Intelligent System

Introduction of Intelligent System

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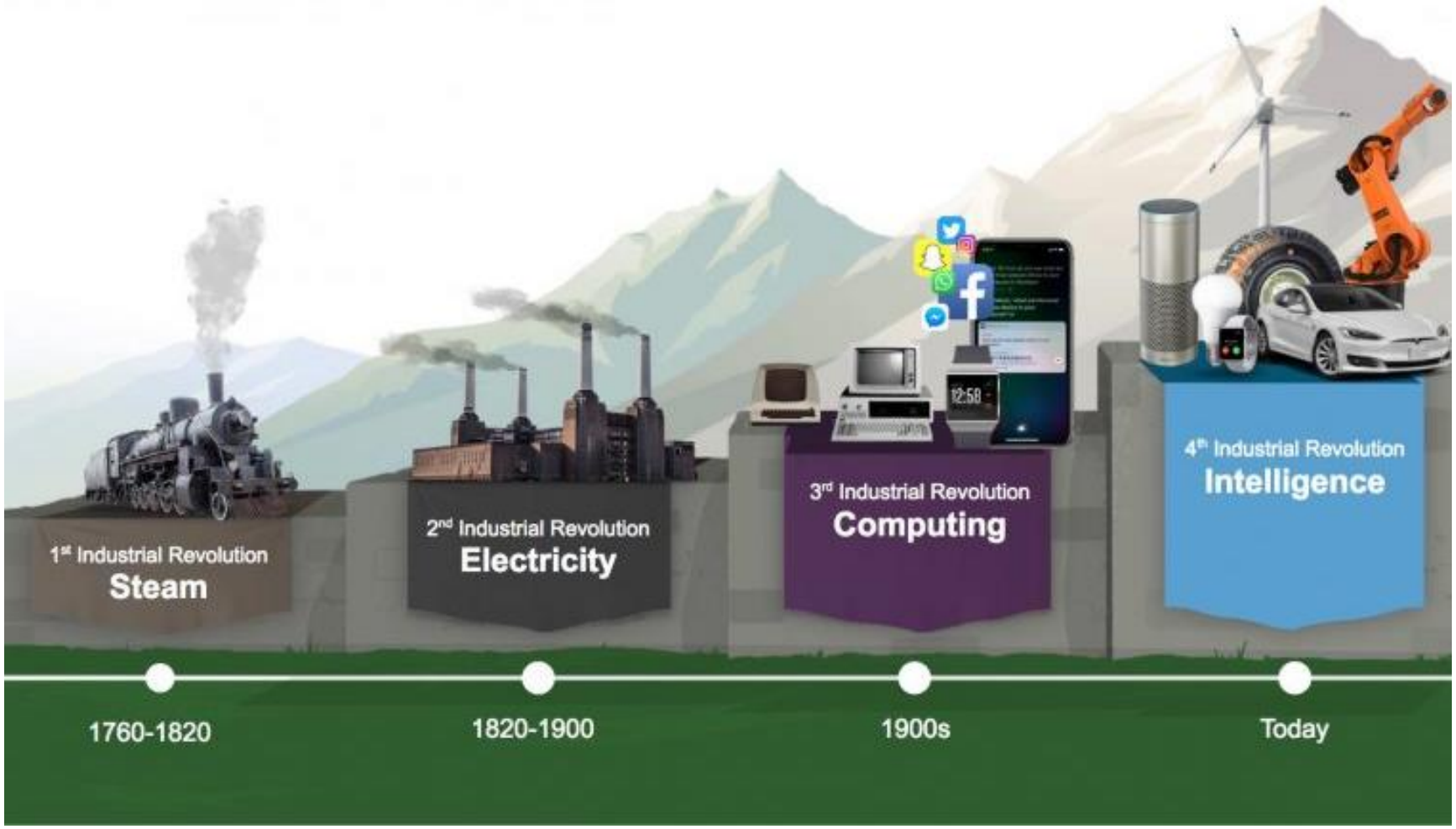
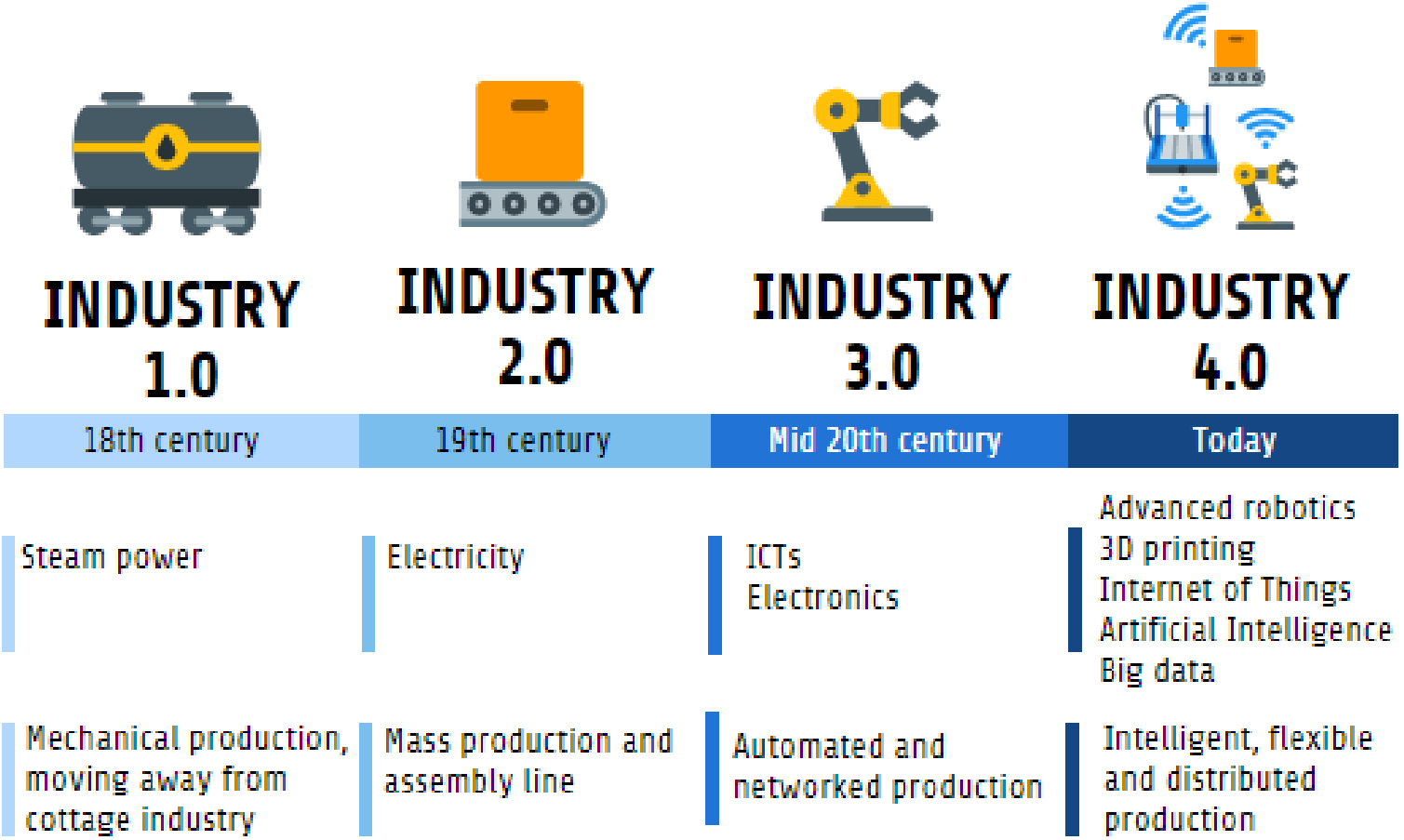
The Journey of Industrial Revolutions: Model 3



The Journey of Industrial Revolutions: Model 4

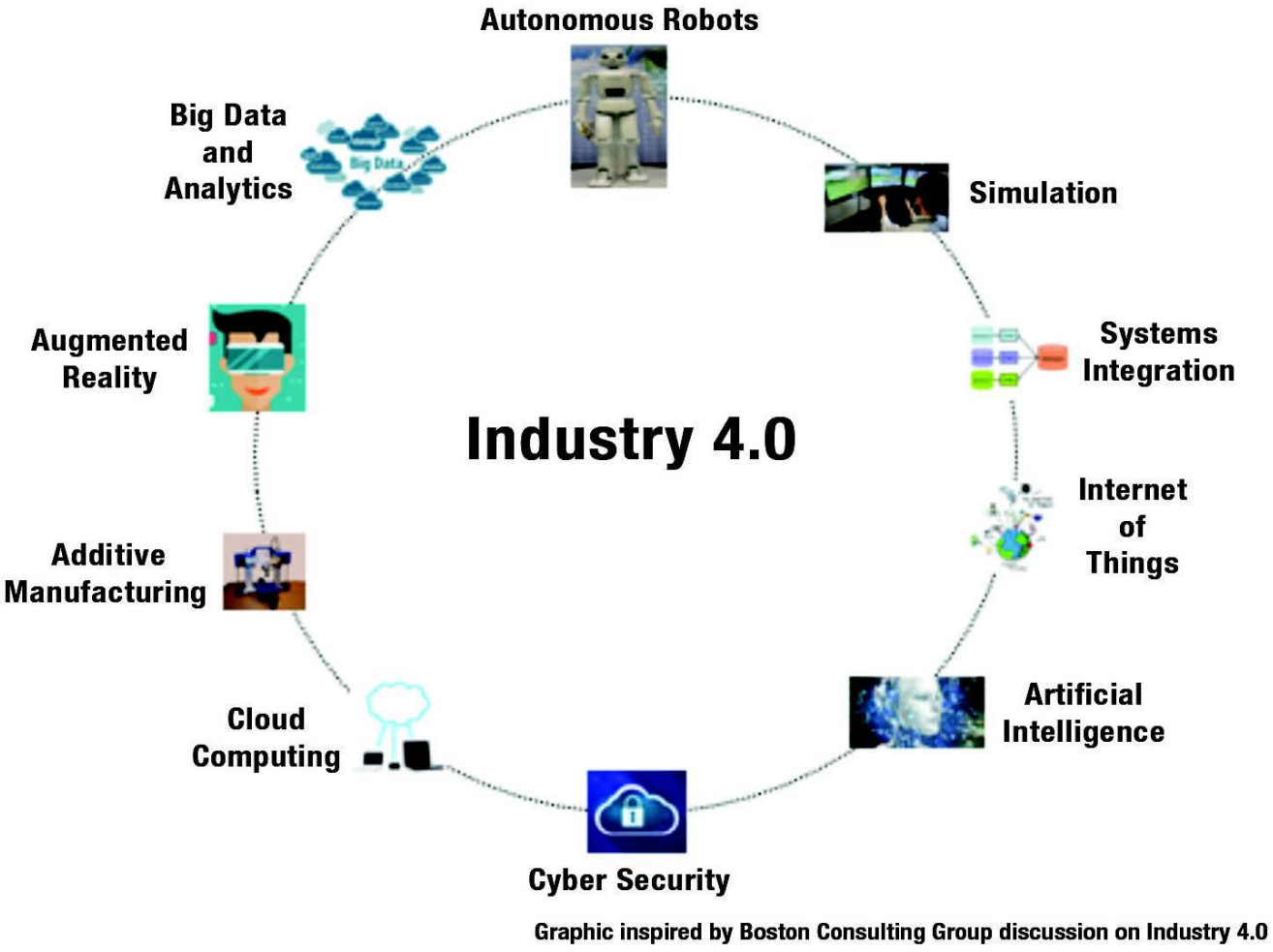


Keywords of Industrial Revolutions

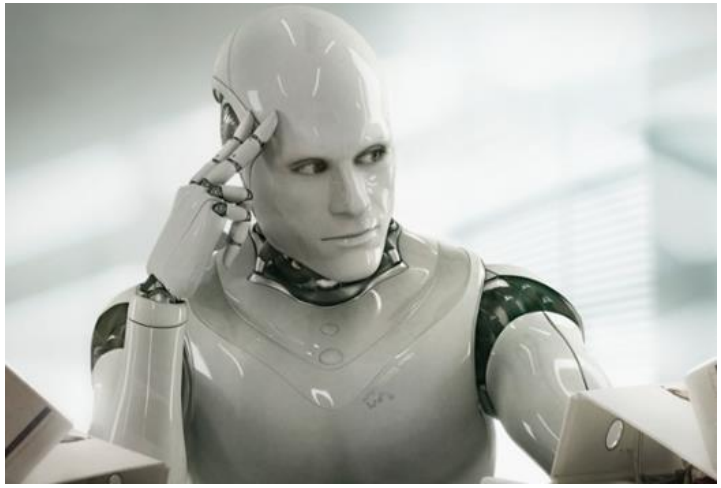
- Industrial revolution 1: Mechanisation
- Industrial revolution 2: Electrification
- Industrial revolution 3: Digitalisation
- Industrial revolution 4: Cyber-physical systems (intelligence & connectivity)

Cybernetics: the science of control and communications in the animal and machine

Industry 4.0


Autonomous Robots
Simulation
Systems Integration
Internet of Things
Artificial Intelligence
Cyber Security
Cloud Computing
Additive Manufacturing
Augmented Reality
Big Data and Analytics
Industry 4.0
Graphic inspired by Boston Consulting Group discussion on Industry 4.0

Intelligent System (#1)



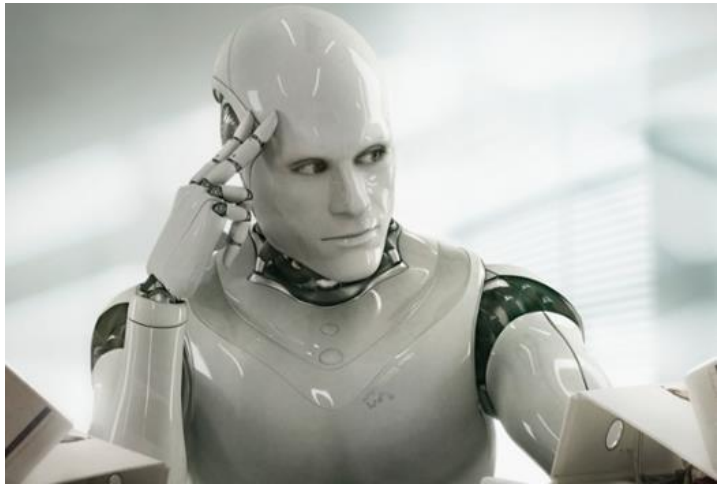
Intelligent system is simply defined as:
"a system that has intelligence".

Philosophers have been trying for over two thousand years to understand and resolve two big questions of the universe:

1. how does a human mind work?
2. can non-humans have minds?

These questions are still unanswered.

Intelligent Machine (#1)



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Intelligent Machine (#2)

- Some philosophers have picked up the computational approach originated by computer scientists and accepted the idea that machines can do everything that humans can do.

- Others have openly opposed this idea, claiming that such highly sophisticated behavior as love, creative discovery, and moral choice will always be beyond the scope of any machine.

- The nature of philosophy allows for disagreements to remain unresolved. In fact, engineers and scientists have already built machines that we can call ‘intelligent’.

The word ‘intelligence’ mean (#1)

1 Someone’s **intelligence** is their ability to understand and learn things.
2 **Intelligence** is the ability to think and understand instead of doing things by instinct or automatically.

(*Essential English Dictionary*, Collins, London, 1990)

According to the first definition, intelligence is the quality possessed by humans. But the second definition suggests a completely different approach and gives some flexibility; it does not specify whether it is someone or something that has the ability to think and understand.

The word ‘intelligence’ mean (#2)

Thinking is the activity of using your brain to consider a problem or to create an idea.

(*Essential English Dictionary*, Collins, London, 1990)

So, in order to think, someone or something has to have a brain, or in other words, an organ that enables someone or something to learn and understand things, to solve problems and to make decisions.

So we can define intelligence as
‘the ability to learn and understand, to solve problems and to make decisions’.

Intelligent Machine (#3)

- The very question that asks whether computers can be intelligent, or whether machines can think, came to us from the ‘dark ages’ of artificial intelligence (from the late 1940s).
- The goal of artificial intelligence (AI) as a science is to make machines do things that would require intelligence if done by humans (Boden, 1977).
- Therefore, the answer to the question ‘Can machines think?’ was vitally important to the discipline.
- Therefore, the answer to the question ‘Can machines think?’ was vitally important to the discipline. However, the answer is not a simple ‘Yes’ or ‘No’, but rather a vague or fuzzy one.
- As humans, we all have the ability to learn and understand, to solve problems and to make decisions; however, our abilities are not equal and lie in different areas.

Alan Turing (#1)

- One of the earliest and most significant papers on machine intelligence, ‘Computing machinery and intelligence’, was written by the British mathematician Alan Turing over fifty years ago (Turing, 1950).

- Alan Turing began his scientific career in the early 1930s by rediscovering the Central Limit Theorem.

- In 1937 he wrote a paper on computable numbers, in which he proposed the concept of a universal machine. Later, during the Second World War, he was a key player in deciphering Enigma, the German military encoding machine.

- After the war, Turing designed the ‘Automatic Computing Engine’. He also wrote the first program capable of playing a complete chess game; it was later implemented on the Manchester University computer.

Alan Turing (#2)

- Turing's theoretical concept of the universal computer and his practical experience in building code-breaking systems equipped him to approach the key fundamental question of artificial intelligence.

- Turing did not provide definitions of machines and thinking, he just avoided semantic arguments by inventing a game, ***the Turing imitation game***.

- Instead of asking, 'Can machines think?', Turing said we should ask, 'Can machines pass a behavior test for intelligence?'

- He predicted that by the year 2000, a computer could be programmed to have a conversation with a human interrogator for five minutes and would have a 30 per cent chance of deceiving the interrogator that it was a human.

Alan Turing (#3)

- Turing defined the intelligent behavior of a computer as the ability to achieve the human-level performance in cognitive tasks.

- In another words, a computer passes the test if interrogators cannot distinguish the machine from a human on the basis of the answers to their questions.

Turing Imitation Game (#1)

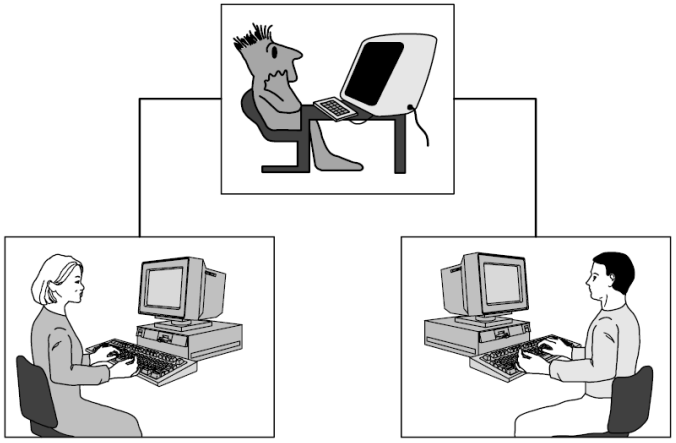


Figure 1.1 Turing imitation game: phase 1

The imitation game proposed by Turing originally included two phases.

1) In the first phase, shown in Figure 1.1, the interrogator, a man and a woman are each placed in separate rooms and can communicate only via a neutral medium such as a remote terminal.

   The interrogator's objective is to work out who is the man and who is the woman by questioning them. The rules of the game are that the man should attempt to deceive the interrogator that he is the woman, while the woman has to convince the interrogator that she is the woman.

Turing Imitation Game (#2)

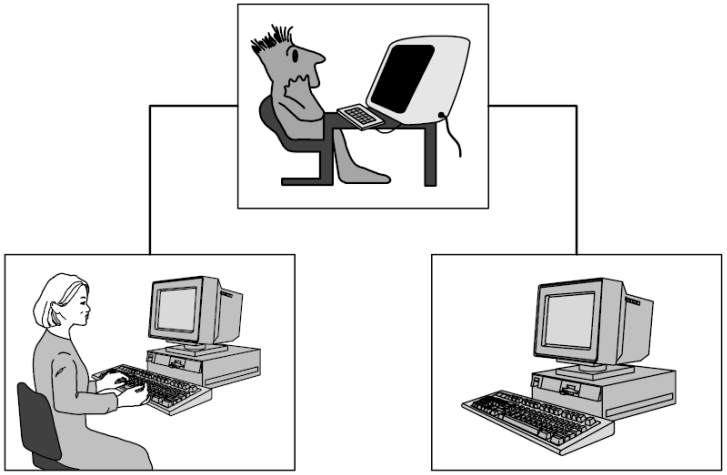


Figure 1.2 Turing imitation game: phase 2

2) In the second phase of the game, shown in Figure 1.2, the man is replaced by a computer programmed to deceive the interrogator as the man did. It would even be programmed to make mistakes and provide fuzzy answers in the way a human would. If the computer can fool the interrogator as often as the man did, we may say this computer has passed the intelligent behavior test.

Turing Imitation Game (#3)

- Physical simulation of a human is not important for intelligence. Hence, in the Turing test the interrogator does not see, touch or hear the computer and is therefore not influenced by its appearance or voice.
- However, the interrogator is allowed to ask any questions, even provocative ones, in order to identify the machine. The interrogator may, for example, ask both the human and the machine to perform complex mathematical calculations, expecting that the computer will provide a correct solution and will do it faster than the human.
- Thus, the computer will need to know when to make a mistake and when to delay its answer.
- The interrogator also may attempt to discover the emotional nature of the human, and thus, he might ask both subjects to examine a short novel or poem or even painting. Obviously, the computer will be required here to simulate a human's emotional understanding of the work.

Turing Imitation Game (#4)

- Turing believed that by the end of the 20th century it would be possible to program a digital computer to play the imitation game.
- Although modern computers still cannot pass the Turing test, it provides a basis for the verification and validation of knowledge-based systems.
- A program thought intelligent in some narrow area of expertise is evaluated by comparing its performance with the performance of a human expert.
- Our brain stores the equivalent of over 1018 bits and can process information at the equivalent of about 1015 bits per second. By 2020, the brain will probably be modelled by a chip the size of a sugar cube – and perhaps by then there will be a computer that can play – even win – the Turing imitation game.

Negnevitsky M., "*Artificial Intelligence – A Guide to Intelligent System*" 2005

Turing Imitation Game (#5)

- However, do we really want the machine to perform mathematical calculations as slowly and inaccurately as humans do? From a practical point of view, an intelligent machine should help humans to make decisions, to search for information, to control complex objects, and finally to understand the meaning of words.

- There is probably no point in trying to achieve the abstract and elusive goal of developing machines with human-like intelligence. To build an intelligent computer system, we have to capture, organize and use human expert knowledge in some narrow area of expertise.

Turing Imitation Game (#6)

- https://www.youtube.com/watch?v=8YUqHLxsmS0
- https://www.youtube.com/watch?v=sXx-PpEBR7k
- Home work: watch movie The Imitation Game 2014

https://www.youtube.com/watch?v=U_xE807vc6g

Quantify the Intelligence of a System

- The adjective *intelligent* (or *smart*) is frequently applied to many common engineering systems
- Though it is hard to quantify the intelligence of a system, one can certainly recognize the following two extremes in relation to some of the characteristics that it may possess:

  (a) Low intelligence: Typically a simple system, it has to be “told" everything and needs complete instructions, needs low-level control, the parameters are set, it is usually mechanical.

  (b) High intelligence: Typically a complex system, it is autonomous to a certain extent and needs few instructions, determines for itself what the goals are, demands high-level control, adaptive, makes decisions and choices, it is usually computerized.

Dr. Mihir Sen, 2006

Smart vs Intelligent

- Smart: Performing actions based on direct input of information or data
- Intelligent: Performing actions based on common sense, experience, and the ability to adapt, taking **context** into account

Jennifer N. Boger, 2009

Definition of Intelligent System

An intelligent system is one that emulates some aspects of intelligence exhibited by nature. These include:

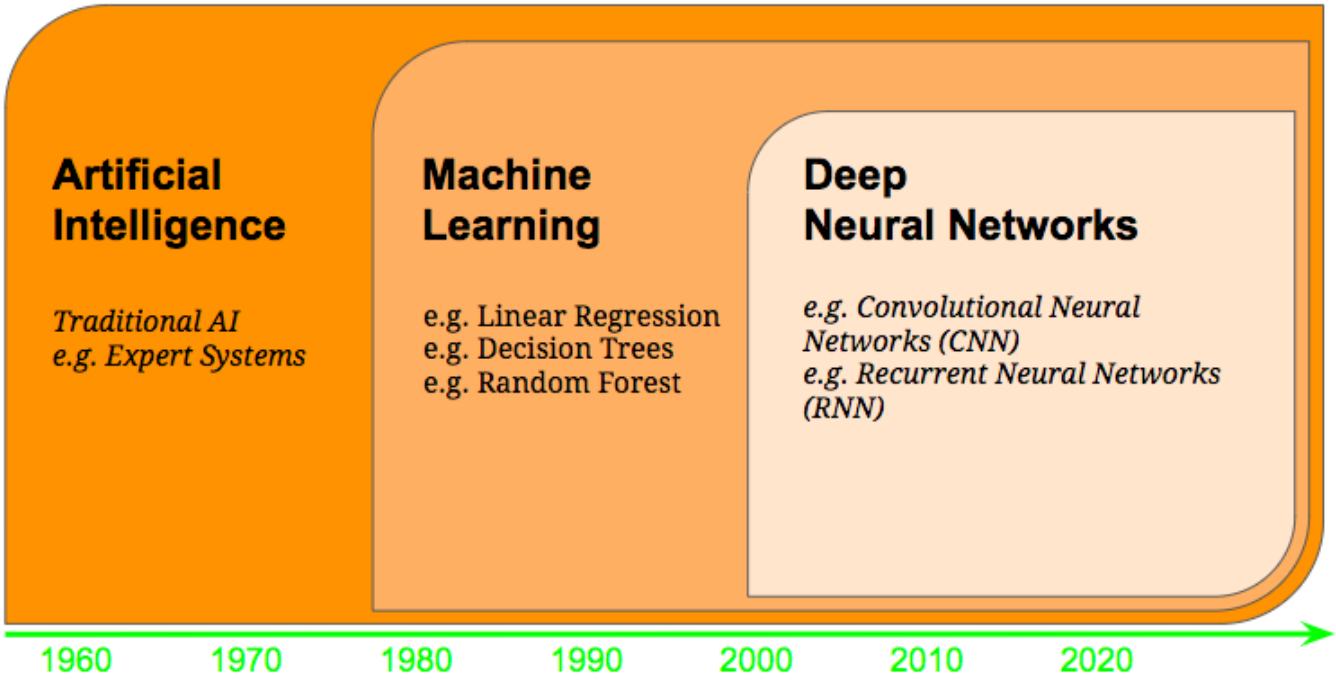
1. Learning
2. Adaptability
3. Robustness across problem domains
4. Improving efficiency (over time and/or space)
5. Information compression (data to knowledge)
6. Extrapolated reasoning

Krishna Kumar, "*Intelligent Systems For Aerospace Engineering--An Overview*"

Artificial Intelligence (AI)

Definition of Artificial Intelligence

- AI is a computer science field that started around 1956, with the premise of bringing human intelligence to computers.



Source:
https://medium.datadriveninvestor.com/artificial-intelligence-premier-for-business-leaders-b44bf7772bd8

Several Types of Artificial Intelligence

1950s – Researchers begin pondering whether computers can think like humans and devise **Symbolic AI** – e.g. chess programs

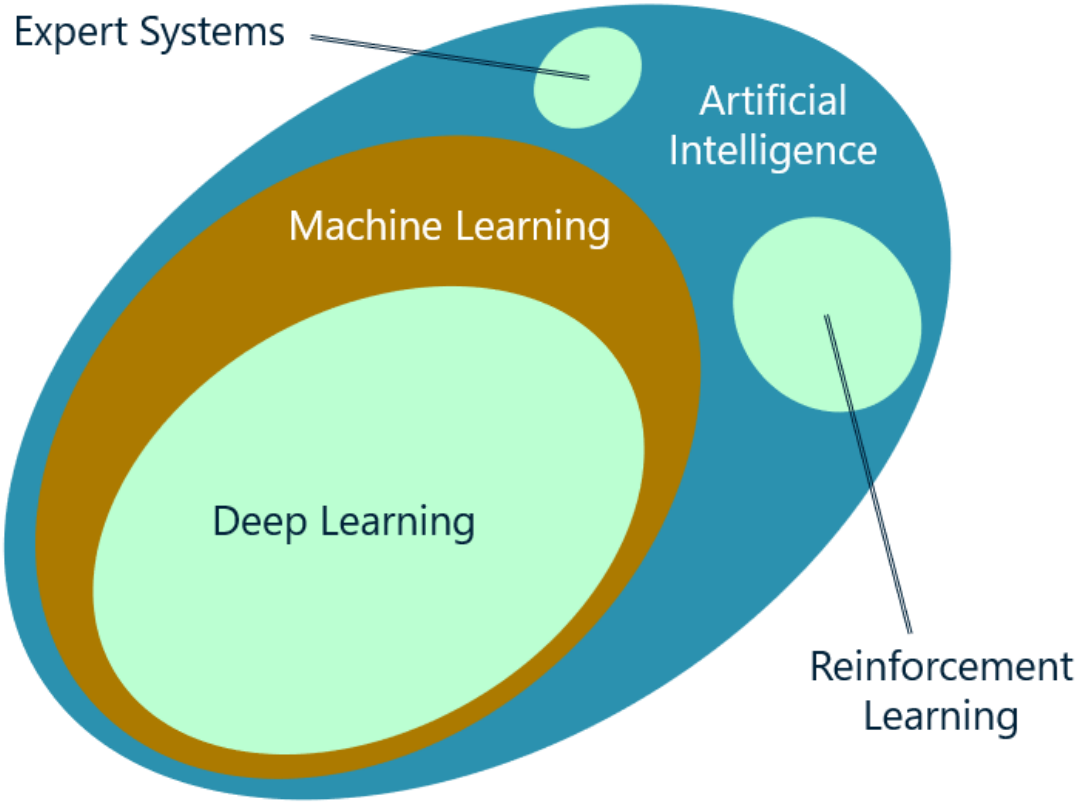
1960s – Early **neural networks** are devised, but training is impractical due to lack of computing power and access to compute resources

1980s – Researchers improve **back-propagation algorithms** for training neural networks and apply them to convolutional neural networks

1990s – Researchers at Bell Labs invent the modern **Support Vector Machine** (SVM) algorithm for discovering decision boundaries

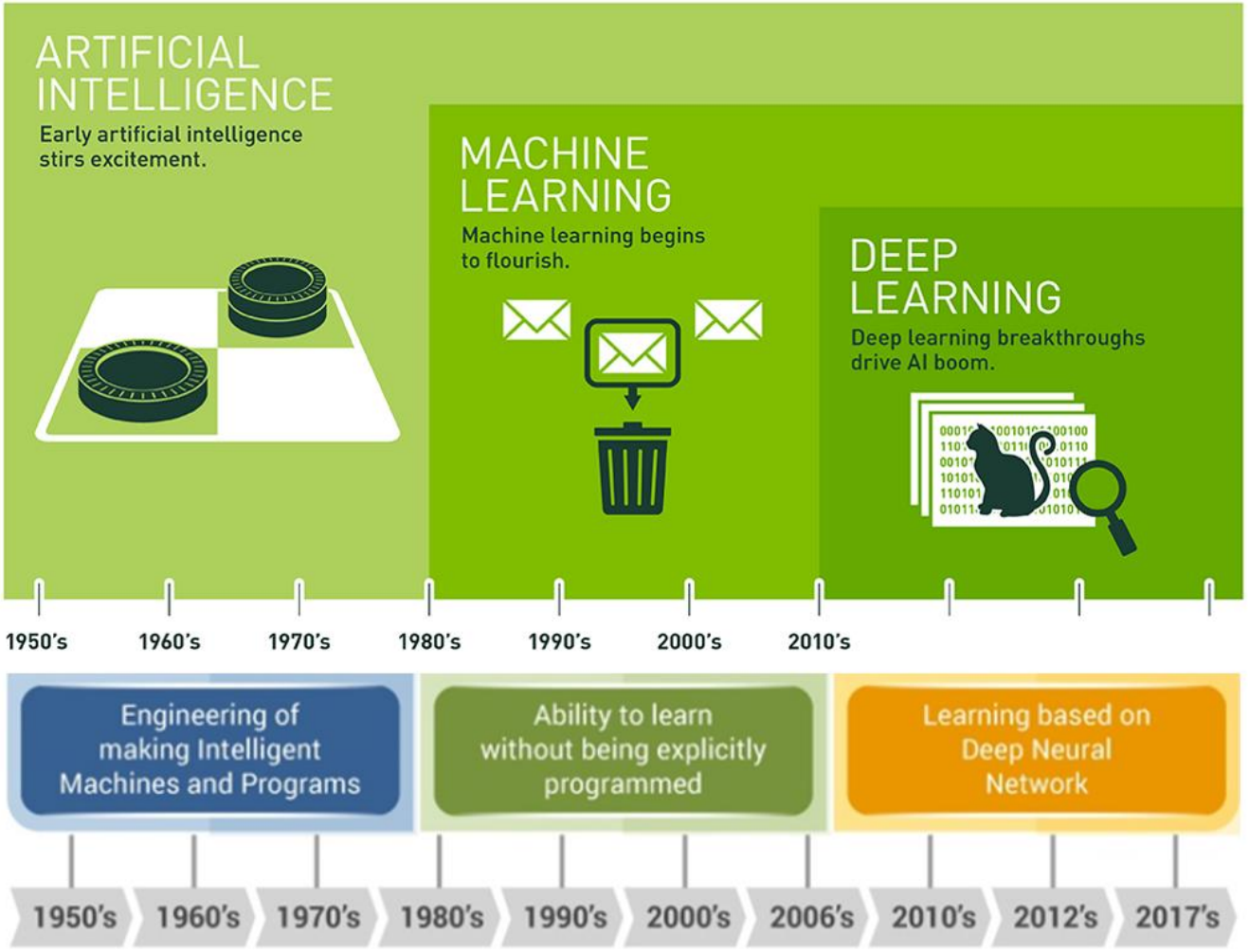
2000s – Algorithmic advances in machine learning give rise to **decision trees, random forests, gradient-boosting machines**, and more

2010s – ML and AI explode due to faster computing hardware (especially **GPUs**), expanded availability of data, and increased research funding

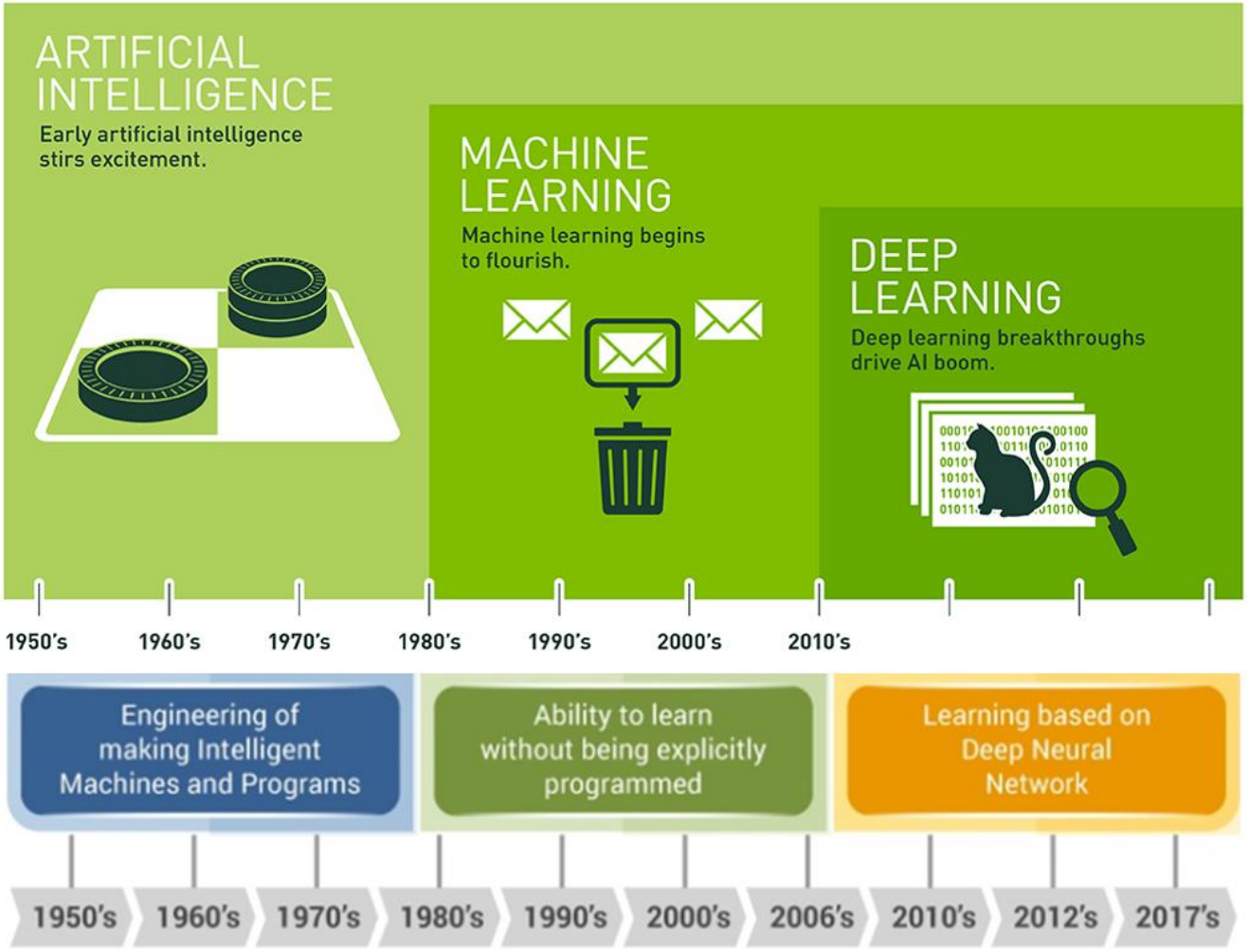


Source:
https://www.wintellect.com/machine-learning-and-ai-for-software-developers/

AI Evolution



AI Evolution (#1)



AI Evolution (#2)