstrated the concept of a machine learning through experience.

- Optimising the search space is a form of feature engineering (more on that in Week 2).
- Experience can be thought of as collecting data by doing.
- Is an example of reinforcement learning (more on that on Thursday).

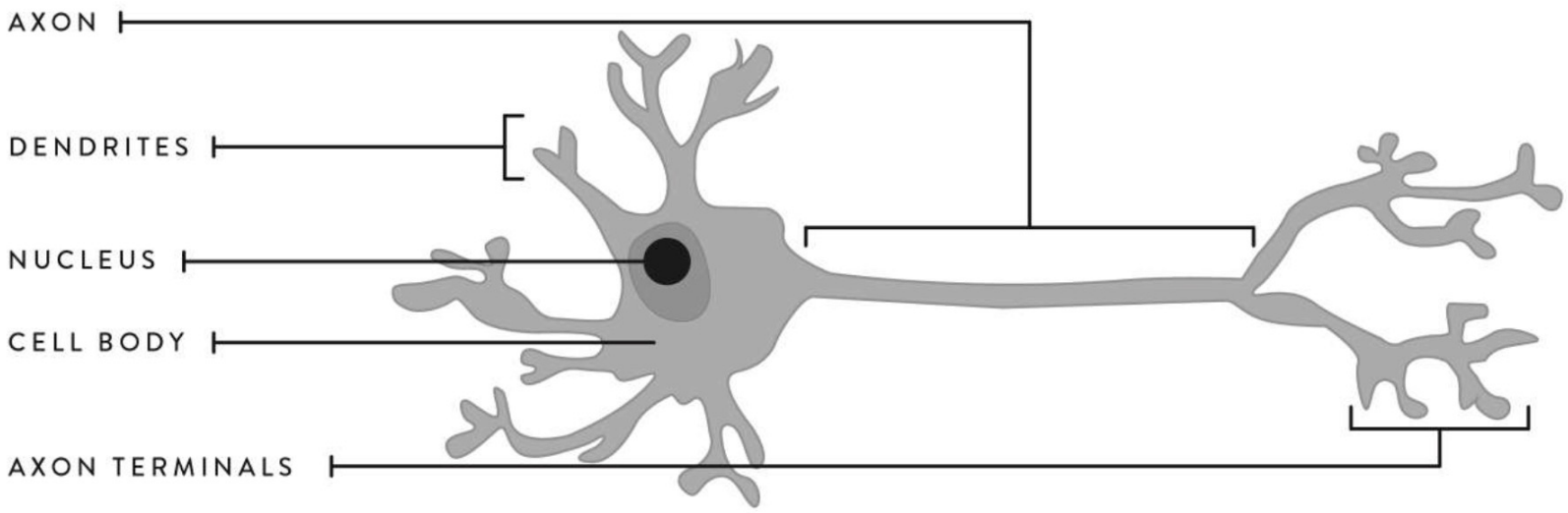
Of course, today it can be implemented as a computer program!

JavaScript version: https://github.com/mscroggs/MENACE

# The Biological Neuron

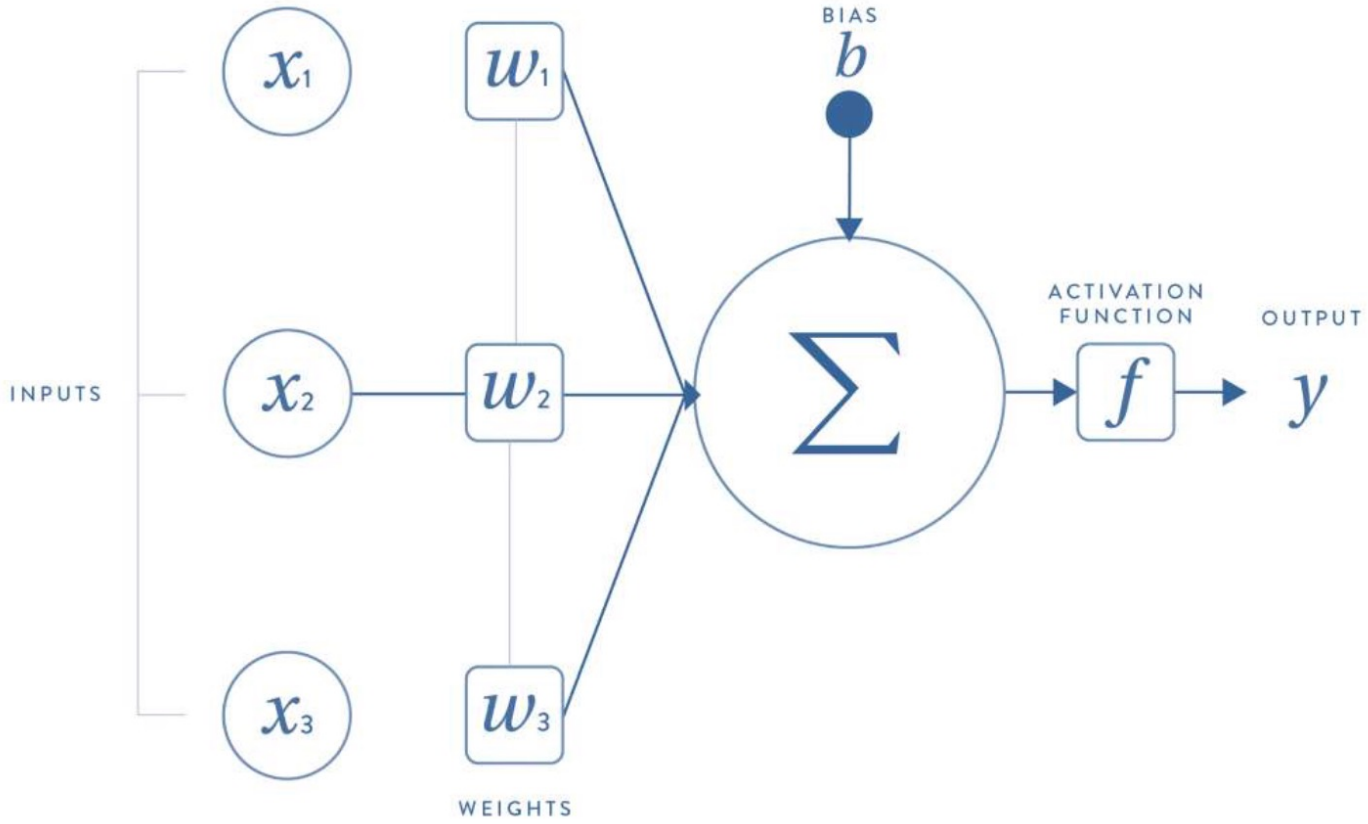
Main parts of the biological neuron:

- **Soma**: Body of the neuron.
- **Dendrites**: Input connections.
- **Axon**: Output connection.




**Axons** link to **dendrites** via **synapses** (like junctions) to connect neurons together.

# The Artificial Neuron

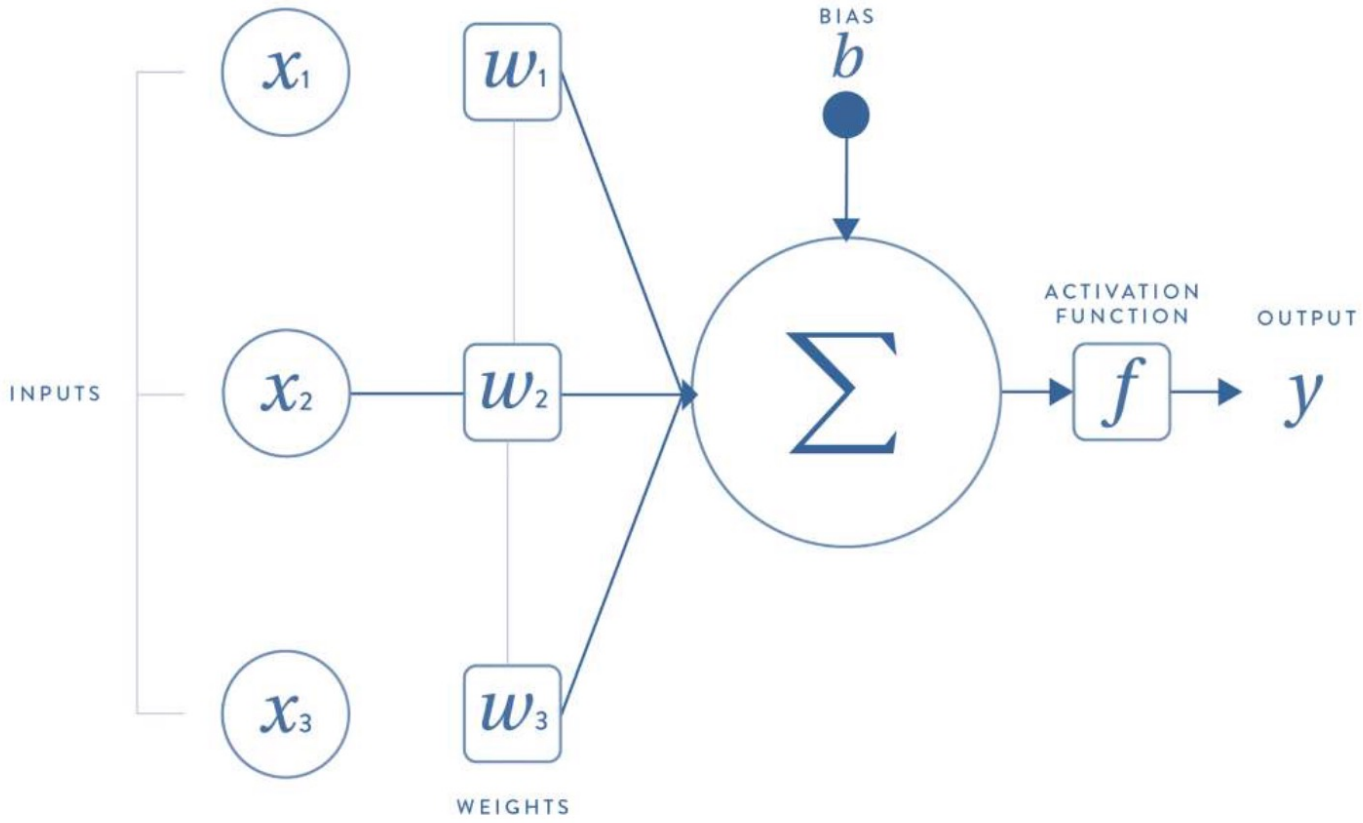



The **perceptron** (a.k.a. artificial neuron) was first proposed by Frank Rosenblatt in 1962.

Features of a perceptron:

- The output from a neuron is either on or off (0 or 1).
- The output depends only on the inputs.
- A certain number must be on at any one time in order to make the neuron "fire".

# The Artificial Neuron



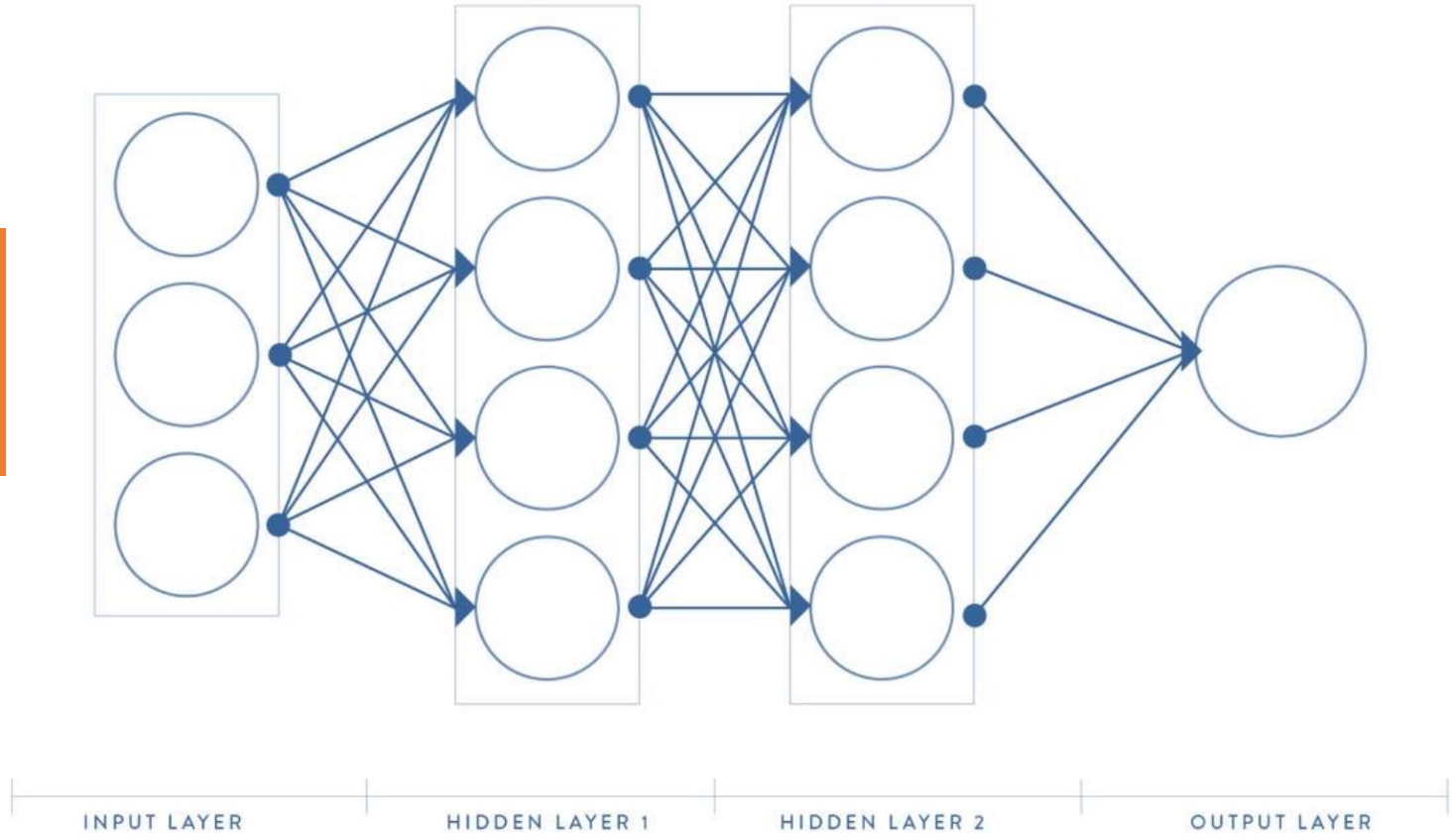

The single-layer perceptron can implement simple problems such as logic gates AND and OR, but is unable to solve implementing XOR.

This led to the idea that we can link the outputs of perceptrons to the inputs of other perceptrons, forming **artificial neural networks**.

By creating networks of neurons, a solution for XOR was found.

* XOR (exclusive OR gate) - is a digital logic gate that **gives a true output iff inputs differ from each other**

# First AI Winter: The death of Neural Networks




While these advances in AI research were promising, they were found to be impractical:

- While XOR was possible, there was no learning algorithm that could *train* such a network to perform the XOR function.
- Many problems that were hoped could be solved by ANNs were intractable.

Interest in AI systems soon waned due to the impracticality of the technology of the day, and that many of the methods could not scale up.

# First AI Revival: The rise of Expert Systems

Interest in AI systems became more optimistic again in the 1980s with the boom in the application of expert systems:

- Based on fundamentally different kind of approach to AI than ANNs.
- Goes back to work that began with the Logic Theorist – logic based problem spaces that are searched over to give answers or discover new knowledge; with tractable search strategies.

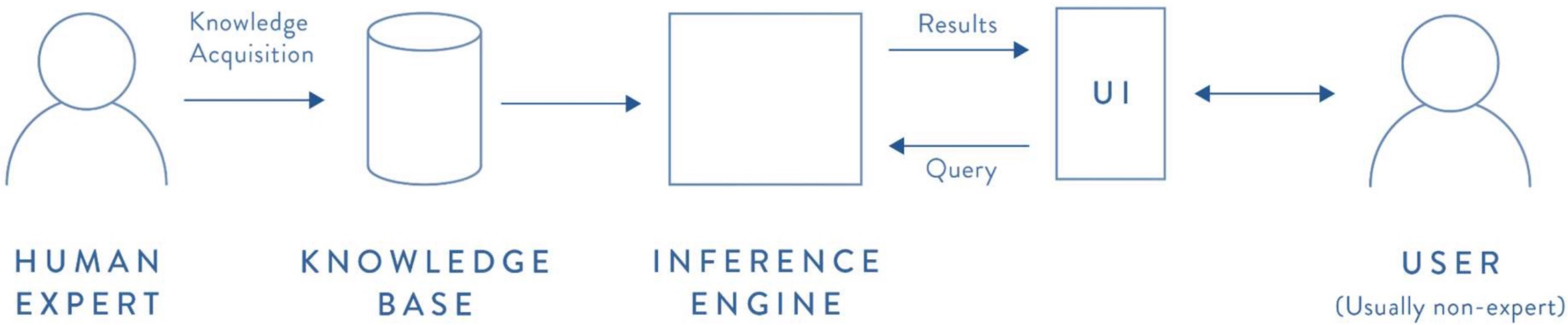
Advantages:

- Simpler to develop and maintain.
- Easy to verify and test against human knowledge.

Disadvantages:

- Do not easily adapt.
- Only as good as the human user (the non-expert user) queries.

# First AI Revival: The rise of Expert Systems



# Second AI Winter: Show me the robots!

A second decline in interest in AI occurred based on perceptions and discussions about what really is an AI system.

Some thought true AI needed to be embodied so that it could interact with and explore the real world.

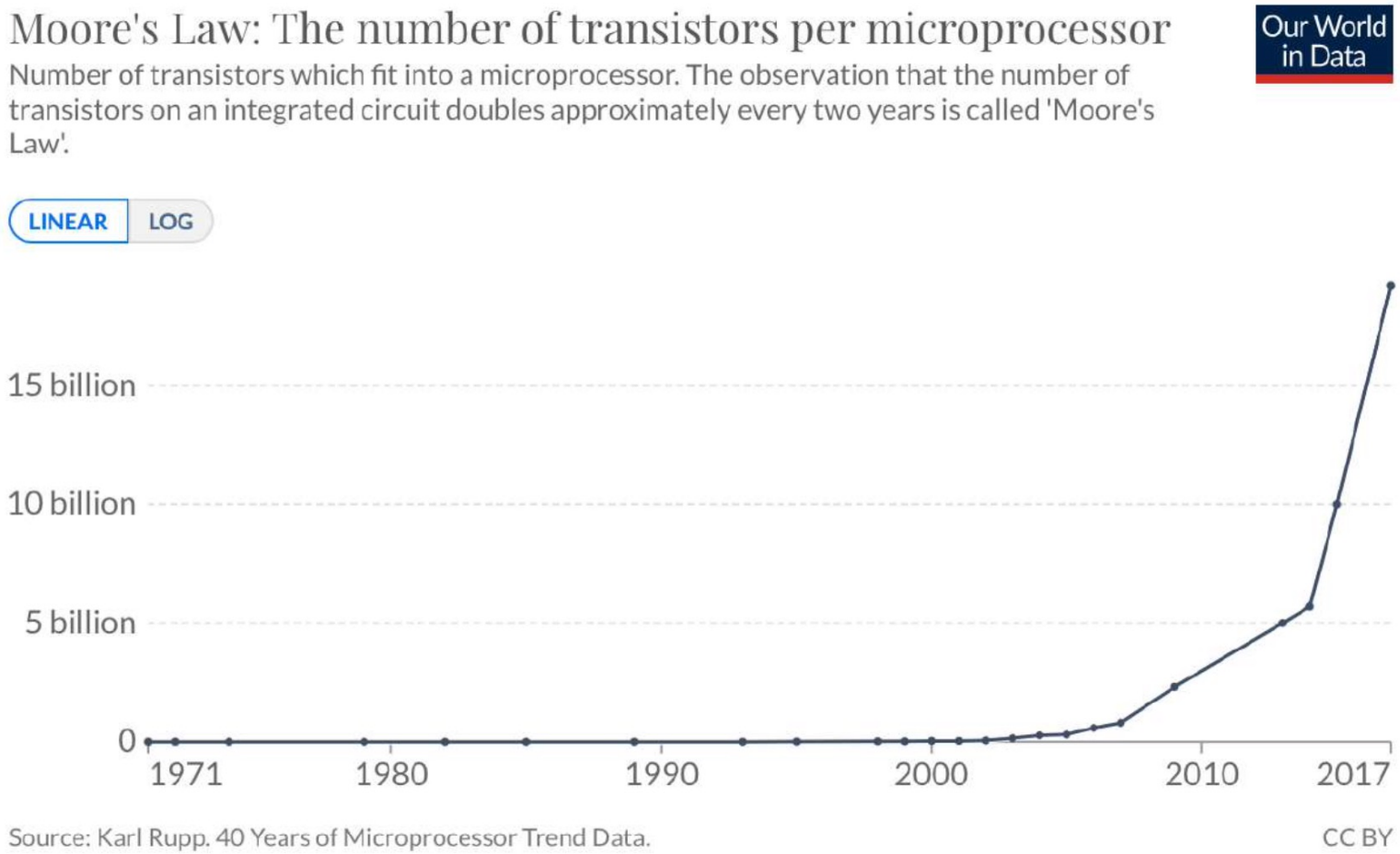
This school of thought suggests that true intelligence should be able to  learn from experience of the real world autonomously, rather than humans "feeding data" into AI engines.

i.e., We want robots!

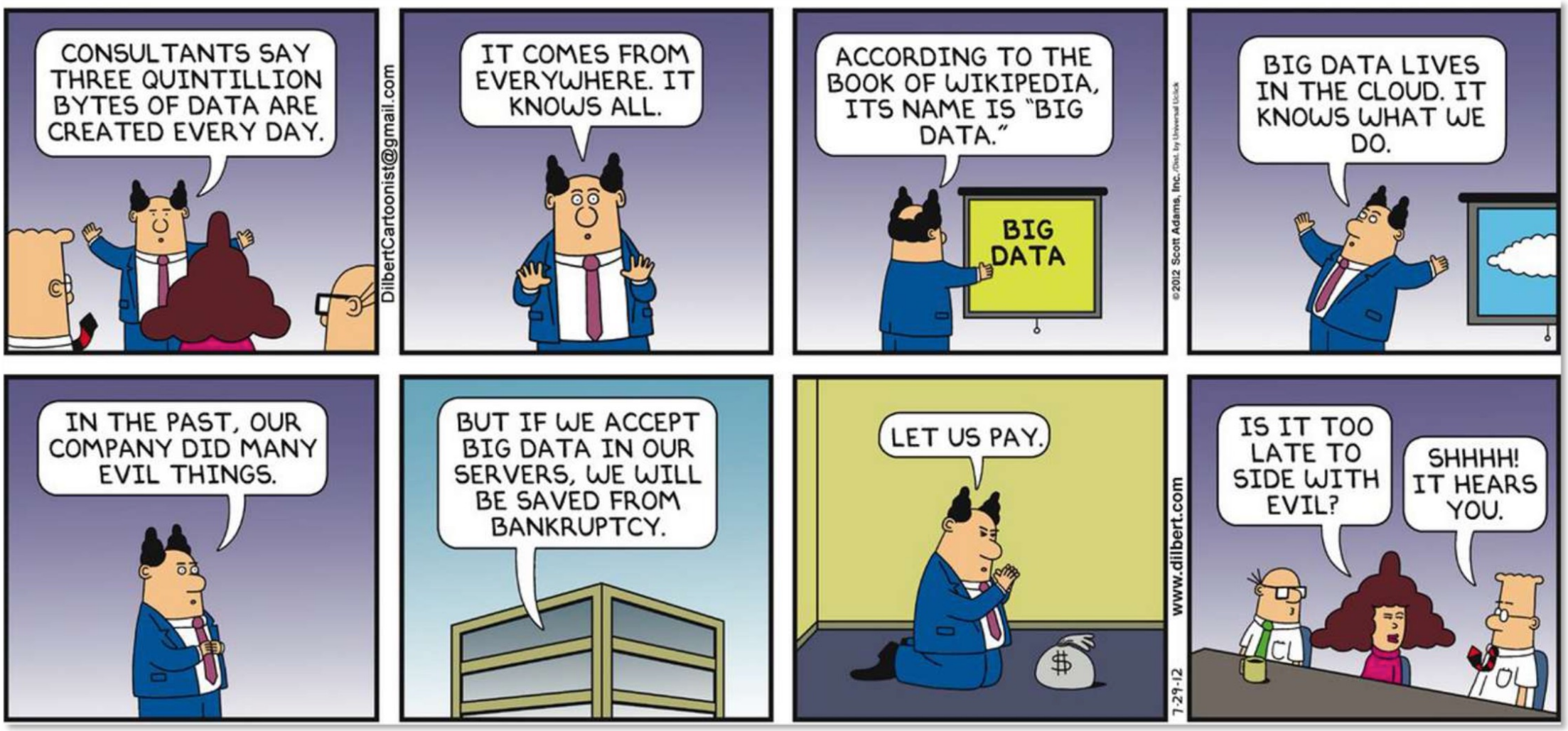
# Golden Age of AI: Driven by Moore's Law

The boom of modern AI, and modern software technology in general, has been driven by Moore's law, an observation that:

*"the number of transistors on a microchip doubles every two years, though the cost of computers is halved".*



# Golden Age of AI: Driven by Big Data



# Recent milestones: Deep Blue beats Kasparov

**1997**

IBM's Deep Blue chess-playing computer system beats world chess grand master Gary Kasparov.

# Recent milestones: DARPA Grand Challenge

**2004**

DARPA Grand Challenge promotes efforts towards the self-driving car.

Challenge won by a team from Stanford University.

# Recent milestones: Watson beats Jeopardy! champions

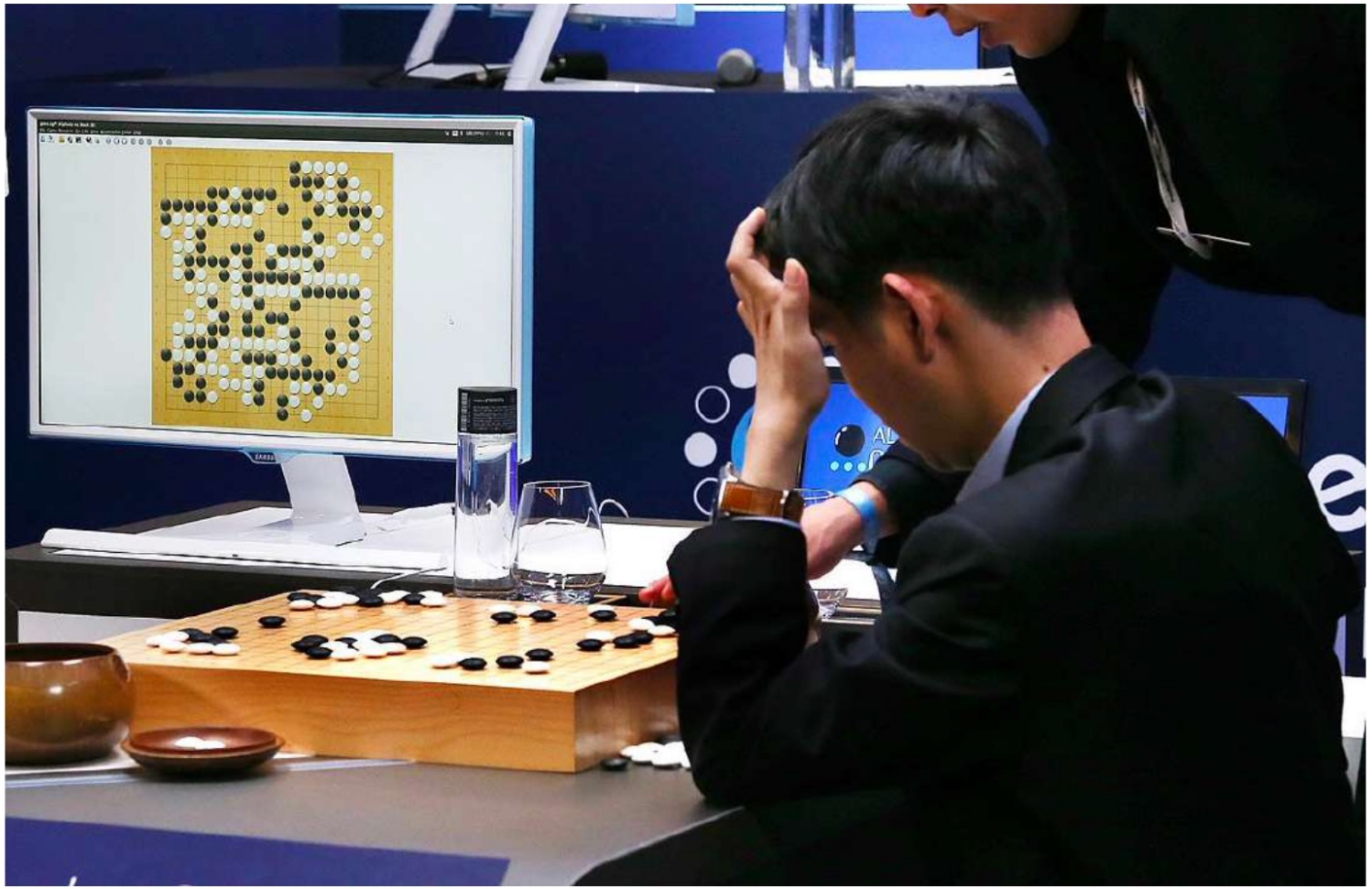
**2011**

IBM's Watson general-purpose Q&A computer system beats Jeopardy! champions.

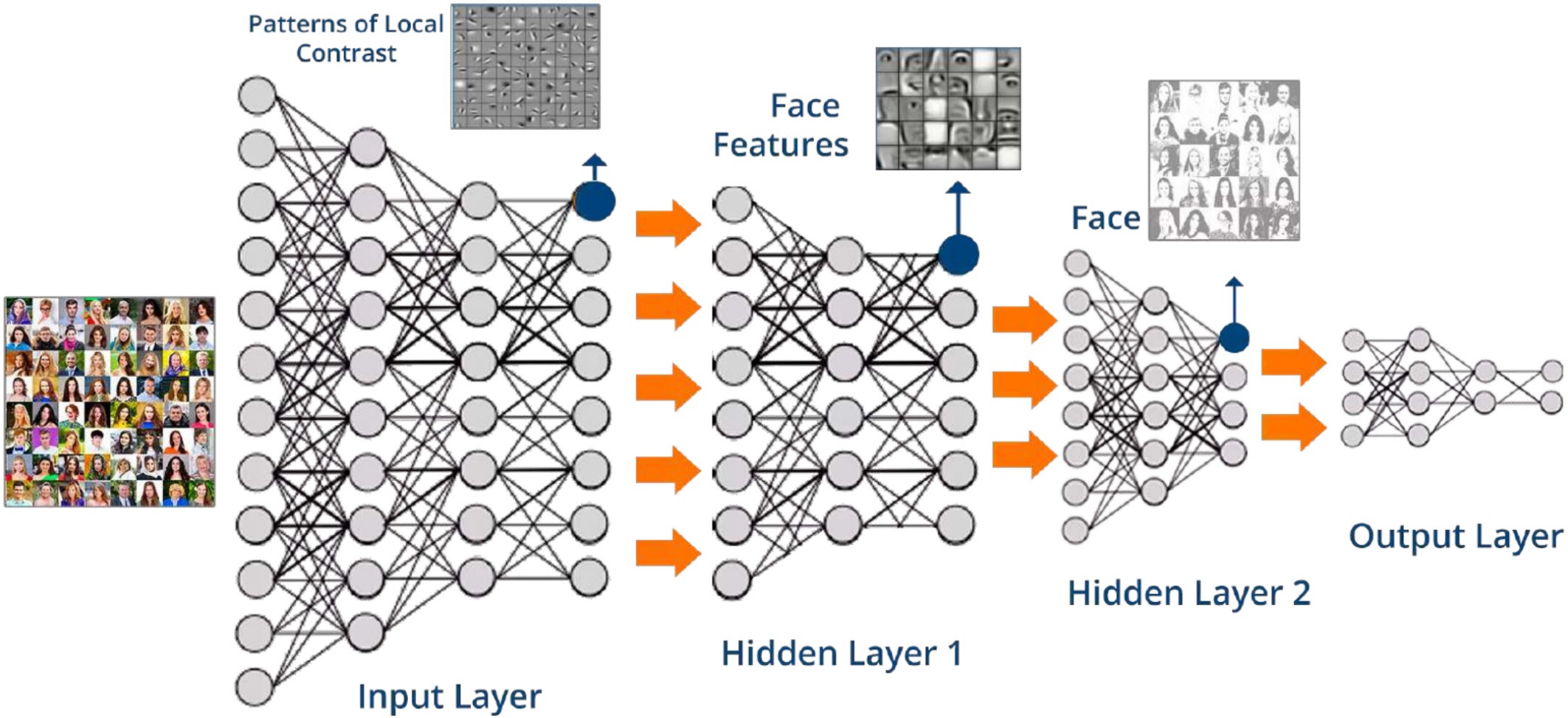
# Recent milestones: AlphaGo beats Lee Sedol

**2016**

DeepMind's AlphaGo computer system beats world champion at Go Lee Sedol.



# Golden Age of AI: Deep Neural Networks



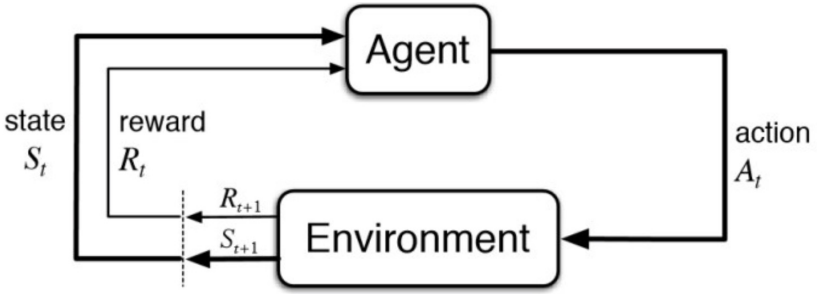
# Golden Age of AI: DNN pioneers win Turing Prize

Yoshua Bengio

Geoffrey Hinton

Yann LeCun

# Reinforcement Learning Recap




- ML-based learning training method based on ***rewarding desired behaviours and/or punishing undesired ones*** as signals for positive and negative behaviour.

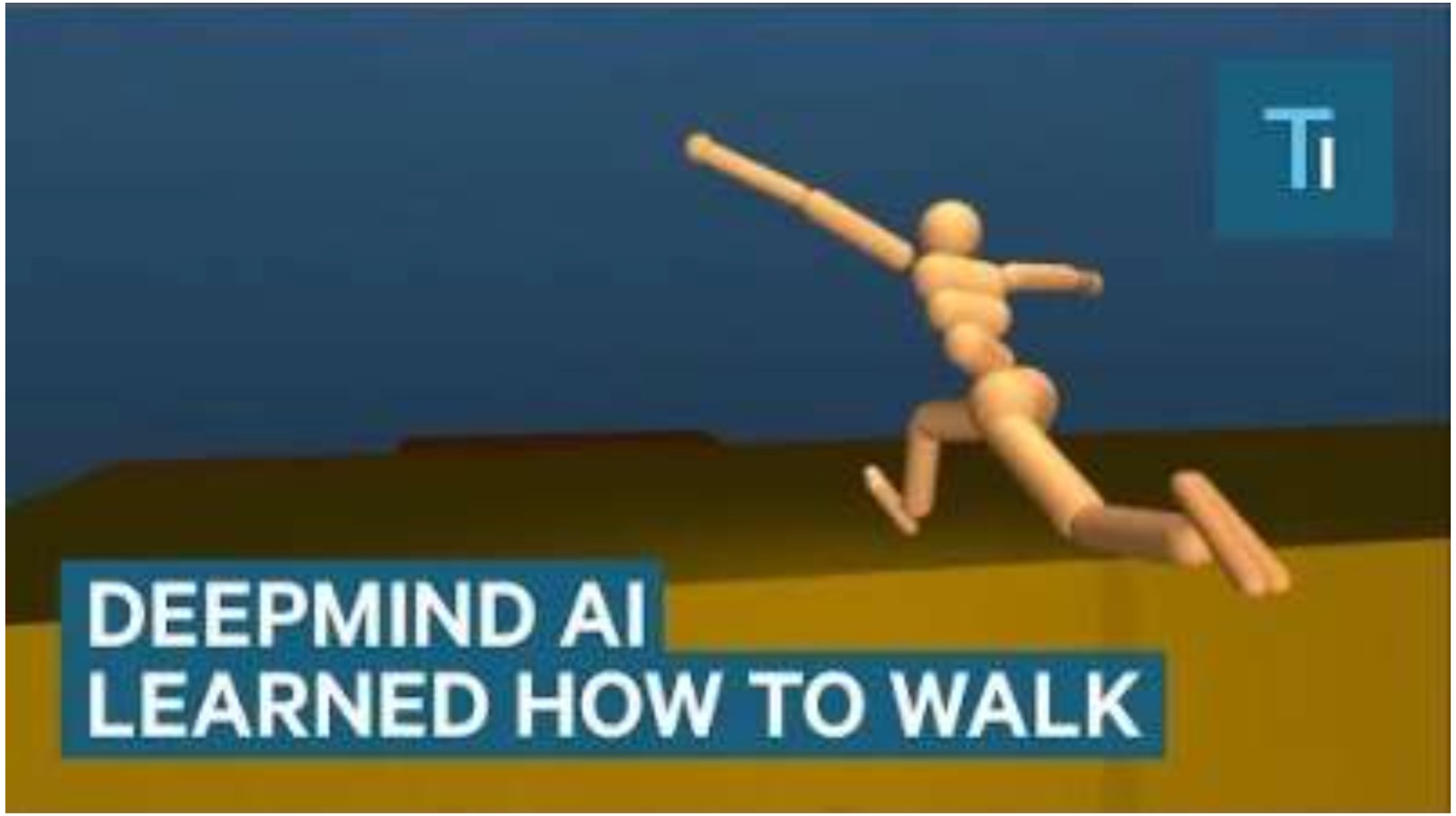
- In general, a reinforcement learning agent is able to perceive and interpret its environment, take actions and learn through trial and error.

- The goal is to find a suitable action model that would ***maximize the total cumulative reward of the agent.***

# Current trends: Reinforcement Learning

# Current trends: Reinforcement Learning

- Only question – notice anything weird or possibly inefficient?
- Why do you think the created humanoid flails its right arm whilst running?



# Current trends: Explainable AI

Building trust in has come to the forefront of discussion in AI research today.

- "Classical" AI models like expert systems are more transparent.
- "Modern" AI models like neural networks are hard to explain.

Researchers are developing methods to try and interpret and explain how AI makes decisions (referred to as XAI, eXplainable AI).

- Use case explanations (e.g. LIME algorithm).
- Explainable models of AI models (e.g. DARPA XAI Program, RICE method).
- Transparency-first AI models (anti-XAI, IBM FactSheets, AI model metadata).

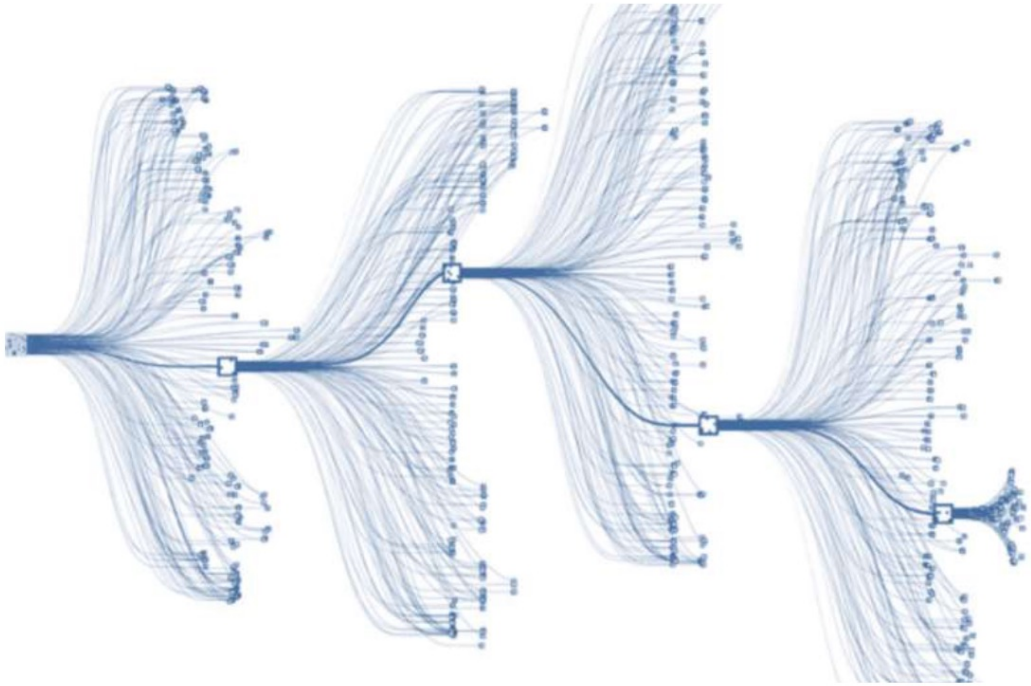
Challenges not only technical but also socio-cultural and organizational.

# Current trends: Combining schools of thought

There is a growing trend to combining very different approaches of AI to solve problems:

- AlphaGo did not just use deep neural networks – it is in fact a hybrid approach of searching the possible next "good" moves, and then evaluating those possible moves with a neural network trained on "what might be a good move".

- In other words, it tries to find the best move based on the current state, then uses a DNN that provides the "intuition" for what is the next best move, based on previous experience.

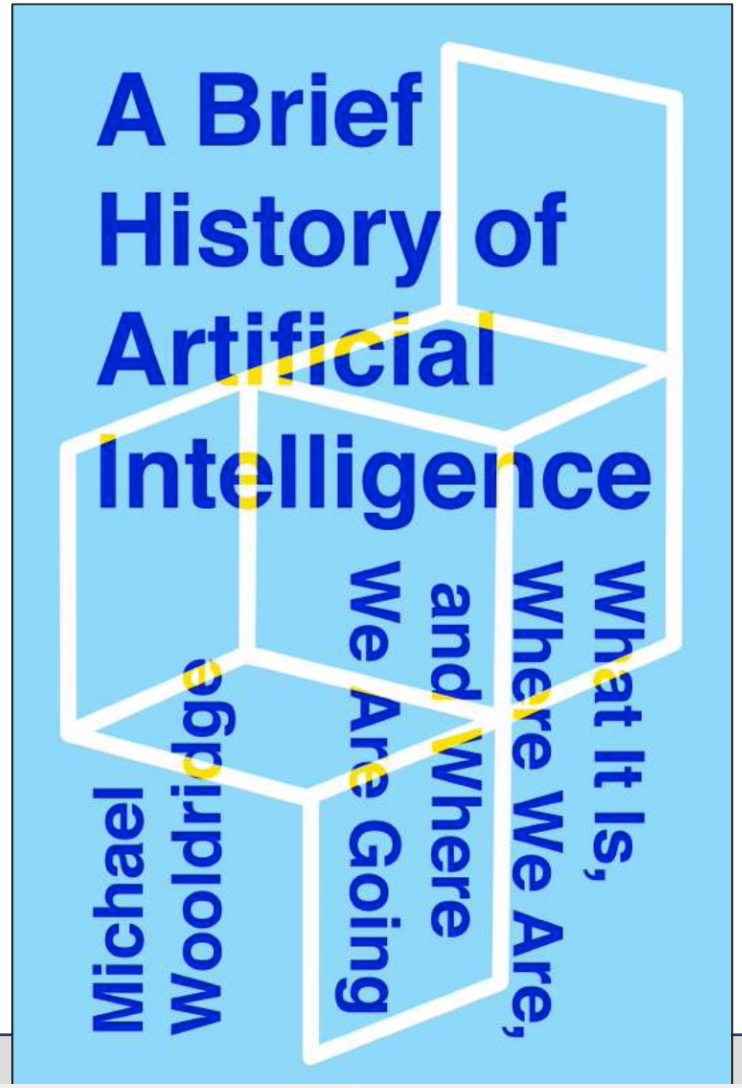


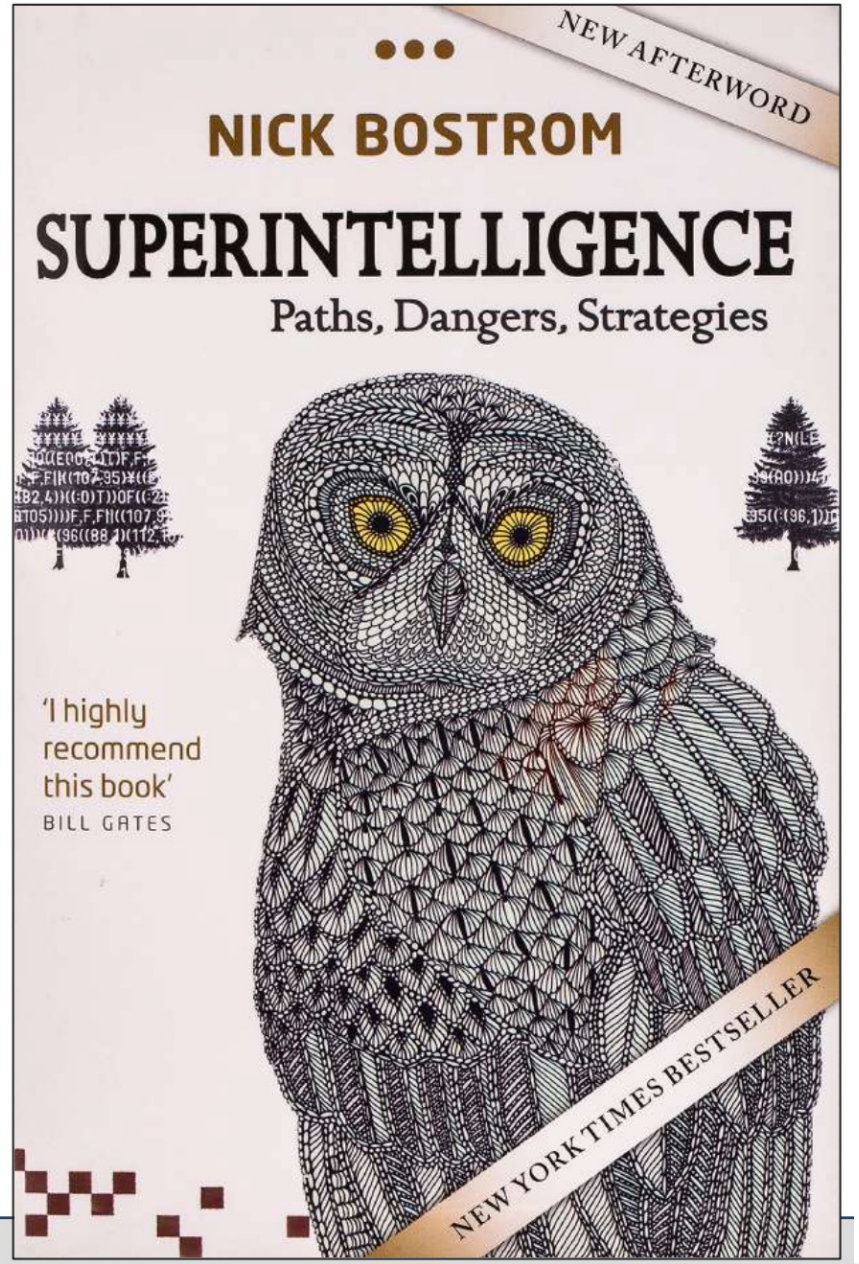
# Future of AI?

Currently AI is already in the mainstream:

- Applications of AI are appearing everywhere – and expect more of it!
- In this Artificial Intelligence Program we hope to help you adopt AI (where appropriate) in your own industries and entities.
- In the near term, the focus will still be on Weak/Narrow AI.

# Further reading

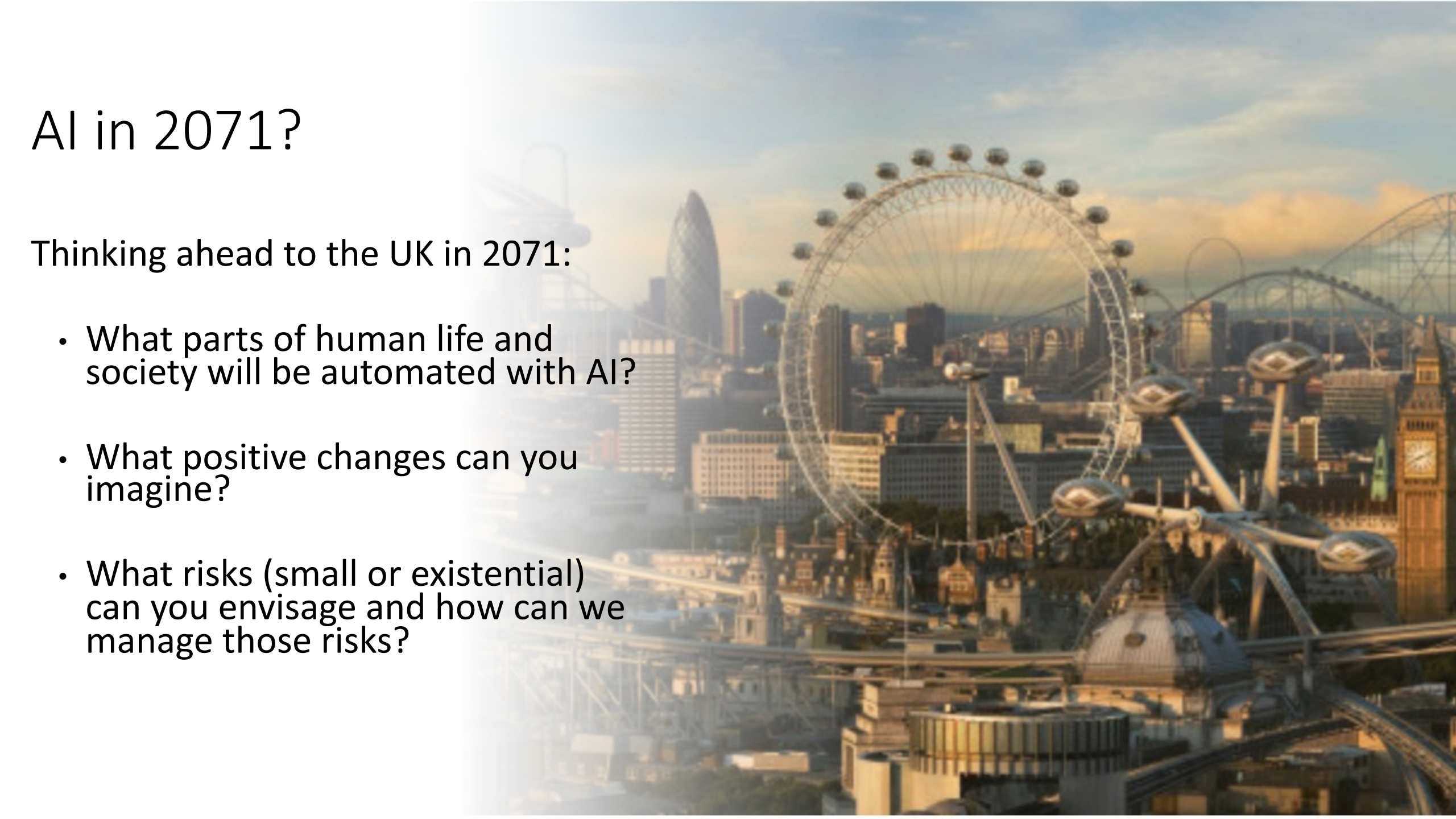


# AI in 2071?

Thinking ahead to the UK in 2071:

- What parts of human life and society will be automated with AI?
- What positive changes can you imagine?
- What risks (small or existential) can you envisage and how can we manage those risks?



# Team Poster continuation

1. Each team to create a ‘Team Poster’
2. Agree a name for your team
3. Agree a ‘Slogan’ or ‘Catch phrase” that helps describe your team and its goals
4. Add some graphics, icons and pictures to illustrate your poster:

What motivates and excites you as a team?

What is your interest in AI?

What is your ‘Big Goal’ as a team?

How will you work together as a high-perfomance team?

# Work on your own!

- Each of you think of the sector/area/field that is currently failing
- Each of you, on your own, think of 3 ‘processes’ that require AI in that field
- State a good reasons why AI is required!

# Back to Teamwork!

Objective:

- Present your objectives to each other in a team
- Write them down in a list

Method:

- Group discussion + voting (select the process you want to work on as a team)