3 : Artificial Intelligence

EN6106 – Emerging Topics in Information Technology

Level III - Semester 6

Overview

- Artificial Intelligence (AI) is a branch of Computer Science that deals with creating intelligent machines that can perform tasks that would normally require human intelligence.

- Some common applications of AI include natural language processing, recommendation systems, autonomous vehicles, object detection, speech recognition etc. These applications would be software-based, hardware-based or even hybrid approaches.

- AI is applied in a wide range of domains such as healthcare, education, transportation, manufacturing, disaster management, agriculture, and finance.

Intended Learning Outcomes

At the end of this lesson, you will be able to;

- Define the term "Artificial Intelligence"
- Distinguish between Human Intelligence and Machine Intelligence
- Understand a brief history and the pioneering figures in the development of AI.
- Understand the usage of AI in society
- Identify the software-based AI applications
- Identify the hardware-based AI applications
- Learn what the future holds in the domain of AI

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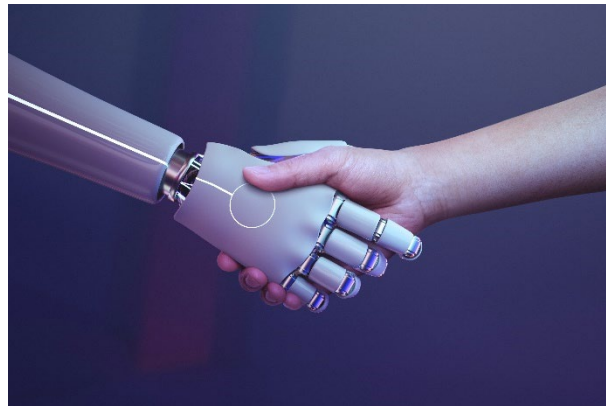
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# 3.1.1 What is Artificial Intelligence : The Introduction

- Artificial Intelligence (AI) is a way of making a computer, a computer-controlled robot, or a software **think intelligently**.

- This way of thinking should be similar to the manner of how an intelligent human thinks.

- According to **John McCarthy**, who is considered as the father of Artificial Intelligence, it is "*The science and Engineering of making intelligent machines, especially intelligent computer programs*".
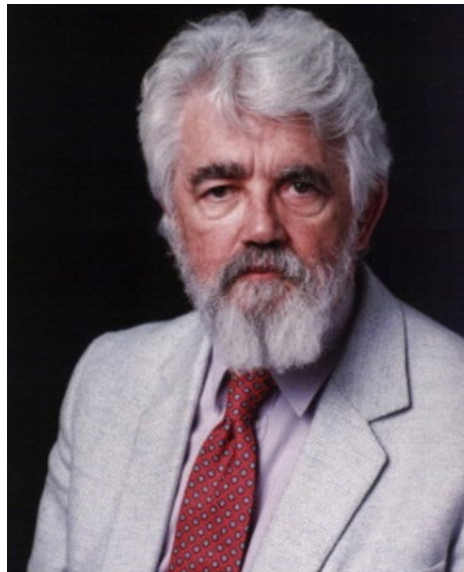
John McCarthy (1927-2011)
(Credit: Mel Lindstrom; Courtesy Stanford News Service)

3.1.1 What is Artificial Intelligence : The Introduction cont.

- Artificial Intelligence is based on a number of disciplines such as Computer Science, Mathematics, Statistics, Engineering, Linguistics, Biology, etc.
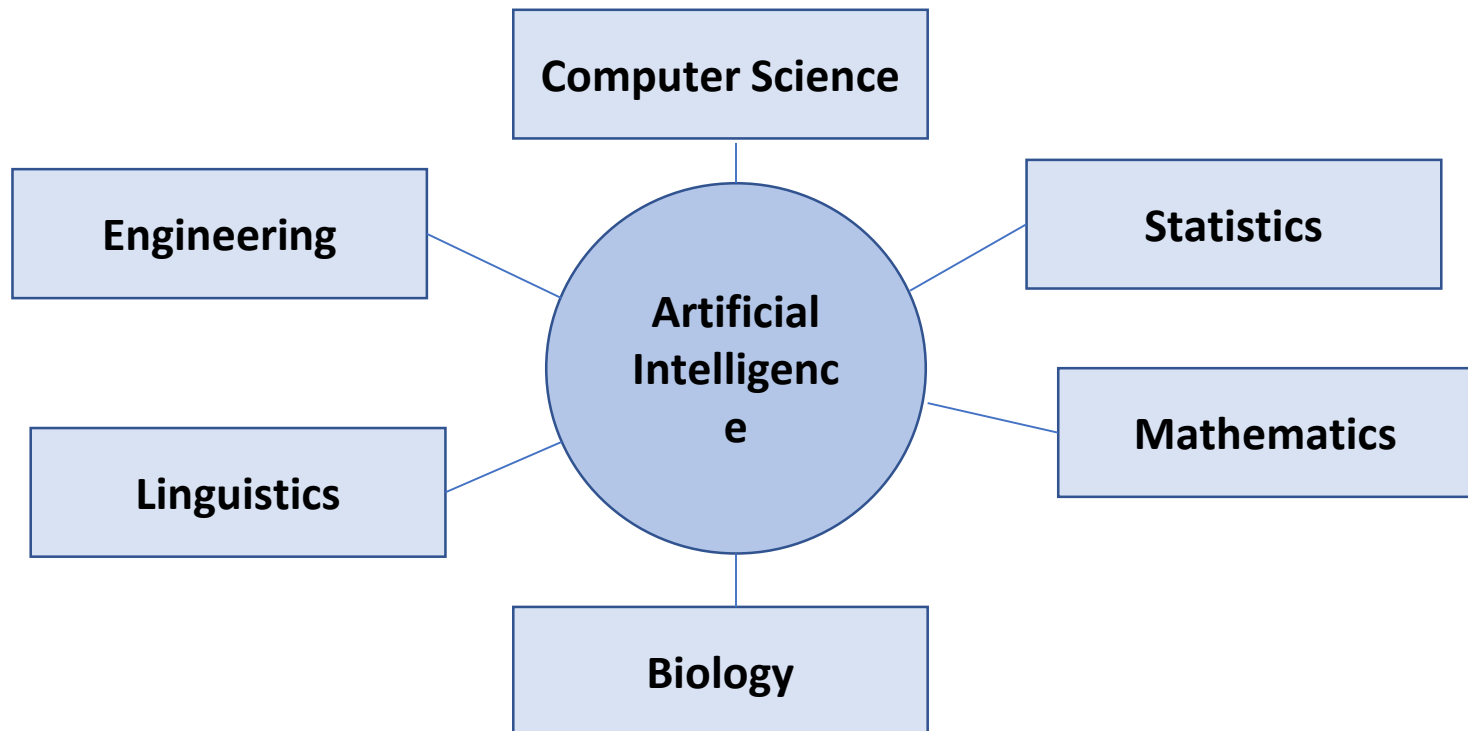
3.1.2 Human Intelligence vs. machine Intelligence

- How do we say that Humans are "Intelligent"? It is because the humans have the abilities such as,
  - Learning
  - Reasoning
  - Problem Solving
  - Social Behavior
  - Interacting with an environment through the senses.

- However, machines are often better than humans when it comes to certain abilities such as,
  - Speed
  - Sensor detection outside human range
  - Computations
  - Alertness
  - Simultaneous activities

3.1.2 Human Intelligence vs. machine Intelligence

- Through AI, humans are trying to **"teach"** computer systems (or machines) to perform tasks that would typically require human intelligence, while conserving the abilities those machines already have.

- Some examples for these tasks would be,
    - Speech recognition
    - Decision making
    - Understanding and responding to natural languages
    - Recognizing images
    - Detecting objects

- This is achieved through the use of computational methods such as machine learning algorithms, neural networks, etc. by enabling the machines to learn through data.

3.1.3 A brief History of AI

- The concept of Artificial Intelligence began to grow with the emergence of modern computer in 1940s and 1950s.

- Even before that, computer scientists such as Alan Turing (1912 – 1954) have suggested the concept of self-modifying and self-improving machines which paved the way to the modern concepts of AI.
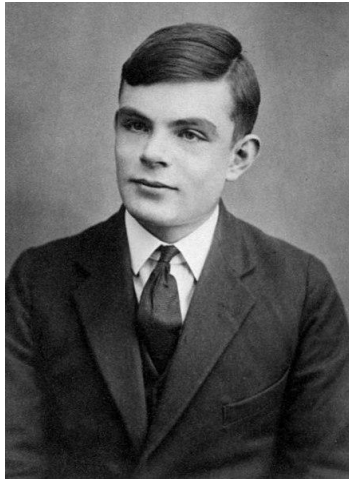

Image 1 : Alan Turing

- In the early years, Allen Newell (1927-1992) and Herbert A. Simon (1916-2001) tried to build intelligent programs by feeding a set of logical rules to a problem solving program.

3.1.3 A brief History of AI cont.

- John McCarthy (1927-2011) invented the List Processing Language (Lisp) which was widely used as a standard tool for the research and design of AI.

- The modern period of AI started at 1970 where some of the most important concepts such as Expert systems, Pattern recognition, etc. were introduced. By 1980s the concept of neural networks was born.

- In 1990s the applicability of AI was further enhanced with the introduction of concepts such as Computer Vision, Virtual Reality, Natural Language Processing, and Data Mining.

- With each passing day, AI is continuously advancing towards grater capabilities.

3.1.3 A brief History of AI cont.

- Some examples for most recent and widely popular applications are as follows.

  - *Tesla Autopilot* : An AI-powered driver-assistance system

  - *ChatGPT* : A conversational AI model which communicates with its users in a human-like way.

  - *IBM Watson Health* : An AI system which has the ability to analyze medical data and assist in making more accurate diagnoses.

  - *PayPal* : An AI-powered fraud detection system for online payments.

Image Source: https://www.freepik.com/free-vector/self-driving-car-concept illustration_30590324.

3.1.4 Initial dilemma of AI

- The initial dilemma of AI was first articulated by the Computer Scientist Alan Turing in his paper "Computing Machinery and Intelligence" published in 1950.

- It was mainly about creating machines with human like thinking and reasoning abilities, and bridging the gap between human intelligence and computational systems.

- The Turing Paradigm which was born as a result of this discussion, mainly focuses on evaluating a machine's ability to show human intelligence indistinguishable from a human.

- As an example, a Turing machine or any other AI artifact is considered to be intelligent if and only if it can convince humans that is is not a machine. And the responses provided by the AI artifact are expected to be identical to the ordinary behaviour of a human.

3.1.4 Initial dilemma of AI cont.

- In addition to the Turing Paradigm, several other AI paradigms were suggested as a result of the initial dilemma of AI. Some examples of such paradigms are as follows.
  - **Connectionist Paradigm** which focuses on the idea of modeling the structure and functions of the brain to develop artificial neural networks.
  - **Evolutionary Paradigm** which focuses on using evolutionary algorithms, concepts of natural selection, and genetic mutation to optimize solutions to problems.
  - **Bayesian Paradigm** which focuses on identifying relationships between different variables and calculating probabilities of different outcomes.
  - **Fuzzy Logic Paradigm** focuses on providing reasoning similar to humans in situations where there can be multiple in-between values for the possibilities rather than just true or false.

3.2 Usages of AI in the Society

- Artificial Intelligence (AI) is being used in a wide range of applications and industries.

- It is transforming the way humans live and work across a wide range of domains. Let's take a closer look at some of the areas where AI is making a big impact.
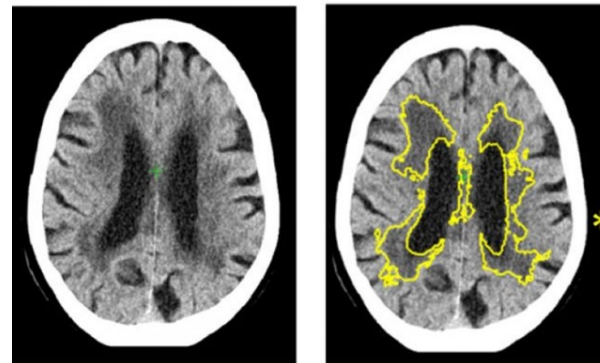
3.2.1 Education

- Some examples of the applicability of AI in education are Adaptive Learning systems, Intelligent tutoring systems, Automated grading systems, and Virtual Assistants.

- Such systems have the ability to analyze the learning patterns of students and to provide customized feedback to improve their learning experiences.

- *Duolingo* and *Coursera* are examples for AI-based tools in education.

3.2 Usages of AI in the Society

3.2.2 Healthcare

- Artificial Intelligence is increasingly used in healthcare to improve disease diagnosis, drug discovery, and personalized medicine.

- AI algorithms can be used to analyze medical images to detect tumors, lesions, or other abnormalities.

- Artificial Intelligence with Bioinformatics can be used to identify disease causing genetic mutations and simulate the effect of certain drugs on human body.

- *IBM Watson Health* and *Zebra Medical Vision* are some examples for AI-based diagnosis systems

Image Sources: https://www.freepik.com/ and https://internetofbusiness.com/uk-machine-learning-improve-dementia-diagnosis/

3.2 Usages of AI in the Society

3.2.3 Transportation

- AI is used in transportation to build autonomous vehicles as well as to optimize the traffic flow.

- *Tesla Autopilot* is an AI-powered driver assistance system developed by Tesla, Inc. It has the ability to make driving decisions up to a certain level, based on the input data from multiple types of sensors and cameras.

Image Source : https://www.govtech.com/transportation/autonomous-vehicles-coming-to-a-road-near-you.html
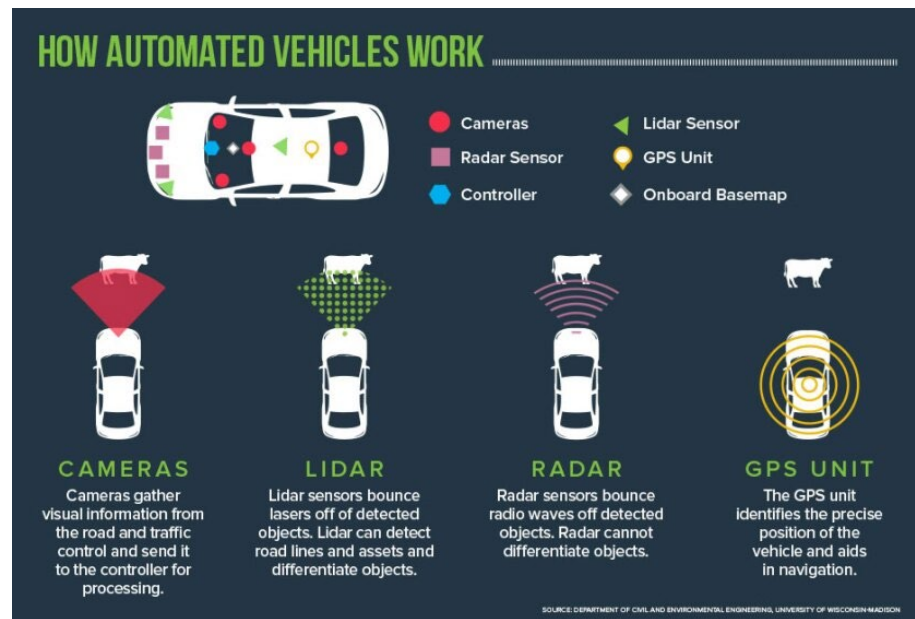
3.2 Usages of AI in the Society

3.2.4 Financial Services, Manufacturing and Retail

- Financial systems use AI-based applications for the tasks of fraud detection, credit scoring, predictive analysis, Customer support Chatbots etc. These applications are often designed by training machine learning algorithms to identify patterns or anomalies in input data.

- AI is being used in manufacturing, to detect defects and other quality issues of the products in real-time. Most of these applications are custom-made to cater to the requirements of the productions.

- In retail, AI is used to improve the shopping experience of customers and to increase the efficiency of supply chains. *Amazon Personalize* is an AI-based recommendation system which suggests the products to customers using their purchasing patterns. *Netflix* uses an AI-based recommendation engine based on a users' viewing history and ratings.

3.2 Usages of AI in the Society

3.2.5 Agriculture

- AI-based systems are widely being used for agriculture to improve crop fields as well as to reduce the wastage.

- Some of these systems use the concepts of computer vision and machine learning algorithms to detect crop diseases, nutrient deficiencies, pests, etc.

- Some other systems use sensor and weather data to predict the optimal levels of water, fertilizer, sunlight etc. for the crop growth.

Image Source: https://v-mr.biz/ai-in-agriculture-market

3.2 Usages of AI in the Society

3.2.6 Entertainment

- AI is being used in entertainment industry to provide a more personalized and engaging experience for the customers. *Spotify* uses a song recommendation system trained with machine learning algorithms to suggest playlists based on a user's listening history.

- Platforms such as *YouTube,* and *Facebook* also use AI algorithms to personalize the suggested content as well as the advertisements.

- *Amazon's Alexa* uses Natural Language Processing to engage with the users by responding to their voice commands with personalized responses.
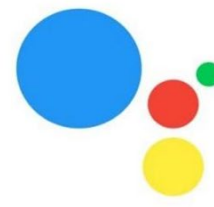

"Hey Cortana"   "Hey Alexa"   "Hey Siri"   "Hey Google"

Image Source: https://medium.com/swlh/ai-revolution-voice-assistants-their-smartness-c7afe2580e74

3.2 Usages of AI in the Society

3.2.7 Environment Monitoring and Disaster Management

- By incorporating sensor data, satellite imagery, weather data etc. with specially designed algorithms, AI helps tackling environmental challenges by monitoring the water quality, air-quality, wildlife, and even the deforestations.

- When it comes to disaster management, AI-based systems such as *IBM's GRAF* has the ability to make weather forecasts and alerts based on input features such as wind speed, temperature, pressure, humidity etc.

3.2 Usages of AI in the Society

3.2.8 Public Safety

- AI-powered crime predictive systems such as *PredPol* has the ability to identify patterns in past crimes and generate predictions on crimes that are likely to occur. Applications such as *IBM Watson Visual Recognition* has the ability to analyze images as well as to detect people and objects in real-time.
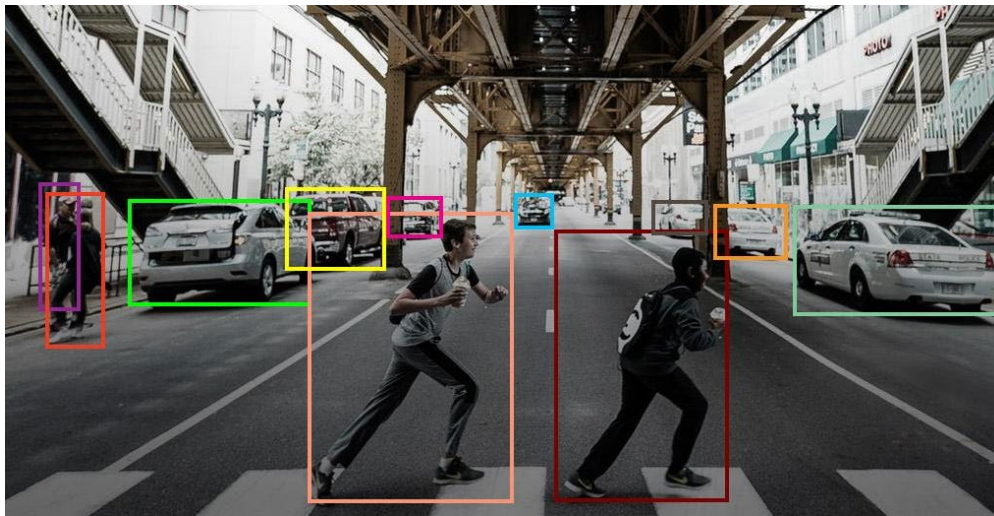

Image Source:https://www.analyticsvidhya.com/blog/2019/08/introduction-slimyolov3-real-time-object-detection/

3.3 Software based AI Applications

- Software-based Artificial Intelligence applications are computer programs that utilize algorithms and data to simulate intelligent behavior.

- Let's examine a few such examples.

3.3.1 Natural Language Processing (NLP)

- It is the ability of a computer program to understand human language.

- NLP "teaches" computers to understand, interpret, and generate natural language in a way humans communicate with each other.

- NLP is comprised of sub-domains such as Natural Language Understanding, Machine Translations, Language Generation, and Speech Understanding.

- *Google Translate*, *GPT-3*, and *Grammarly* are some popular NLP-based applications.

3.3 Software based AI Applications

3.3.2 Computer Vision

- Computer Vision enables machines to interpret and understand visual data from the world around them.

- It teaches computers to "see" like humans and be able to analyze, interpret, and understand images and videos.

- Below are some examples for computer vision based applications.

  - *Google Photos* uses computer vision to recognize objects in photos as well as videos.

  - Apps such as *FaceID* uses computer vision to recognize a user, based on his/her facial features.
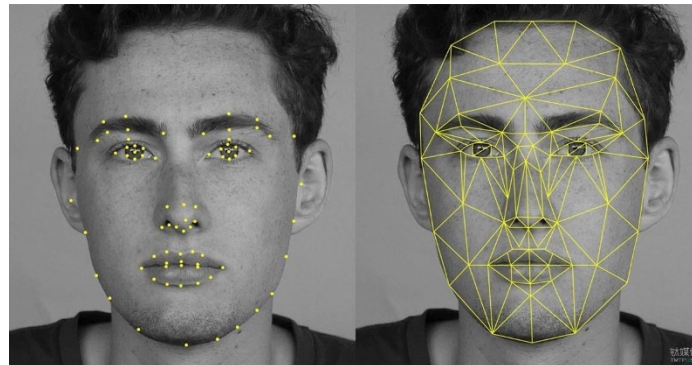

Image Source: https://rapidapi.com/blog/top-facial-recognition-apis/

3.3 Software based AI Applications

3.3.2 Computer Vision cont.

- Medical Imaging systems such as *IBM Watson Health* has the ability to analyze medical images to make more accurate diagnoses.

- *Snapchat filters* uses computer vision along with Augmented Reality concepts to apply certain effects on users' faces in real-time.

3.3.3 Speech Recognition Systems

- These systems have the ability to convert spoken languages into text or commands that a computer can understand. Nowadays these systems are embedded in mobile devices as well as smart home appliances. Some popular examples are Google Assistant, Apple's Siri, and Amazon's Alexa.

3.3 Software based AI Applications

3.3.4 Expert Systems

- Expert systems are the application-specific systems that rely on obtaining the knowledge of human experts in a certain area and programming that knowledge into a computer.

- Here, a computer "learns" special information or patterns related to a given input through reasoning and advices. Then it uses that knowledge to provide useful insights back to the user.

- Some examples to expert systems are,
    - Financial decision making systems
    - Classification systems
    - Diagnosis systems
    - Recommendation systems

3.4 AI in Hardware-based Applications

- There are several hardware-based Artificial Intelligence applications that are being developed and used today. Below are a few examples.

3.4.1 Robots

- Robots are able to perform the tasks given by a human.
- They have efficient processors, multiple sensors and huge memory to exhibit intelligence. They also have sensors to detect physical data from the real world such as temperature, motion, sound etc.
- In addition, they are capable of learning from their mistakes and they can adapt to a new environment.

3.4 AI in Hardware-based Applications

3.4.2 Autonomous Vehicles

- Self-driving (autonomous) vehicles use Artificial Intelligence fed with sensor data and camera captures to travel between destinations without human operation or with minimum human intervention.

- Computer Vision concepts such as object detection, and neural networks are often used to train these vehicles to make real-time decisions by identifying patterns in input data.

- The capabilities of these vehicles have not yet reached the fullest capacity to attain the human decision making capabilities when driving.

- However, these systems benefit a lot by reducing the accidents caused due to human error, enhancing driver and passenger safety, and by reducing the traffic congestion.

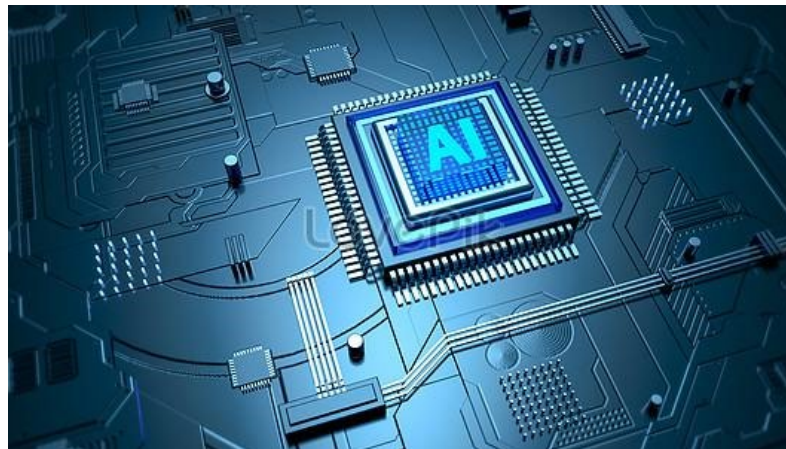# 3.4 AI in Hardware-based Applications

3.4.3 Drones

- AI algorithms are increasingly being used in drones to help them navigate and make decisions in real-time. This requires specialized hardware that is small and lightweight, yet powerful enough to run the necessary algorithms.

- Recent trends in AI-based drones focus on combining the computer vision concepts such as object detection with machine learning algorithms to make smarter and more autonomous decisions.

Image Source: https://unsplash.com/s/photos/drone

# 3.4 AI in Hardware-based Applications

3.4.4 AI Chips

- Several companies, including Google, Intel, and NVIDIA, have developed specialized chips designed for AI tasks. These chips can perform the matrix multiplication operations needed for deep learning algorithms more efficiently than traditional CPUs and GPUs.

- These chips are able to learn and process multiple streams of information simultaneously (at the same time) similar to how human brain works.

3.4 AI in Hardware-based Applications

3.4.5 Smart Home Devices

- These devices use AI algorithms to understand user preferences and adapt to their behavior over time.

- By incorporating the AI applications in living spaces, smart homes enable its users to save time and effort as well as to ensure the safety properties.

- Adjusting temperature and lights, play music according to personalized user preferences, automating day-to-day activities such as washing and cleaning, smart voice assistants, facial and voice recognition systems, smoke and fire detection systems are some widely being used AI applications implemented in smart homes.

Image Source: https://www.freepik.com/
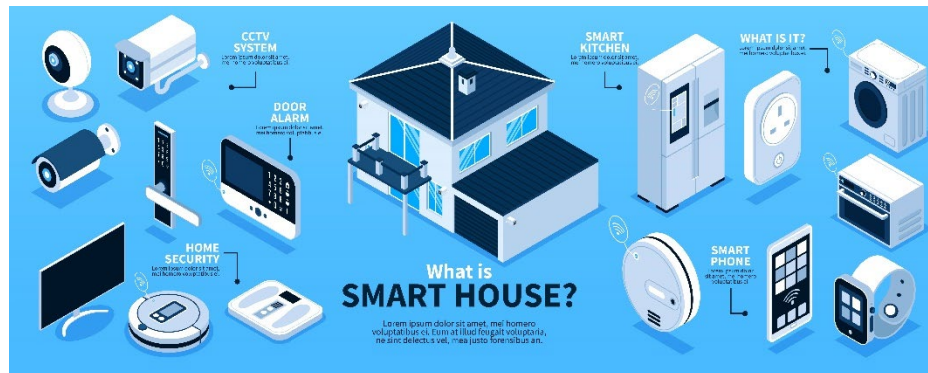
3.5 Future of Artificial Intelligence

- There are two major concepts of Artificial Intelligence namely the Weak AI and Strong AI. In Strong AI, the machines are capable of solving complex problems similar to an intelligent human. Such machines are not just tools but much more similar to a real mind in terms of reasoning, decision making and solving problems.

- Weak or Narrow AI is designed to perform a narrow task. Such machines do not have the intelligence similar to a human being. Their decision making and problem solving abilities could be similar to humans but can not be equal.

- The Artificial Intelligence we use today are actually Weak AI. They do not use the full range of cognitive abilities that humans possess.

- The long-term goal in the domain of AI is to create Strong AI systems which are " as smart as typical human".

- Strong AI systems are also called as Artificial General Intelligence (AGI).

3.5 Future of Artificial Intelligence cont.

- Will the AI expedition be able to reach its destination once AGI has been achieved? **The answer is No!**

- The scientists already have the hypothetical goal in achieving Artificial Super Intelligence (ASI) which has the ability to surpass the highest intelligence a human can perceive.
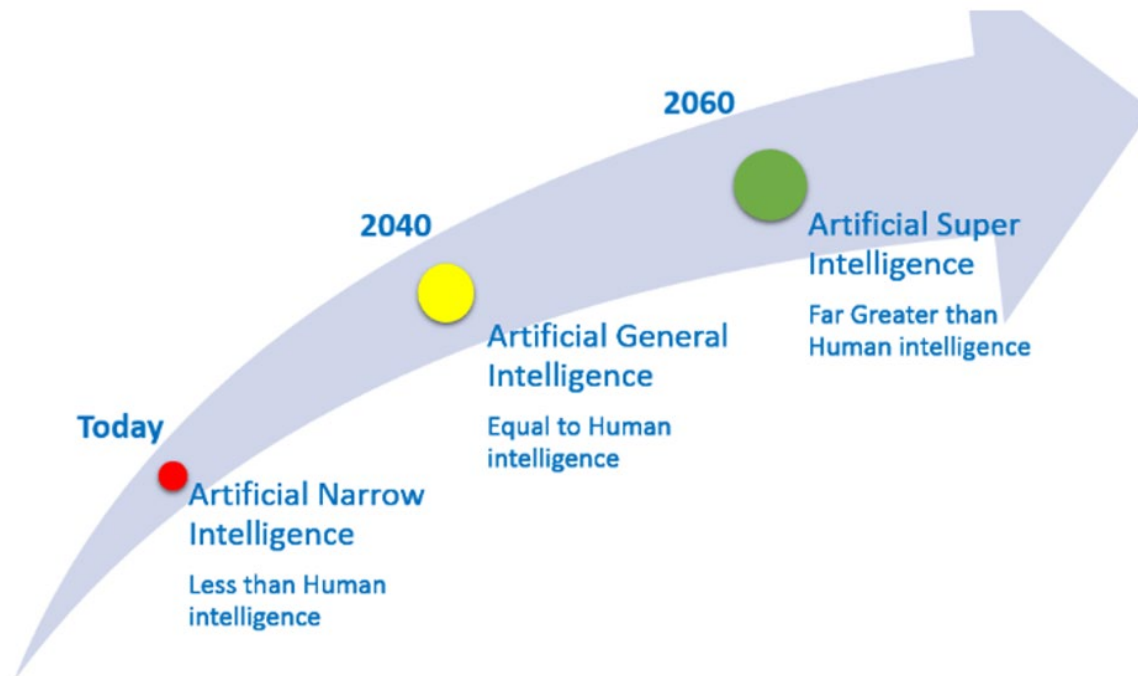

Image Source: Saleh, Ziyad. (2019). Artificial Intelligence Definition, Ethics and Standards.

3.5 Future of Artificial Intelligence cont.

- Researchers also hope to build future AI-based systems based of the *Theory of Mind*.

- These systems will be able to imitate human mental models by forming representations about the world as well as other agents. These systems would have the capacity to work with the emotions, memories, and behavioral models that a normal AI system do not have the capability to work with.

- *Self-awareness machines* are also considered as an ultimate goal of AI development.

Summary

- Artificial Intelligence refers to the development of computer systems that can perform tasks that typically require human intelligence.

- It is comprised of sub-domains such as rule-based systems, machine learning, and deep learning.

- Software-based AI applications such as Computer Vision, Natural Language Processing, and Expert Systems are simulating intelligent behavior by understanding data patterns through specialized algorithms.

- Hardware-based AI applications such as Autonomous Vehicles, Drones, and Robots often make decisions based on sensor inputs.

- The future of AI focuses on creating Strong AI systems which are " as smart as typical human" or even has the ability to surpass the human intelligence.

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