Universiti Malaysia PAHANG
Engineering • Technology • Creativity

CHAPTER 1
Introduction to Artificial Intelligence

ARTIFICIAL INTELLIGENCE (BSD2513)
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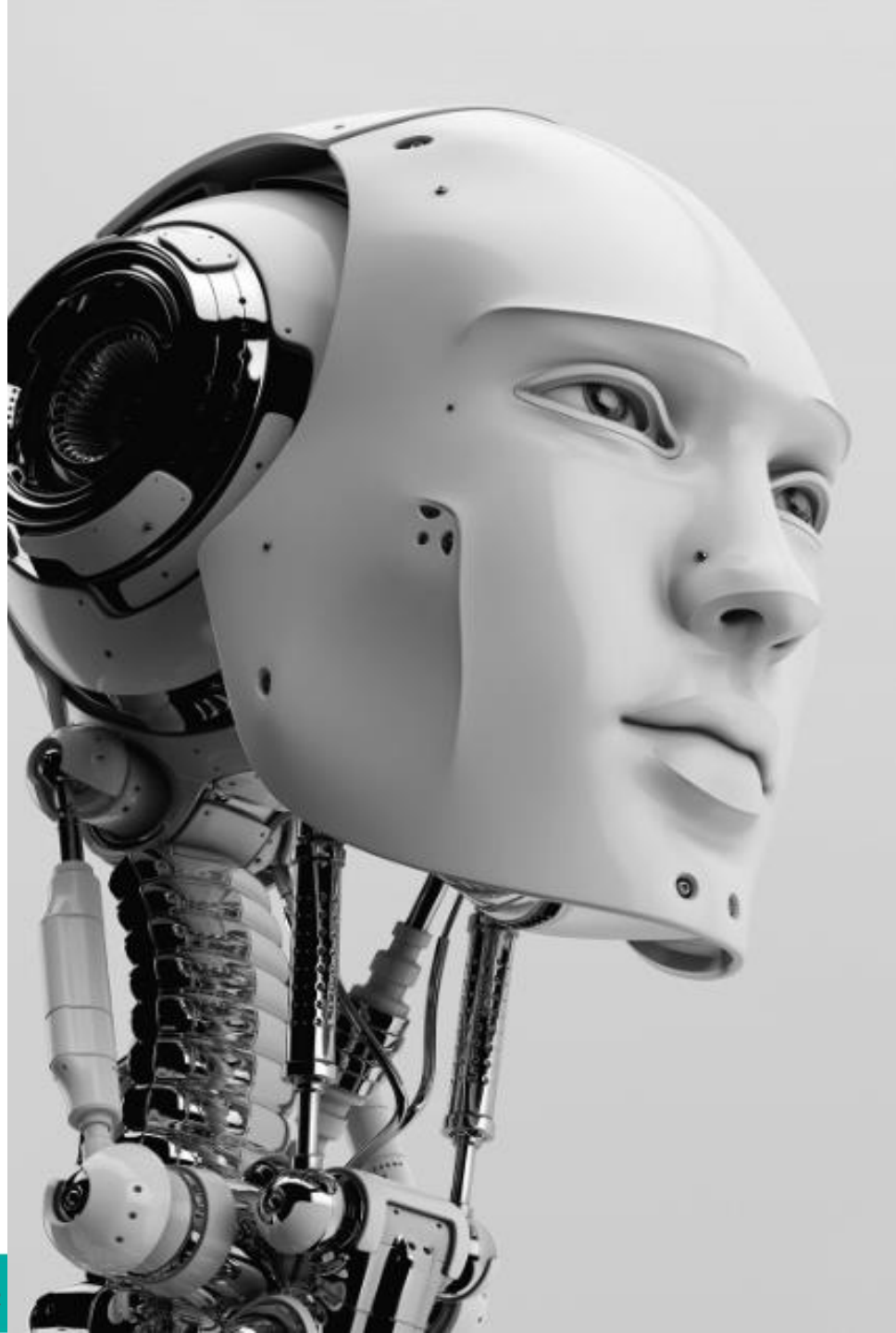
Content

Chapter 1.1: Concepts of Artificial Intelligence

By the end of this topic, you should be able to:

- understand the concept of artificial intelligence (AI) and how it's applied in the real world.
- understand the needs why to study artificial intelligence.
- acquire the knowledge regarding the history of artificial intelligence.



An Overview

- Human being spend a significant portion interacting with smart systems for every single day.
- This can be in the form of searching for something on the internet, biometric facial recognition, or converting spoken words to text.
- AI is at the heart of all this and it's becoming an important part of our modern lifestyle.
- All these systems are complex real-world applications and AI solves these problems with data supported mathematics and algorithms.

- John McCarthy first coined the term artificial intelligence in 1956 when he invited a group of researchers from a variety of disciplines including language simulation, neuron nets, complexity theory.
- McCarthy spent most of his career at Stanford University.
- He received many accolades and honors, such as the 1971 Turing Award for his contributions to the topic of AI, the United States National Medal of Science, and the Kyoto Prize.

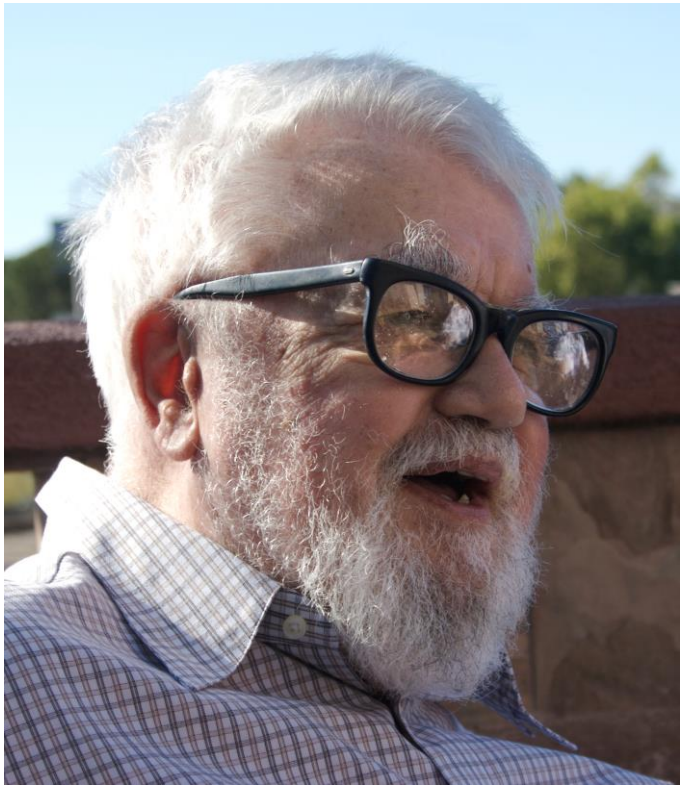


Figure 1.1: John McCarthy at a conference in 2006.

AI Definitions

"Artificial intelligence is an entity (or collective set of cooperative entities), able to receive inputs from the environment, interpret and learn from such inputs, and exhibit related and flexible behaviors and actions that help the entity achieve a particular goal or objective over a period of time."

(emerj,2021)

"Artificial intelligence (AI) is wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence. AI is an interdisciplinary science with multiple approaches, but advancements in machine learning and deep learning are creating a paradigm shift in virtually every sector of the tech industry."

(builtin,2021)

"Artificial intelligence (AI) is the capability of a computer to imitate intelligent human behavior. Through AI, machines can analyze images, comprehend speech, interact in natural ways, and make predictions using data."

(Microsoft, 2021)

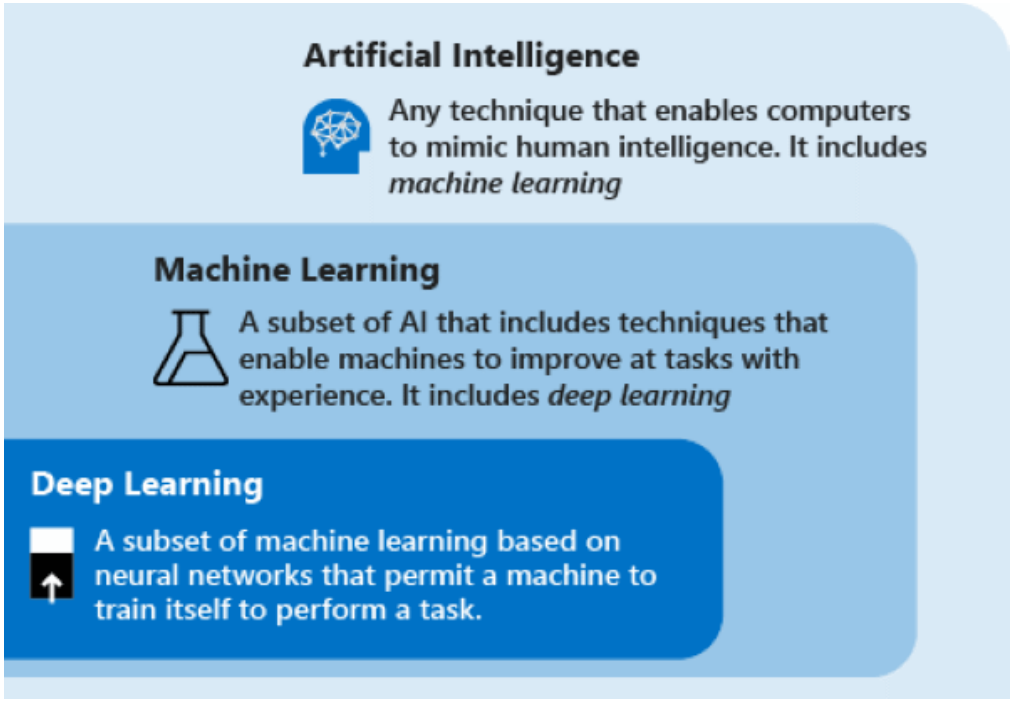


Figure 1.2: The connection oh set knowledge of AI.

- There is a close connection and overlap among the fields of machine learning, AI, and deep learning, as depicted in Figure 1.3.
- AI can be understood as the quest for developing non-biological systems that exhibit human-like forms of intelligence.
- Early and promising approaches included symbolic models and reasoning, early versions of neural networks, and expert systems.

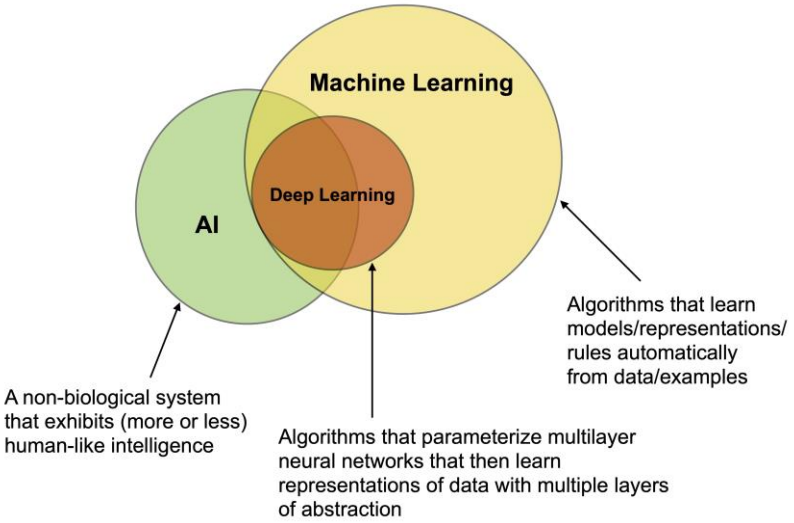
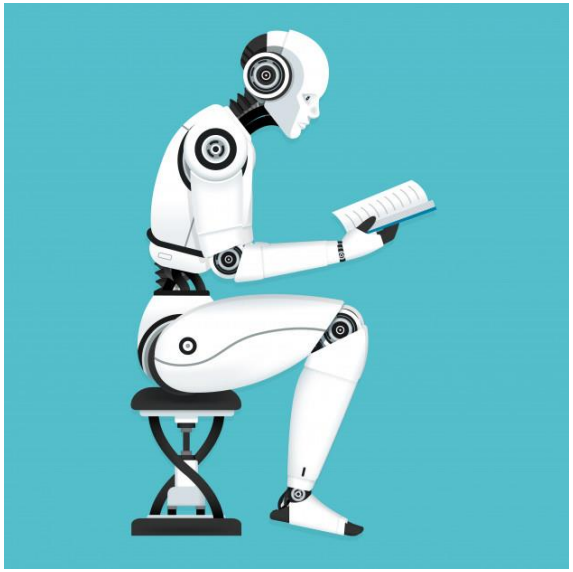


Figure 1.3: The close connection and overlap between the fields of machine learning, deep learning, and AI.

Why do We Need to Study AI?

Making Machines Think Like Humans

- Once we gather enough data, we can create a model to simulate the human process. This model can be used to create software that can think like humans. Of course, this is easier said than done!
- All we care about is the output of the program given an input. If the program behaves in a way that matches human behavior, then we can say that humans have a similar thinking mechanism.



- The following diagram shows different levels of thinking and how our brain prioritizes things:

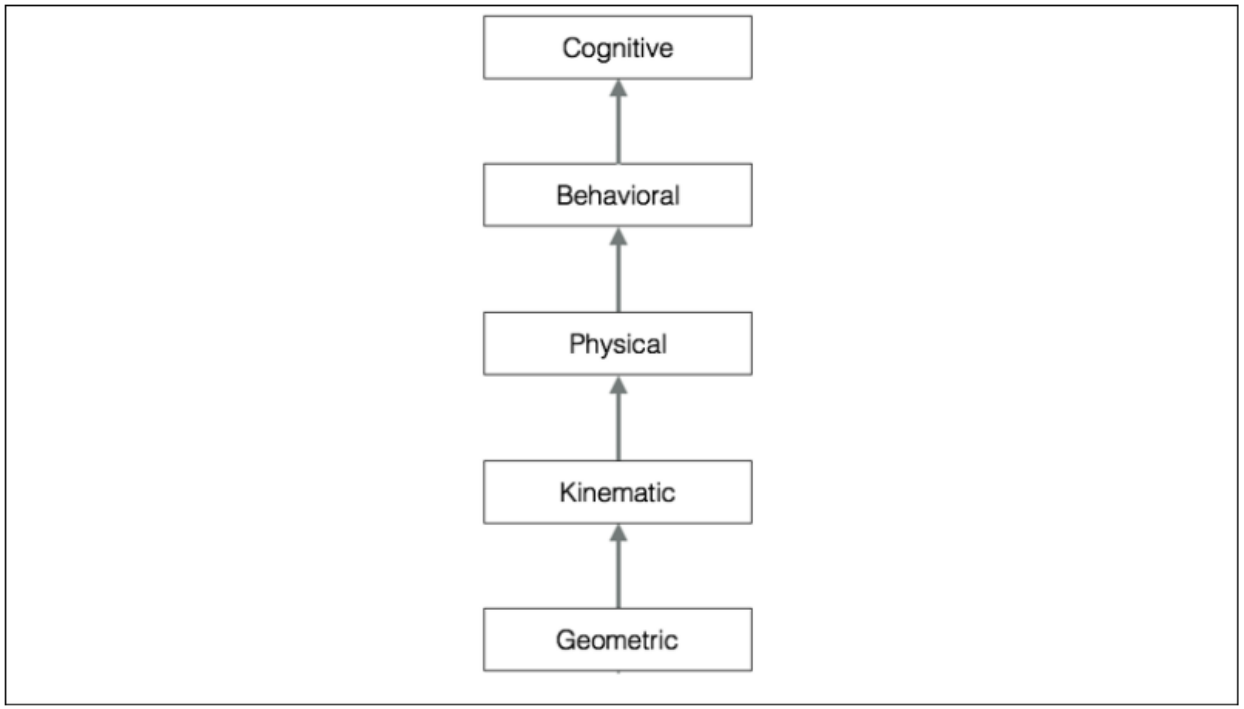
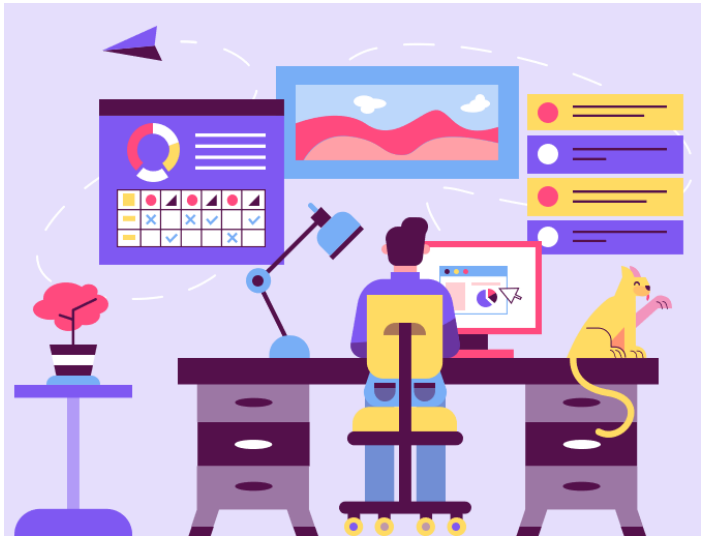


Figure 1.4: The levels of thought

- Within computer science, there is a field of study called **Cognitive Modeling** that deals with simulating the human thinking process.
- It tries to understand how humans solve problems. It takes the mental processes that go into this problem-solving process and turns it into a software model. This model can then be used to simulate human behavior.
- Cognitive modeling is used in a variety of AI applications such as deep learning, expert systems, natural language processing, robotics, and so on.



History of AI

- Artificial Intelligence is a buzz word that in not new word or technology for researchers. Even there are the myths of Mechanical men in Ancient Greek and Egyptian Myths.

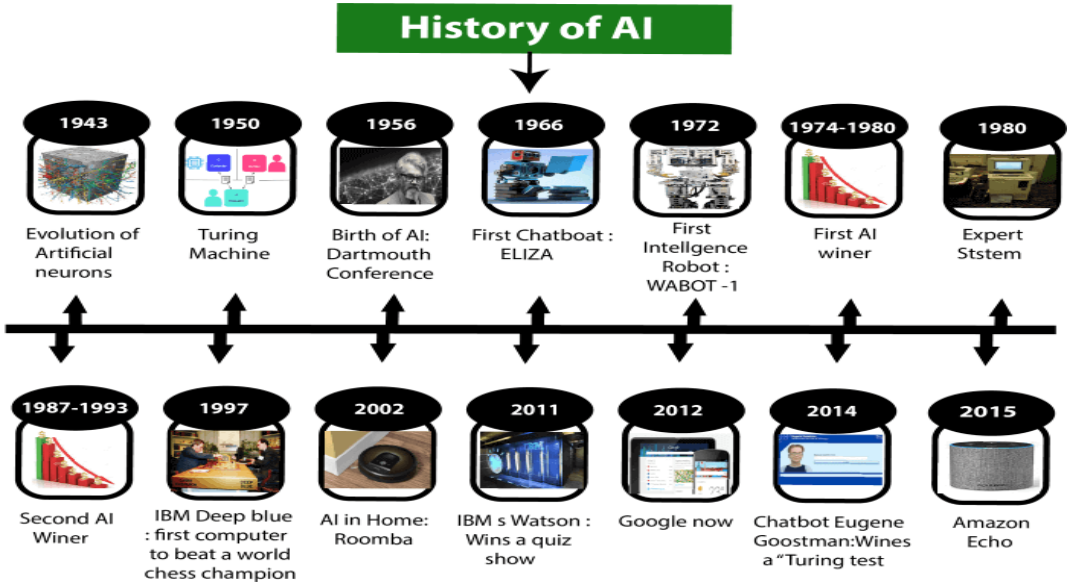


Figure 1.4: AI development milestone.

Maturation of Artificial Intelligence (1943-1952)

Year 1943: The first work which is now recognized as AI was done by Warren McCulloch and Walter pits in 1943.

Year 1949: Donald Hebb demonstrated an updating rule for modifying the connection strength between neurons. His rule is now called Hebbian learning.

Year 1950: The Alan Turing who was an English mathematician and pioneered Machine learning in 1950. Alan Turing publishes "Computing Machinery and Intelligence" in which he proposed a test. The test can check the machine's ability to exhibit intelligent behavior equivalent to human intelligence, called a Turing test.

The birth of Artificial Intelligence (1952-1956)

Year 1955: An Allen Newell and Herbert A. Simon created the "first artificial intelligence program"Which was named as "Logic Theorist". This program had proved 38 of 52 Mathematics theorems, and find new and more elegant proofs for some theorems.

Year 1956: The word "Artificial Intelligence" first adopted by American Computer scientist John McCarthy at the Dartmouth Conference. For the first time, AI coined as an academic field.

At that time high-level computer languages such as FORTRAN, LISP, or COBOL were invented. And the enthusiasm for AI was very high at that time.

The golden years-Early enthusiasm (1956-1974)

Year 1966: The researchers emphasized developing algorithms which can solve mathematical problems. Joseph Weizenbaum created the first chatbot in 1966, which was named as ELIZA.

Year 1972: The first intelligent humanoid robot was built in Japan which was named as WABOT-1.

The first AI winter (1974-1980)

The duration between years 1974 to 1980 was the first AI winter duration. AI winter refers to the time period where computer scientist dealt with a severe shortage of funding from government for AI researches.

During AI winters, an interest of publicity on artificial intelligence was decreased.

A boom of AI (1980-1987)

Year 1980: After AI winter duration, AI came back with "Expert System". Expert systems were programmed that emulate the decision-making ability of a human expert.

In the Year 1980, the first national conference of the American Association of Artificial Intelligence was held at Stanford University.

The second AI winter (1987-1993)

The duration between the years 1987 to 1993 was the second AI Winter duration.

Again Investors and government stopped in funding for AI research as due to high cost but not efficient result. The expert system such as XCON was very cost effective.

The emergence of intelligent agents (1993-2011)

Year 1997: In the year 1997, IBM Deep Blue beats world chess champion, Gary Kasparov, and became the first computer to beat a world chess champion.

Year 2002: for the first time, AI entered the home in the form of Roomba, a vacuum cleaner.

Year 2006: AI came in the Business world till the year 2006. Companies like Facebook, Twitter, and Netflix also started using AI.

Deep learning, big data and artificial general intelligence (2011-present)

Year 2011: In the year 2011, IBM's Watson won jeopardy, a quiz show, where it had to solve the complex questions as well as riddles. Watson had proved that it could understand natural language and can solve tricky questions quickly.

Year 2012: Google has launched an Android app feature "Google now", which was able to provide information to the user as a prediction.

Year 2014: In the year 2014, Chatbot "Eugene Goostman" won a competition in the infamous "Turing test."

Year 2018: The "Project Debater" from IBM debated on complex topics with two master debaters and also performed extremely well.

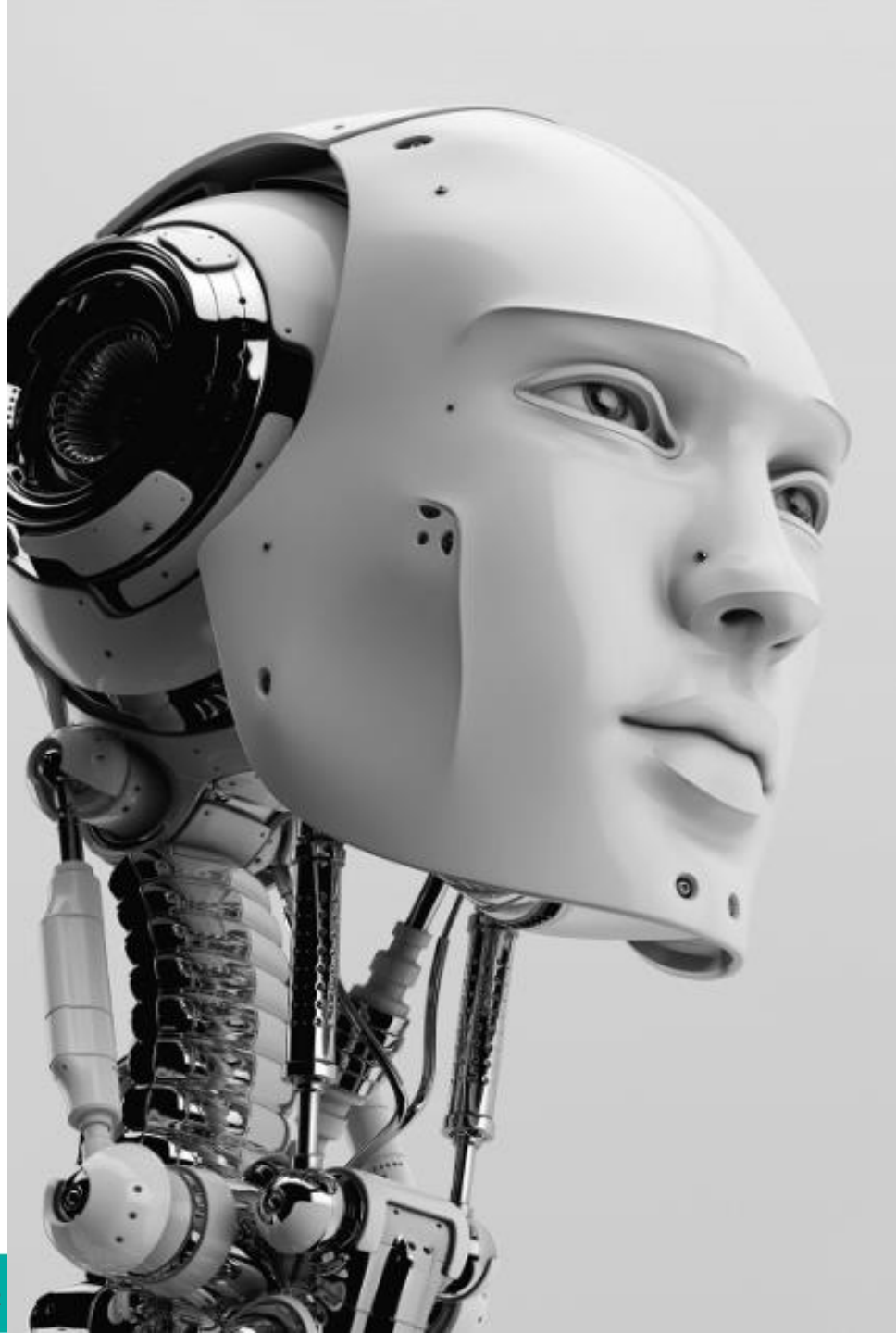
Google has demonstrated an AI program "Duplex" which was a virtual assistant and which had taken hairdresser appointment on call, and lady on other side didn't notice that she was talking with the machine.

Now AI has developed to a remarkable level. The concept of Deep learning, big data, and data science are now trending like a boom. Nowadays companies like Google, Facebook, IBM, and Amazon are working with AI and creating amazing devices. The future of Artificial Intelligence is inspiring and will come with high intelligence.

Chapter 1.2: Types of Artificial Intelligence

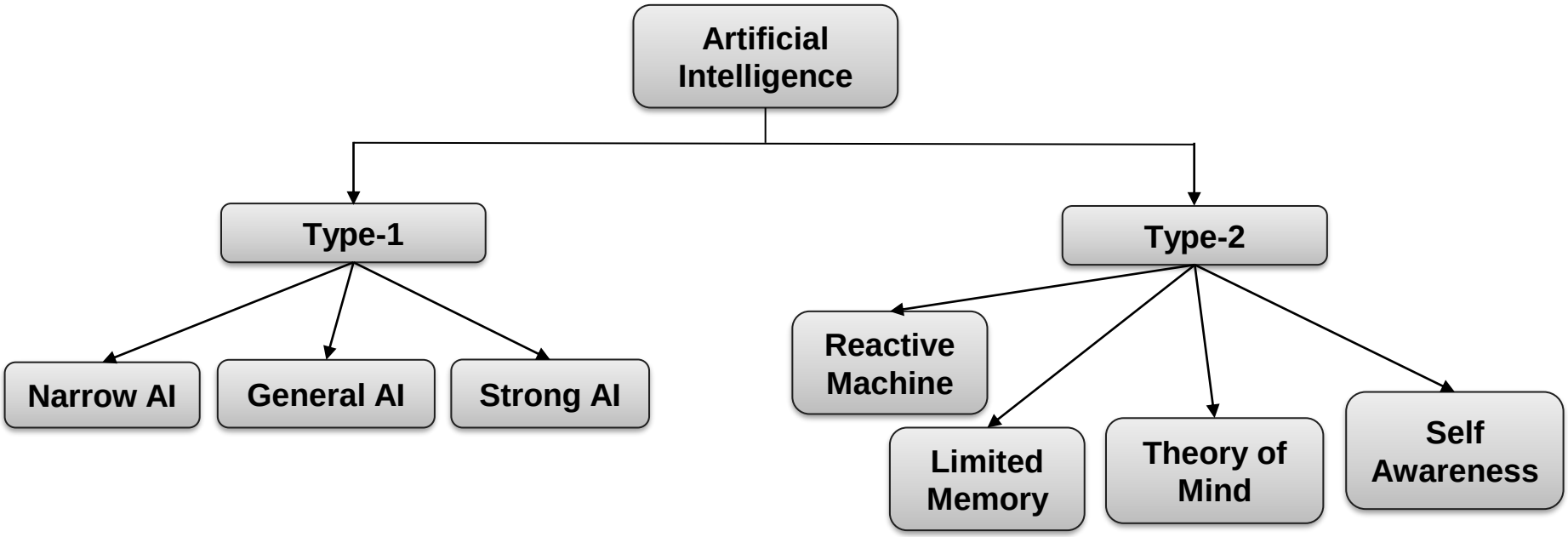
By the end of this topic, you should be able to:

- understand the difference perspective types of artificial intelligence (AI) between capabilities and functionality.
- understand the applications of these types in the real world.



Types of Artificial Intelligence

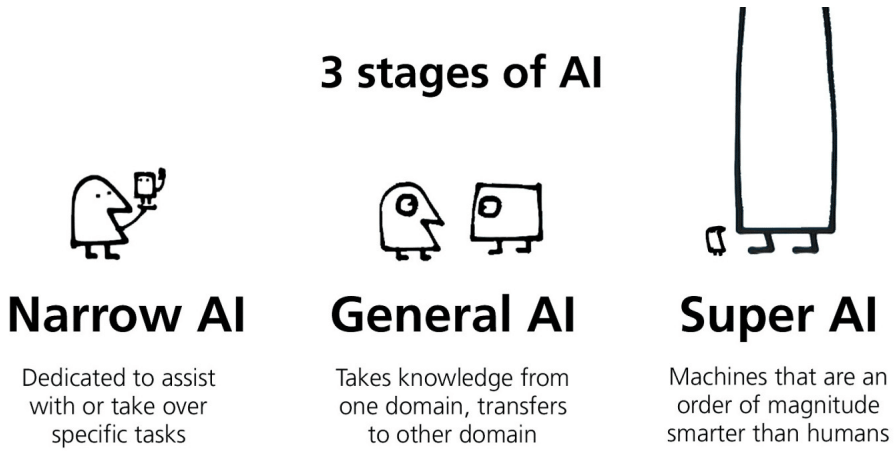
Artificial Intelligence can be divided in various types, there are mainly two types of main categorization which are based on capabilities and based on functionally of AI. Following is flow diagram which explain the types of AI.



Type-1: Based on Capabilities

These are the three type-1 through which AI can evolve:

1. Artificial Narrow Intelligence (ANI)
2. Artificial General Intelligence (AGI)
3. Artificial Super Intelligence (ASI)



Artificial Narrow Intelligence (ANI)

- Also known as Weak AI, ANI is the stage of AI involving machines that can perform only a narrowly defined set of specific tasks.
- At this stage, the **machine does not possess any thinking ability**, it just performs a set of pre-defined functions.
- Examples of Weak AI include Siri, Alexa, Self-driving cars, Alpha-Go, Sophia the humanoid and so on. Almost all the AI-based systems built till this date fall under the category of Weak AI.

Figure 1.5: Siri – built-in, voice controlled personal assistant available for Apple users.

Artificial General Intelligence (AGI)

- Also known as Strong AI, AGI is the stage in the evolution of AI wherein **machines will possess the ability to think and make decisions just like us humans.**
- There are currently no existing examples of Strong AI, however, it is believed that we will soon be able to create machines that are as smart as humans.
- Strong AI is considered a threat to human existence by many scientists, including Stephen Hawking.

Artificial Super Intelligence (ASI)

- Artificial Super Intelligence is the stage of AI when the capability of computers will surpass human beings.
- ASI is currently a hypothetical situation as depicted in movies and science fiction books, where machines have taken over the world.
- I believe that machines are not very far from reaching this stage taking into considerations our current pace.
- Elon Musk said, The pace of progress in artificial intelligence is incredibly fast. Unless you have direct exposure to groups like Deepmind, you have no idea how fast—it is growing at a pace close to exponential. The risk of something seriously dangerous happening is in the five-year timeframe. 10 years at most.

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AI Type-2: Based on Functionality

When someone asks you to explain the different types of Artificial Intelligence systems, you must categorize them based on their functionalities.

Based on the functionality of AI-based systems, AI can be categorized into the following types (Zulaikha Lateef, 2020):

1. Reactive Machines AI
2. Limited Memory AI
3. Theory of Mind AI
4. Self-aware AI

Reactive Machine AI

- This type of AI includes machines that operate solely based on the present data, taking into account only the current situation.
- Reactive AI machines cannot form inferences from the data to evaluate their future actions. They can perform a narrowed range of pre-defined tasks.
- An example of Reactive AI is the famous IBM Chess program that beat the world champion, Garry Kasparov.

Figure 1.6: Reactive Machine AI.

Limited Memory AI

- Like the name suggests Limited Memory AI, can make informed and improved decisions by studying the past data from its memory.
- Such an AI has a short-lived or a temporary memory that can be used to store past experiences and hence evaluate future actions.
- Self-driving cars are Limited Memory AI, that uses the data collected in the recent past to make immediate decisions.
- For example, self-driving cars use sensors to identify civilians crossing the road, steep roads, traffic signals and so on to make better driving decisions. This helps to prevent any future accidents.

Figure 1.7: Limited Memory AI.

Theory of Mind AI

- The Theory Of Mind AI is a more advanced type of Artificial Intelligence.
- This category of machines is speculated to play a major role in psychology.
- This type of AI will focus mainly on **emotional intelligence** so that human believes and thoughts can be better comprehended.
- The Theory of Mind AI has not yet been fully developed but rigorous research is happening in this area.

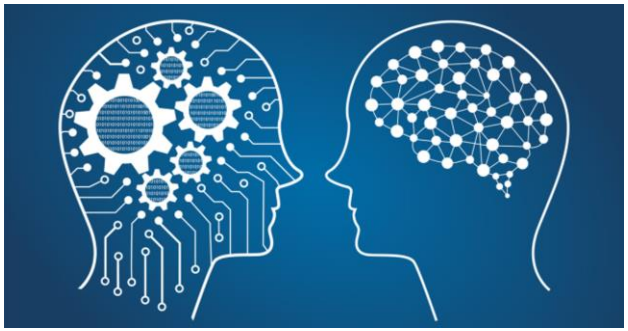


Figure 1.8: Theory of Mind AI.

Self-Aware AI

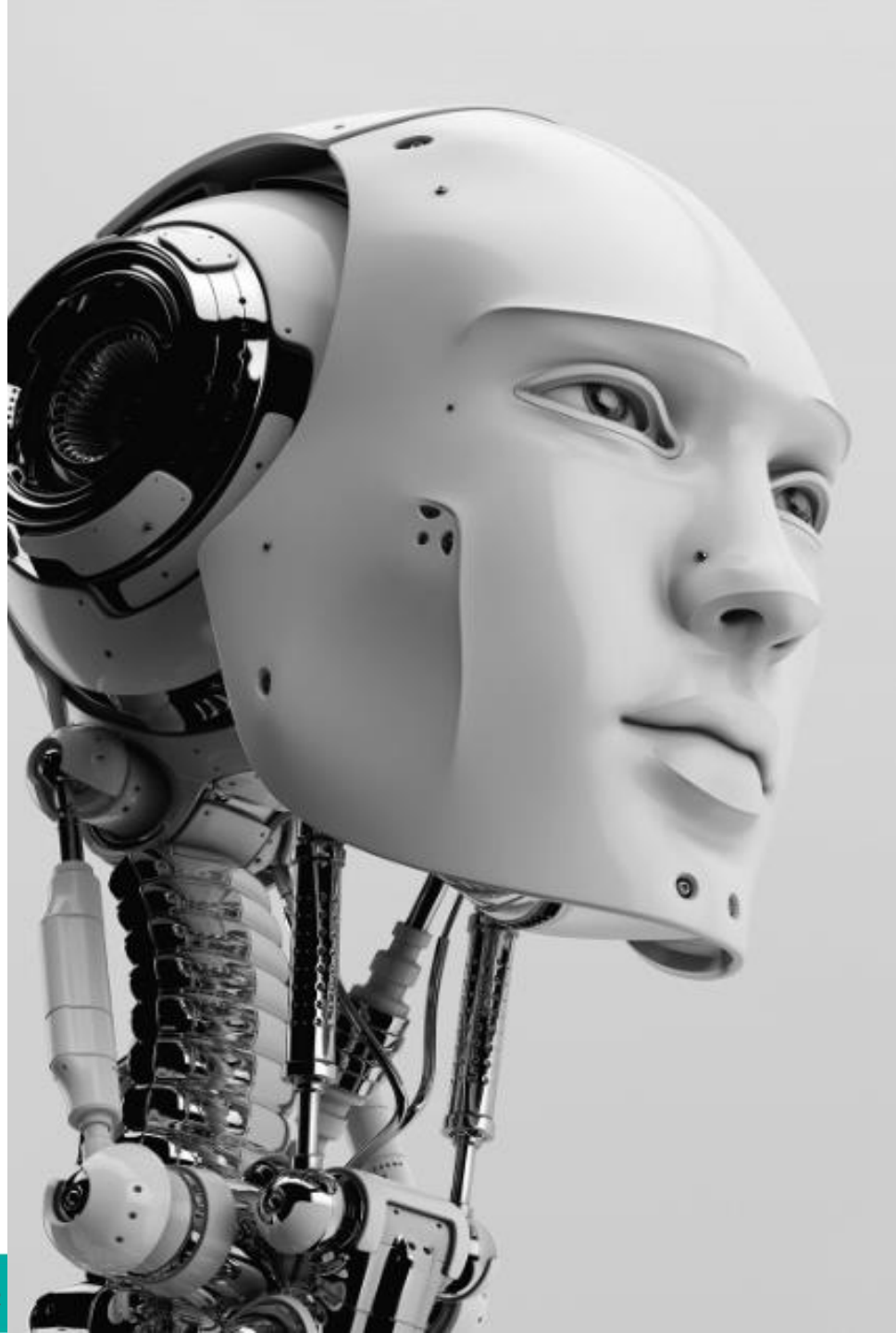
- Let's just pray that we don't reach the state of AI, where machines have their own consciousness and become self-aware.
- This type of AI is a little far fetched given the present circumstances. However, in the future, achieving a stage of superintelligence might be possible.
- Geniuses like Elon Musk and Stephen Hawkings have consistently warned us about the evolution of AI. Let me know your thoughts on this in the comment section.

Figure 1.9: Reactive Machine AI.

Chapter 1.3: Branches of Artificial Intelligence

By the end of this topic, you should be able to:

- understand the branches of artificial intelligence (AI).
- recognize that have been applied in the real world phenomena.



Branches of AI

It is important to understand the various fields of study within AI so that we can choose the right framework to solve a given real-world problem. Here's a list of topics that are dominant by human function:

1. Machine Learning
2. Deep Learning
3. Natural Language Processing
4. Robotics
5. Expert Systems
6. Fuzzy Logic

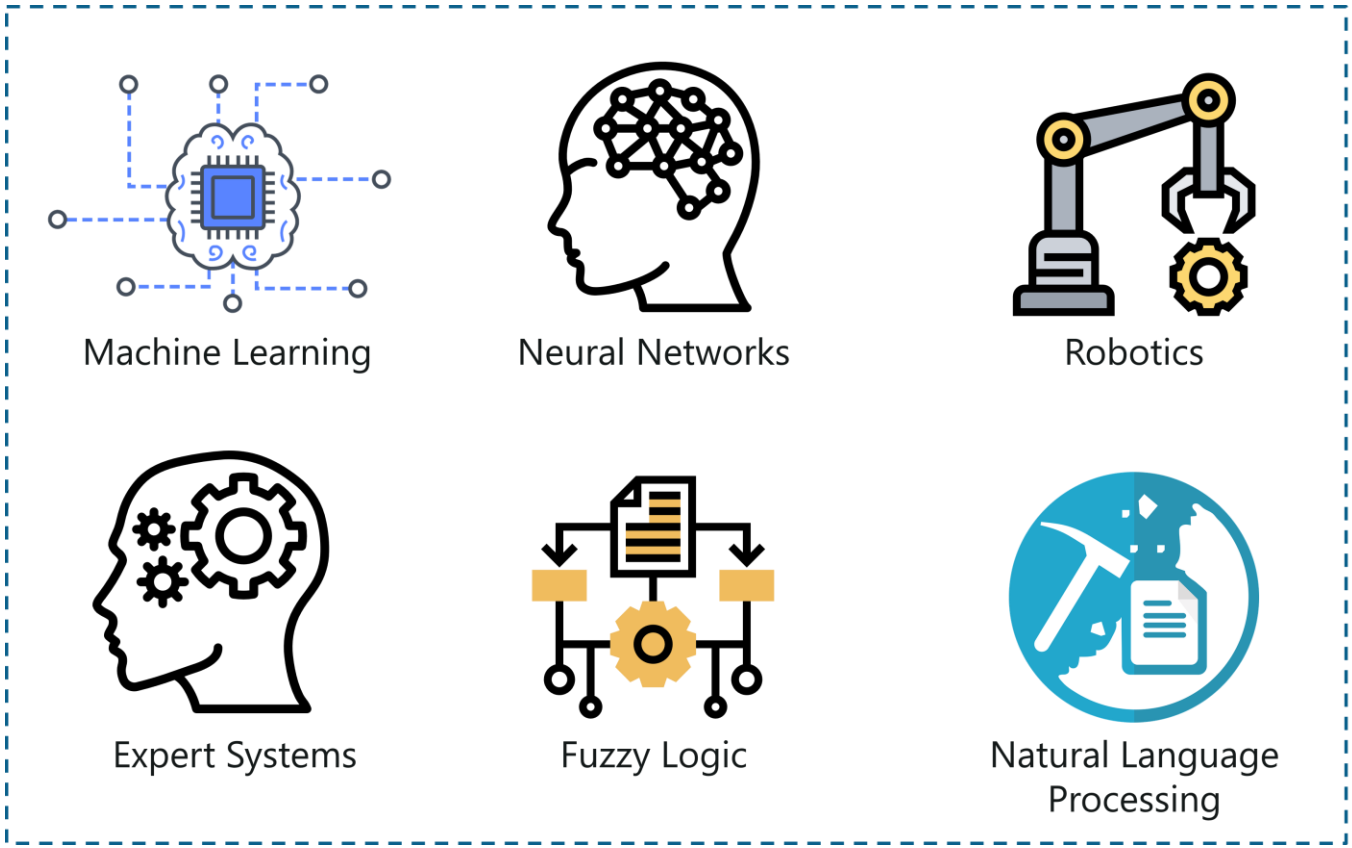


Figure 1.10: The branches of AI.

Machine Learning

- Machine learning is the science of getting machines to interpret, process and analyze data in order to solve real-world problems.
- Under machine learning there are three categories:
  a. Supervised learning
  b. Unsupervised learning
  c. Reinforcement learning

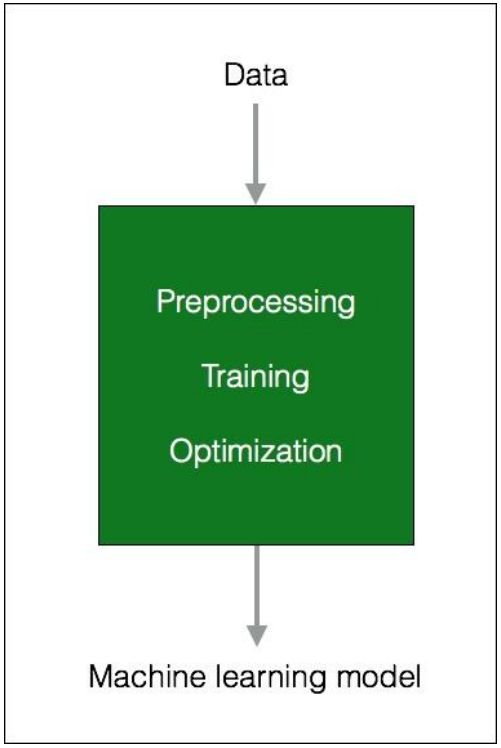


Figure 1.11: Typical machine learning system

Deep Learning

- Deep learning is the process of implementing Neural Networks on high dimensional data to gain insights and form solutions.
- Deep learning is an advanced field of machine learning that can be used to solve more advanced problems.
- Deep Learning is the logic behind the face verification algorithm on Facebook, self-driving cars, virtual assistants like Siri, Alexa and so on.

Natural Language Processing

- Natural Language Processing (NLP) refers to the science of drawing insights from natural human language in order to communicate with machines and grow businesses.
- Twitter uses NLP to filter out terroristic language in their tweets, Amazon uses NLP to understand customer reviews and improve user experience.

Robotics

- Robotics is a branch of Artificial Intelligence which focuses on different branches and application of robots.
- AI Robots are artificial agents acting in a real-world environment to produce results by taking accountable actions.
- Sophia the humanoid is a good example of AI in robotics.

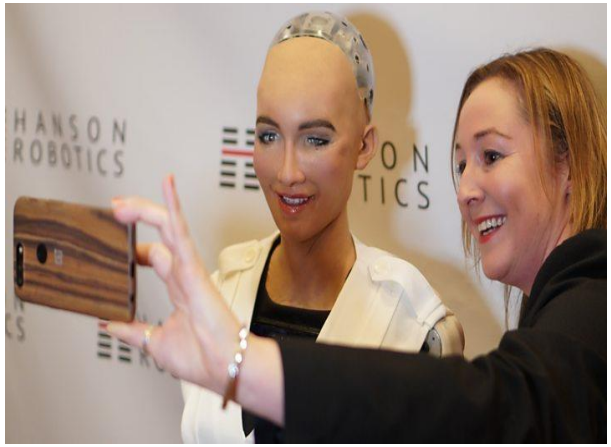


Figure 1.12: Sophia the humanoid

Fuzzy Logic

- Fuzzy logic is a computing approach based on the principles of “degrees of truth” instead of the usual modern computer logic i.e. boolean in nature.
- Fuzzy logic is used in the medical fields to solve complex problems that involve decision making.
- They are also used in automatic gearboxes, vehicle environment control and so on.

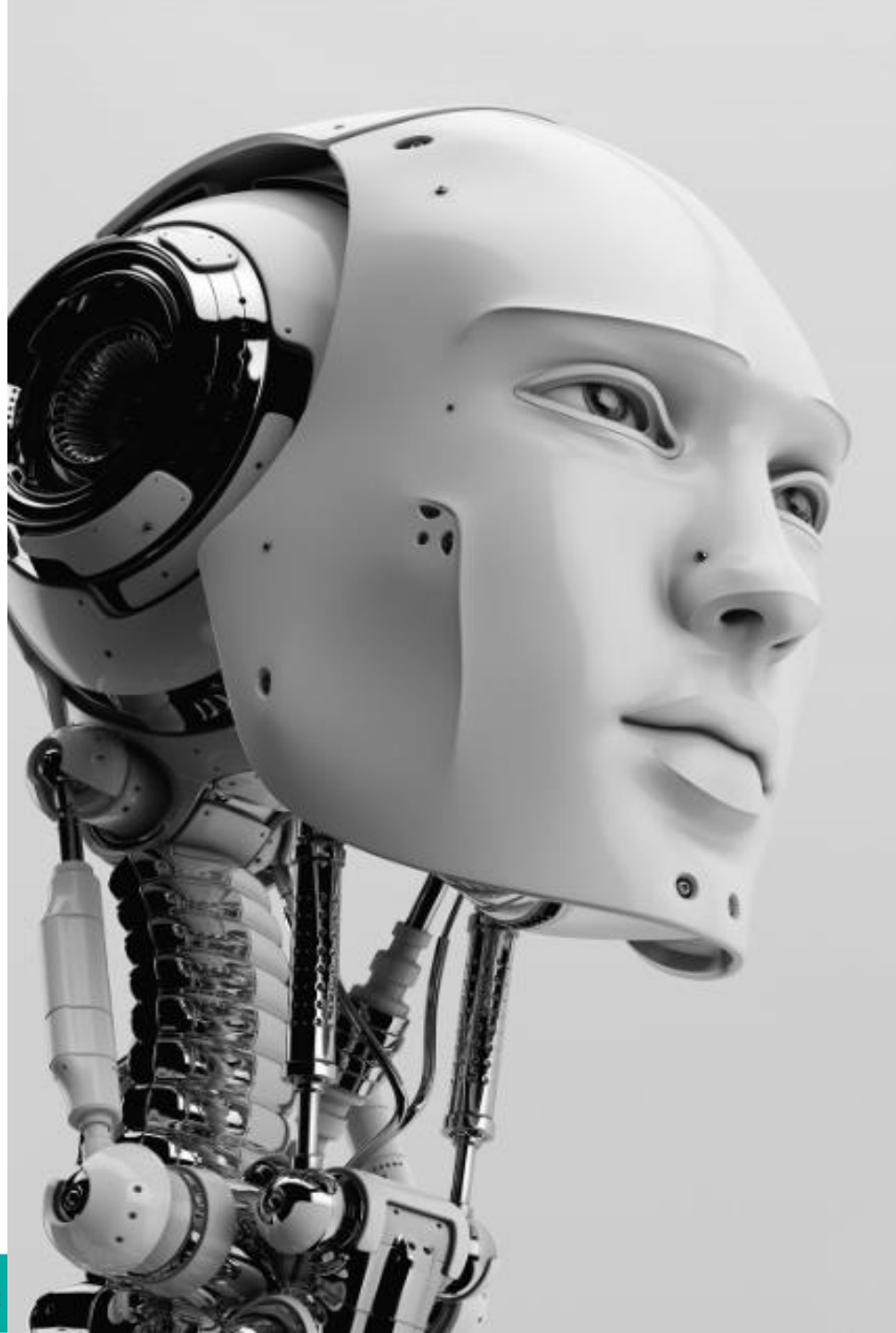
Expert Systems

- An expert system is an AI-based computer system that learns and reciprocates the decision-making ability of a human expert.
- Expert systems use if-then logical notations to solve complex problems. It does not rely on conventional procedural programming.
- Expert systems are mainly used in information management, medical facilities, loan analysis, virus detection and so on.

Chapter 1.4: Defining Intelligence Using the Turing Test

By the end of this topic, you should be able to:

- define the intelligence using Turing test.
- implement the Turing test toward human being and machine.



The Turing Test

- The legendary computer scientist and mathematician, Alan Turing, proposed the Turing test to provide a definition of intelligence.
- It is a test to see if a computer can learn to mimic human behavior. He defined intelligent behavior as the ability to achieve human-level intelligence during a conversation.
- This performance should be enough to trick an interrogator into thinking that the answers are coming from a human.
- To see if a machine can do this, he proposed a test setup: he proposed that a human should interrogate the machine through a text interface.

- Another constraint is that the human cannot know who's on the other side of the interrogation, which means it can either be a machine or a human.
- To enable this setup, a human will be interacting with two entities through a text interface. These two entities are called respondents. One of them will be a **human** and the other one will be the **machine**.
- The respondent machine passes the test if the interrogator is unable to tell whether the answers are coming from a machine or a human. The following diagram shows the setup of a Turing test:

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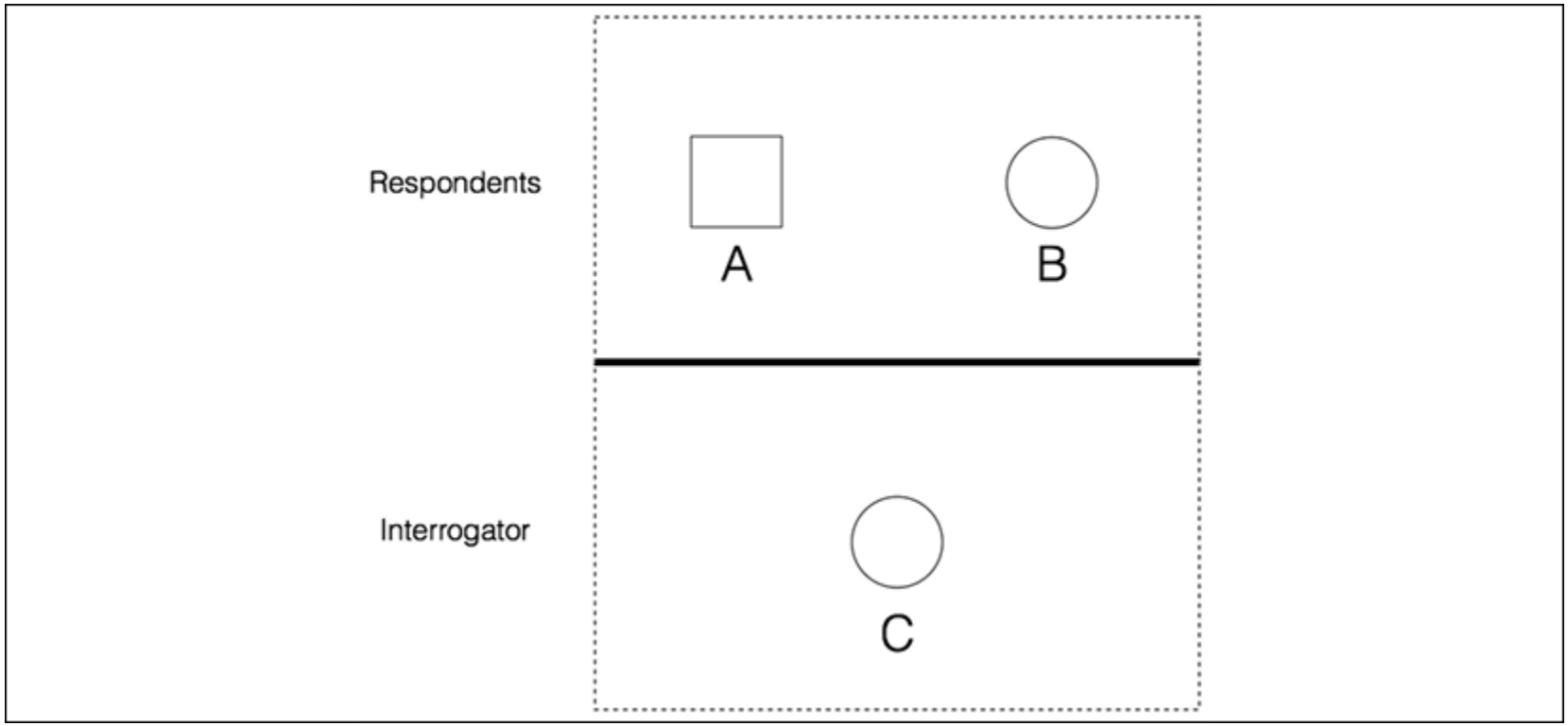


Figure 1.13: The Turing Test

- As you can imagine, this is quite a difficult task for the respondent machine. There are a lot of things going on during a conversation. At the very minimum, the machine needs to be well versed with the following things:

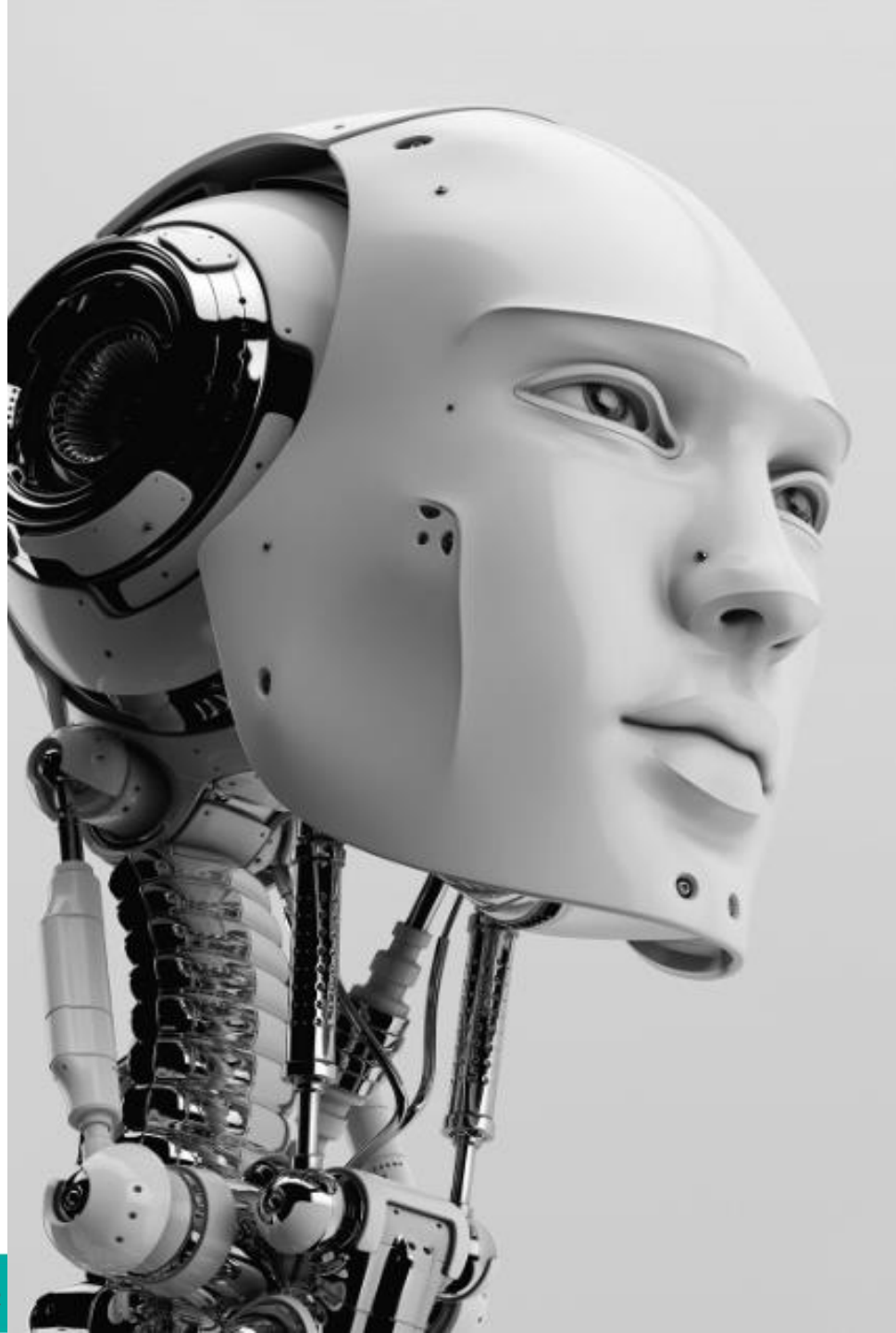
  - **Natural language processing:** The machine needs this to communicate with the interrogator. The machine needs to parse the sentence, extract the context, and give an appropriate answer.
  - **Knowledge representation:** The machine needs to store the information provided before the interrogation. It also needs to keep track of the information being provided during the conversation so that it can respond appropriately if it comes up again.
  - **Reasoning:** It's important for the machine to understand how to interpret the information that gets stored. Humans tend to do this automatically in order to draw conclusions in real time.
  - **Machine learning:** This is needed so that the machine can adapt to new conditions in real time. The machine needs to analyze and detect patterns so that it can draw inferences.

- You must be wondering why the human is communicating with a text interface.
- According to Turing, physical simulation of a person is unnecessary for intelligence.
- That's the reason the Turing test avoids direct physical interaction between the human and the machine.
- There is another thing called the Total Turing Test that deals with vision and movement. To pass this test, the machine needs to see objects using computer vision and move around using robotics.

Chapter 1.5:
Building Rational Agent

By the end of this topic, you should be able to:

- define the rational agent.
- understand to the purpose of rational agent before build the intelligent agent.



Building Rational Agent

- A lot of research in AI is focused on building rational agents. What exactly is a rational agent? Before that, let us define the word rationality within the context of AI. Rationality refers to observing a set of rules and following their logical implications in order to achieve a desirable outcome.
- This needs to be performed in such a way that there is maximum benefit to the entity performing the action.
- An agent, therefore, is said to act rationally if, given a set of rules, it takes actions to achieve its goals. It just perceives and acts according to the information that's available. This system is used a lot in AI to design robots when they are sent to navigate unknown terrains.

- How do we define what is desirable? The answer is that it depends on the objectives of the agent.
- The agent is supposed to be intelligent and independent. We want to impart the ability to adapt to new situations.
- It should understand its environment and then act accordingly to achieve an outcome that is in its best interests. The best interests are dictated by the overall goal it wants to achieve. Let's see how an input gets converted to action:

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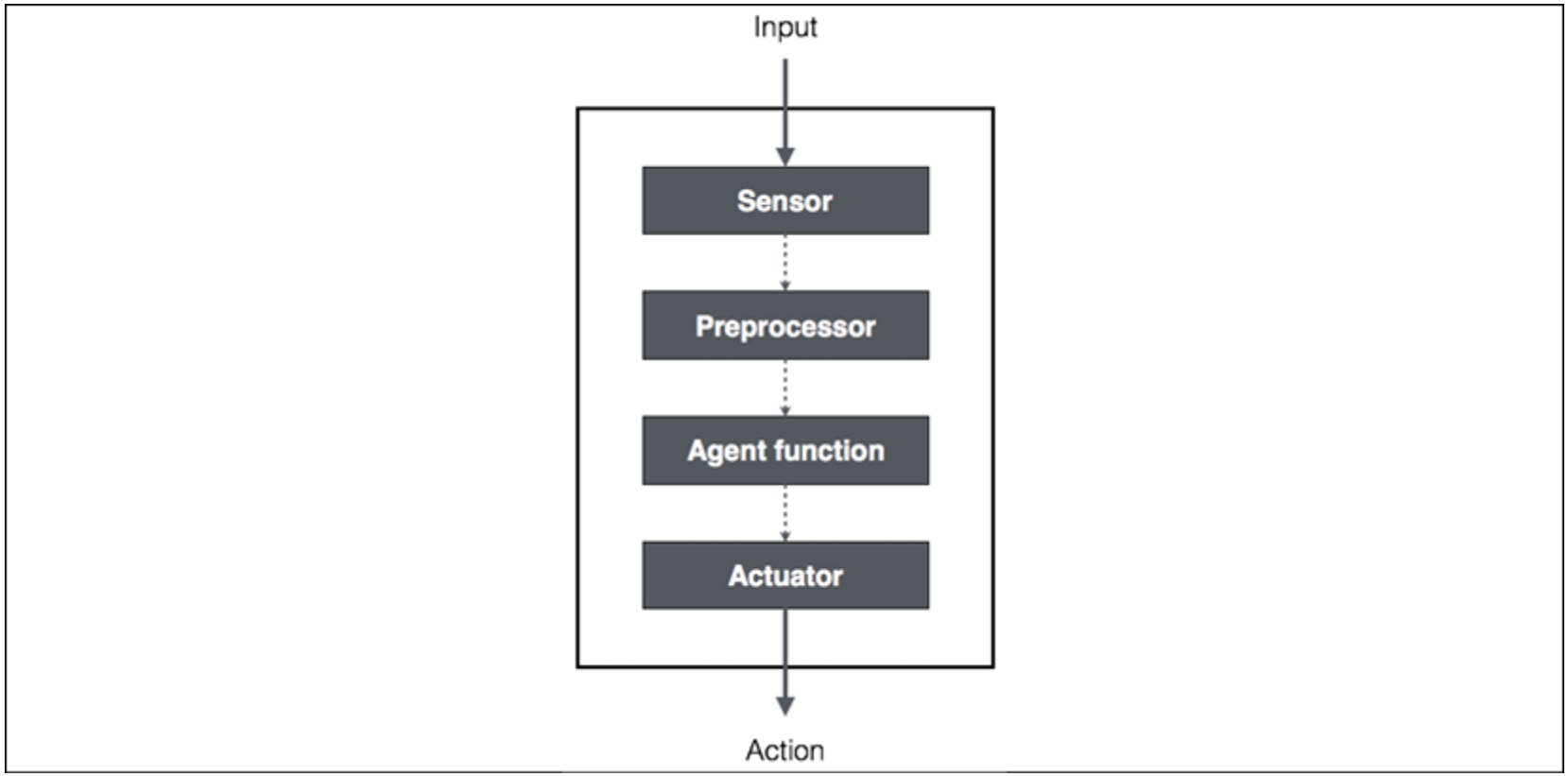


Figure 1.14: Converting input into action.

- How do we define the performance measure for a rational agent? One might say that it is directly proportional to the degree of success.
- The agent is set up to achieve a task, so the performance measure depends on what percentage of that task is complete. But we must think as to what constitutes rationality in its entirety. If it's just about results, we don't consider the actions leading up to the result.
- Making the right inferences is a part of being rational, because the agent must act rationally to achieve its goals. This will help it draw conclusions that can be used successively.

- But, what about situations where there are no provably right things to do? There are situations where the agent doesn't know what to do, but it still must do something.
- Imagine a self-driving car that's going at 60 miles an hour and suddenly someone crosses its path. For the sake of the example, assume that given the speed the car is going, it only has two choices. Either the car crashes against a guard rail knowing that it will kill the car occupant, or it runs over the pedestrian and kills them. What's the right decision? How does the algorithm know what to do? If you were driving, would you know what to do?
- We now are going to learn about one of the earliest examples of a rational agent – the General Problem Solver. As we'll see, despite the lofty name, it really wasn't capable of solving any problem, but it was a big leap in the field of computer science nonetheless.

General Problem Solver

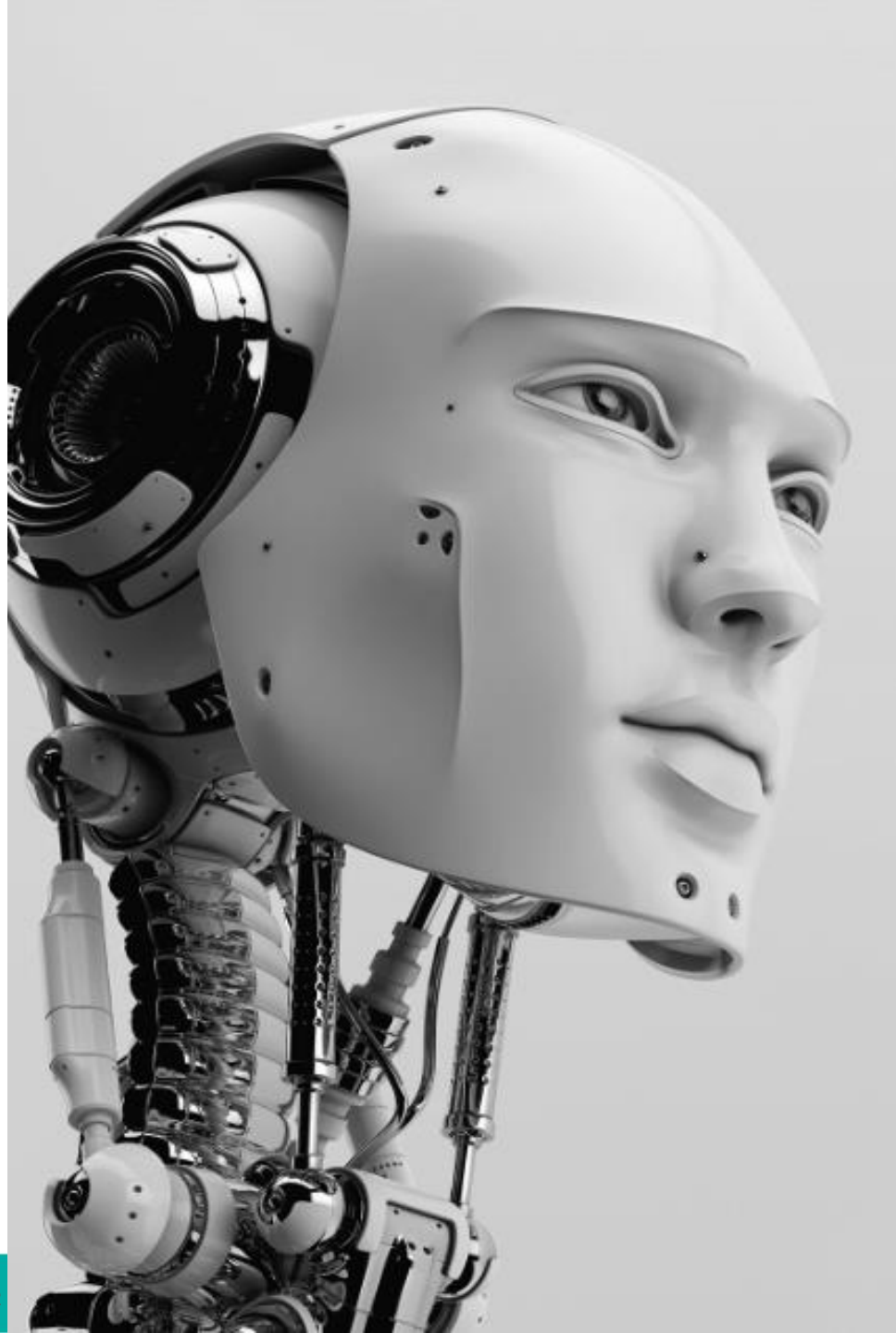
- The General Problem Solver (GPS) was an AI program proposed by Herbert Simon, J.C. Shaw, and Allen Newell.
- It was the first useful computer program that came into existence in the AI world. The goal was to make it work as a universal problem-solving machine.
- GPS was the first program that was intended to solve any general problem. GPS was supposed to solve all the problems using the same base algorithm for every problem.
- To program the GPS, the authors created a new language called Information Processing Language (IPL).
- The basic premise is to express any problem with a set of well-formed formulas. These formulas would be a part of a directed graph with multiple sources and sinks.

- In a graph, the source refers to the starting node and the sink refers to the ending node. In the case of GPS, the source refers to axioms and the sink refers to the conclusions.
- Even though GPS was intended to be a general purpose, it could only solve well-defined problems, such as proving mathematical theorems in geometry and logic.
- It could also solve word puzzles and play chess. The reason was that these problems could be formalized to a reasonable extent. But in the real world, this quickly becomes intractable because of the number of possible paths you can take.
- If it tries to brute force a problem by counting the number of walks in a graph, it becomes computationally infeasible.

Chapter 1.6: Building Intelligent Agent

By the end of this topic, you should be able to:

- define the intelligent agent.
- understand to the purpose of intelligent agent developed.



Intelligence Agent

- There are many ways to impart intelligence to an agent.
- The most commonly used techniques include machine learning, stored knowledge, rules, and so on.
- In this example, we will focus on machine learning. In this method, the way we impart intelligence to an agent is through data and training.
- Let's see how an intelligent agent interacts with the environment:

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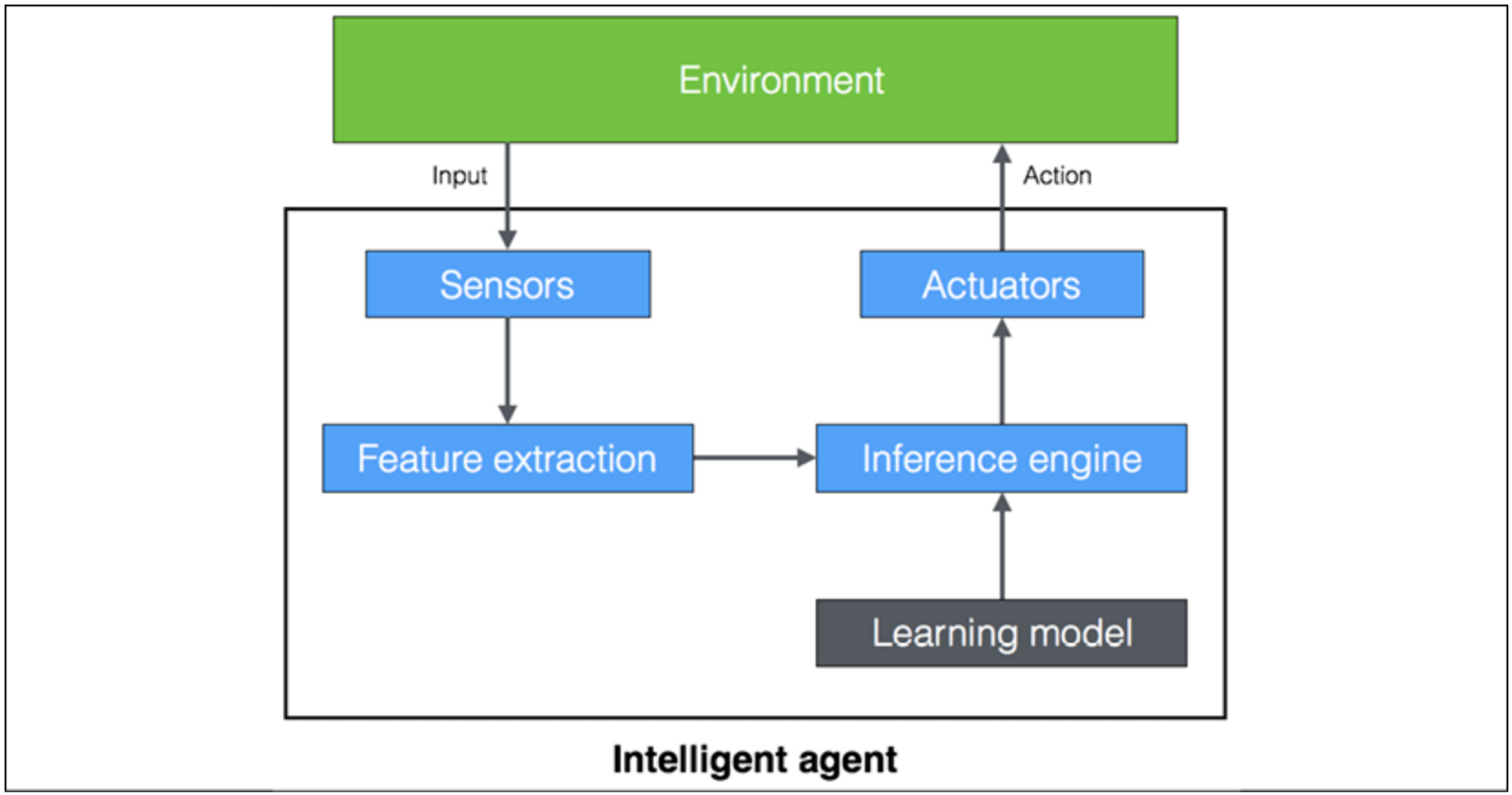

Figure 1.15: An intelligent agent interaction with its environment

- With machine learning, sometimes we want to program our machines to use labeled data to solve a given problem. By going through the data and the associated labels, the machine learns how to extract patterns and relationships.
- In the preceding example, the intelligent agent depends on the learning model to run the inference engine. Once the sensor perceives the input, it sends it to the feature extraction block. Once the relevant features are extracted, the trained inference engine performs a prediction based on the learning model.
- This learning model is built using machine learning. The inference engine then takes a decision and sends it to the actuator, which then takes the required action in the real world.

- There are many applications of machine learning that exist today. It is used in image recognition, robotics, speech recognition, predicting stock market behavior, and so on.
- In order to understand machine learning and build a complete solution, you will have to be familiar with many techniques from different fields such as pattern recognition, artificial neural networks, data mining, statistics, and so on.