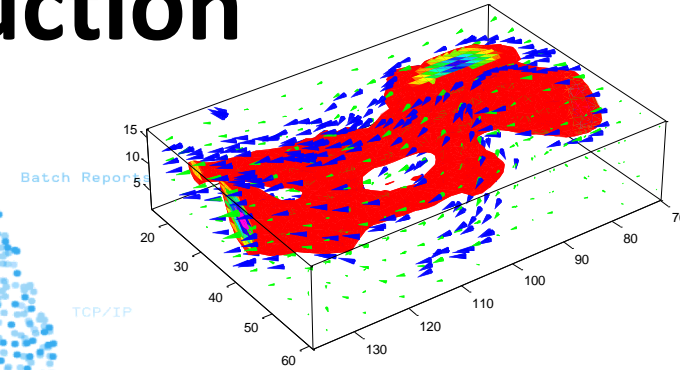
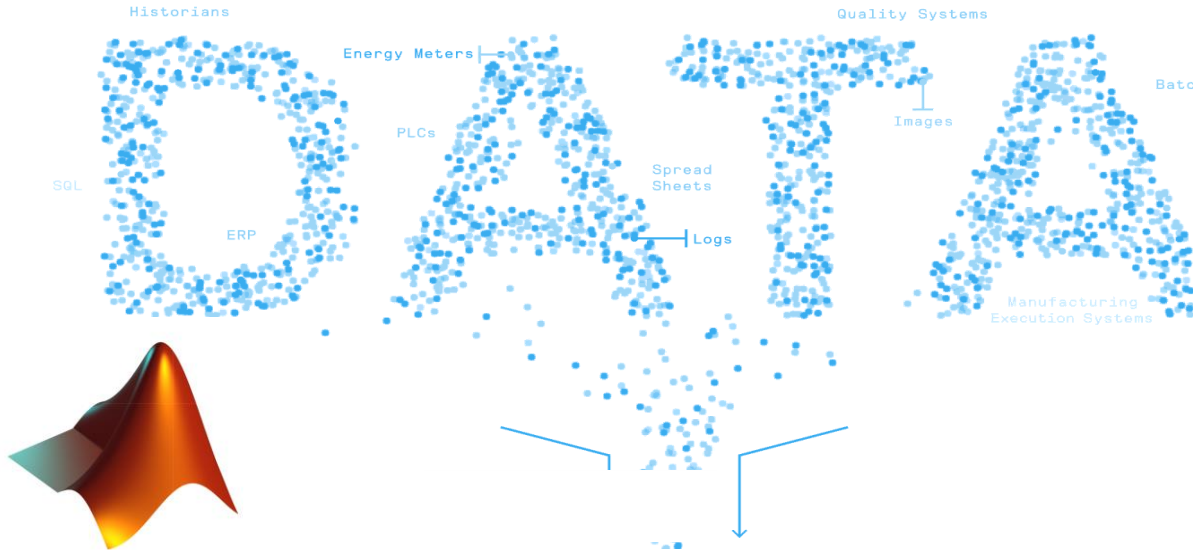




Introduction to Artificial Intelligence

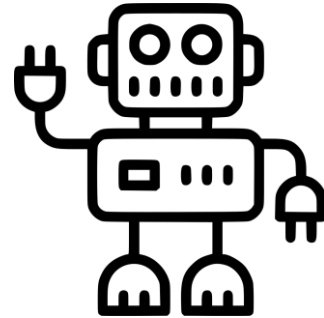
- 01-04 An Introduction



Dr Leo Chen
leo.chen@ieee.org
21/Feb/2024

Module Contents

- 1. Introduction**
- 2. Evolutionary Computation**
- 3. Artificial Neural Network**
- 4. Fuzzy Logic and Fuzzy Systems**
- 5. More AI Subsets**
- 6. AI and Industry 4.0**
- 7. AI Applications**
- 8. Labs**
- 9. Courseworks**



Chapter Contents

1. Definition of Artificial Intelligence

2. History of artificial intelligence

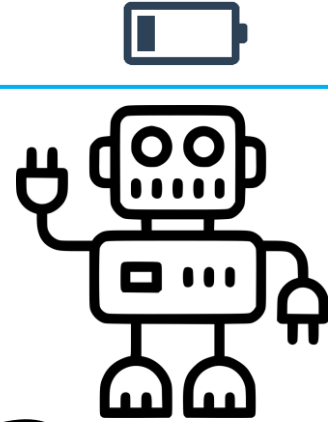
3. Key Drivers and Enablers

4. Related Concepts

5. National Importance and Strategies

6. Applications

7. AI Ethics

- 
- Class Discussions
 - Reading List
 - FAQ
 - Appendix
 - Reference

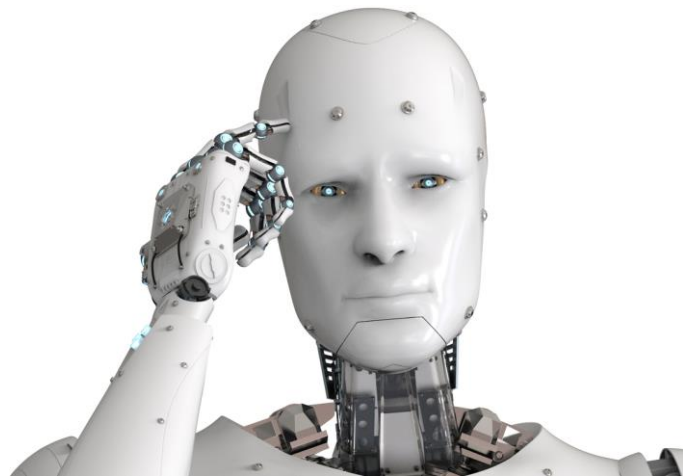
Contents

- **Three Branches of Artificial Intelligence**
- **Evolutionary Computation**
- **Artificial Neural Network**
- **Machine Learning**
- **Deep Learning**
- **Reinforcement Learning**
- **Natural Language Processing (NLP)**
- **Computer Vision**



Contents

- **Big Data**
- **Digital Twins**
- **Industry 4.0**
- **Block Chain**
- **Internet of things, IoT**
- **Cyber-physical System, CPS**
- **The 4th Paradigm**
- **AI 2.0**



Three Branches of Artificial Intelligence

AI = Computational Intelligence (CI)

1. Evolutionary Computation: Learning **from nature**
(population, generation, operator, fitness, etc)

2. Artificial Neural Network: Learning **from brain as white box** (neuron, layer, weighting, summation, activation, etc.)

3. Fuzzy Logic system: Learning **from brain as black box**
(fuzzy logic, natural language, membership function, fuzzification, inference, defuzzify, etc.)

Machine Learning^[40]

- Machine Learning (ML) is a subset of AI that focuses on the ability of enabling machines to 'learn' a task from experience (data) without programming them specifically about that task.
- This process starts with feeding them good quality data and training the machines by building various models using different algorithms.
- The choice of algorithms depends on the kind of task.

Machine Learning^[40]

- **Basically, 3 types:**

- *Supervised learning,*
- *Unsupervised learning*
- *Reinforcement learning*

- **In recent years:**

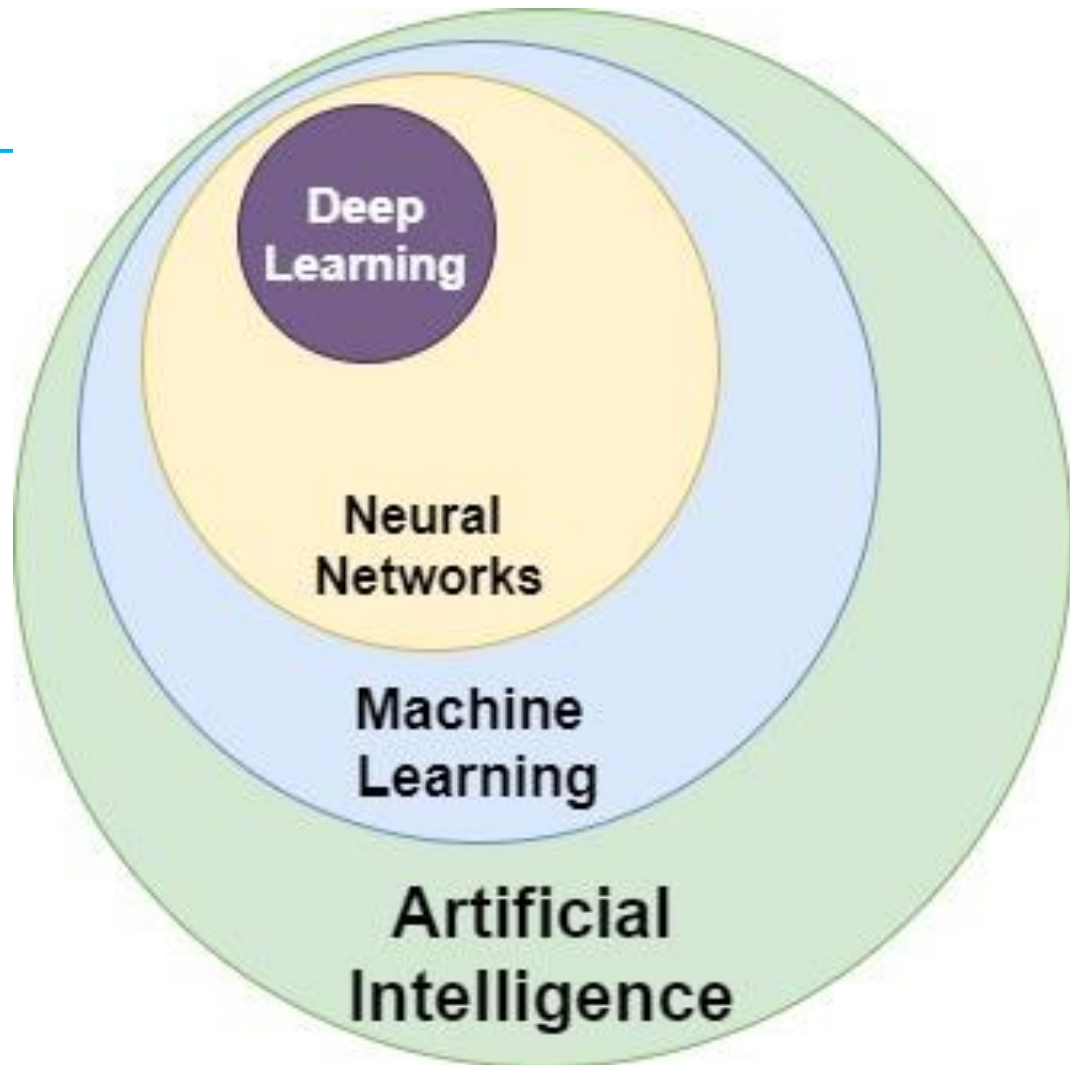
- *Semi-supervised learning*
- *Federated learning*
- *Extreme Learning Machines (ELM)*
- *One-shot learning (OSL)*
- *Zero-shot learning (ZSL)*

Deep Learning

- Deep Learning (DL) is a **subset of ML**. It enables processing of data and creating predictions using **ANN**.
- These ANN are connected in a web/like structure like the networks in the human brain.
- This web-like structure of ANN is able to process data in a **non-linear approach**, which is a significant advantage over traditional algorithms.

Reinforcement Learning

- Reinforcement learning (RL) is a part of ML in which the machine learns something in a way that is similar to how humans learn.
- As an example, assume that the machine is a student. Here the hypothetical student learns from its own mistakes over time through trial and error.
- The algorithm decides the next action by learning behaviours that are based on its current state and that will maximise the reward in the future.



Robotics

- A **robot** is a mechanical or virtual **artificial agent**, usually an electro-mechanical machine that is guided by a computer **program** or electronic circuitry.
- **AI** allows robots to act **intelligently** in certain situations.
- These robots may be able to solve problems in a limited sphere or even learn in controlled environments.



Natural Language Processing

- In Natural Language Processing (**NLP**) where machines analyse and **understand** language and speech. There are many subparts of NLP that deal with language such as *speech recognition, natural language generation, natural language translation*, etc.

Natural Language Processing

NLP is currently extremely popular for customer support applications, particularly the chatbot, e.g. ChatGPT



These chatbots use ML and NLP to interact with the users in textual form and solve their queries.



[What is ChatGPT and How You Can Use It \(4:](#)

Recommender Systems

- When you are using **Netflix/Youtube/Douyin**, do you get a recommendation of movies and series based on your past choices or genres you like? This is done by Recommender Systems that **provide you some guidance** on what to choose next among the vast choices available online.
- A Recommender System can be based on **Content-based Recommendation** or even **Collaborative Filtering**.



Recommender Systems

- **Content-Based Recommendation** is done by analyzing the content of all the items. For example, you can be recommended books you might like based on a description of the item and your own basic profile.
- On the other hand, **Collaborative Filtering** is done by analysing the past reading behaviour of people similar to you and then recommending results based on that.

Cognitive Analytics

- Cognitive Analytics is a **subfield of AI** that deals with cognitive behaviour we **associate** with '**thinking**' as opposed to perception and motor control. **Thinking** allows an entity to **obtain information from observations**, to learn and communicate.
- A cognitive system is capable of **extracting information** from unstructured data by extracting concepts and relationships into a **knowledge base**.

Cognitive Analytics

- The Cognitive System **improves** its performance over time in **two** major ways:
 - 1 through **interaction with humans**, and using feedback from the conversation partner or by observing two interacting humans.
 - 2 from all the **data in the knowledge base**, new knowledge can be obtained using inference.



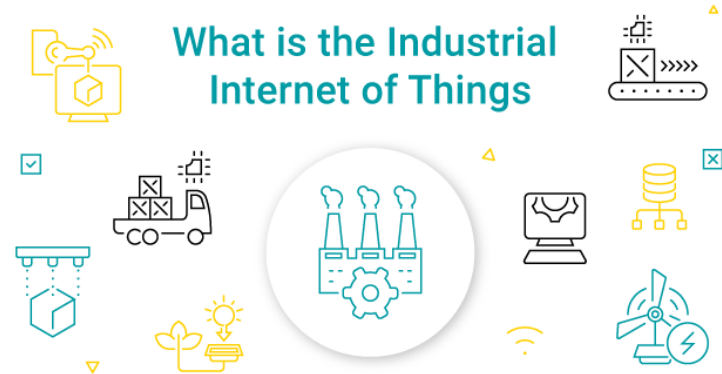
Computer Vision

- Computer Vision uses AI to **extract information** from images. This information can be object detection in the image, identification of image content to group various images together, etc.
- An application of computer vision is navigation for **autonomous vehicles** by analysing images of surroundings.



Internet of Things

- All these IoT devices generate a lot of data that needs to be collected and mined for actionable results. This is where **AI** comes into the picture.
- AI deals with the creation of systems that can learn to emulate human tasks using their prior experience and **without** any manual intervention.

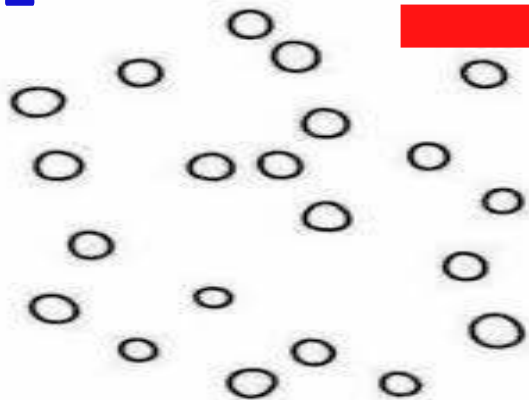


Big Data

- What is big data? [Everyday](#)(5:35mins), [industry](#)(1:26mins)
- **Big data** is data sets that are so big and complex that traditional data-processing application software are inadequate to deal with them.
- Data challenges **include** capturing data, data storage, data analysis, search, sharing, transfer, visualisation, querying, updating, information privacy and data source.
- **5V** features: Volume, Velocity, Variety, Value, Veracity

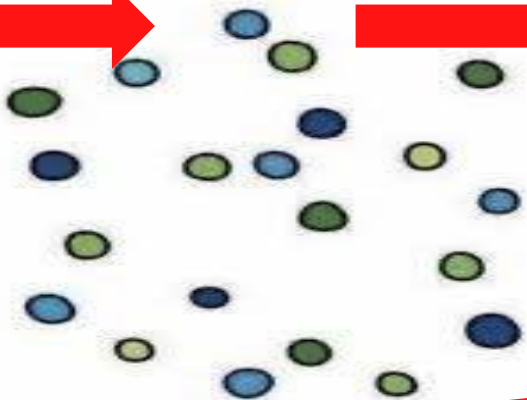
1

data:



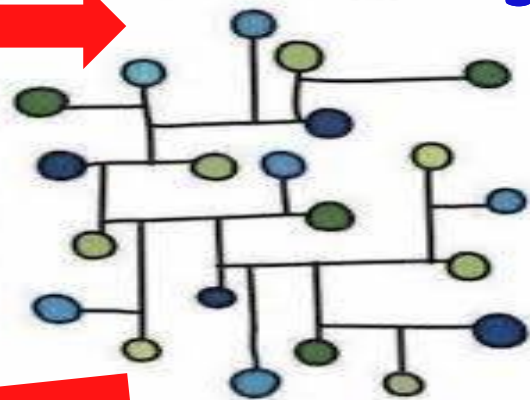
2

information:



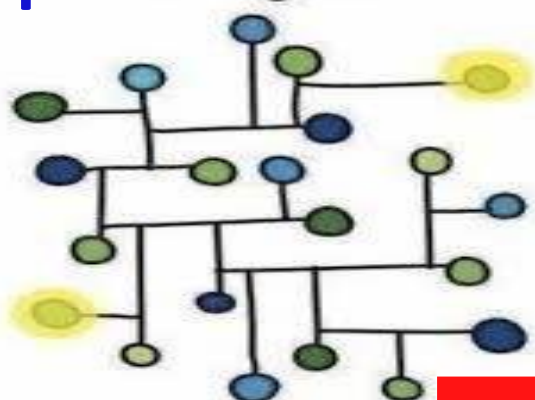
3

knowledge:



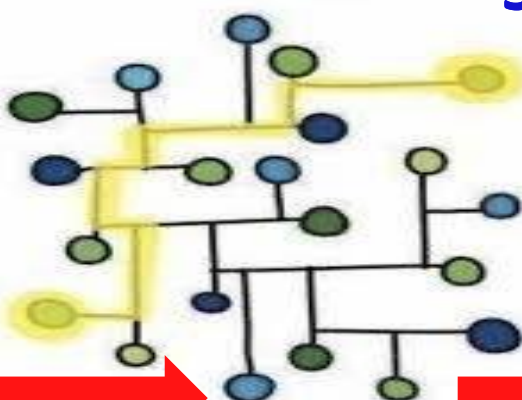
4

insight:



5

wisdom:



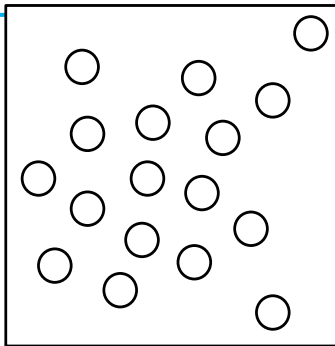
6

impact:

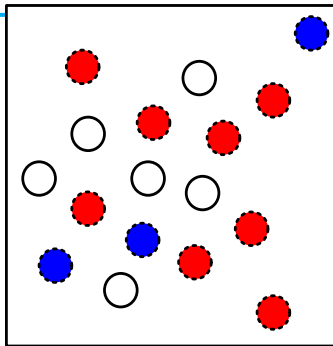




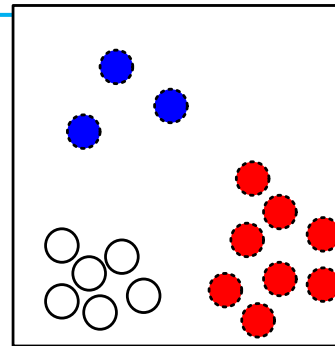
1: Data



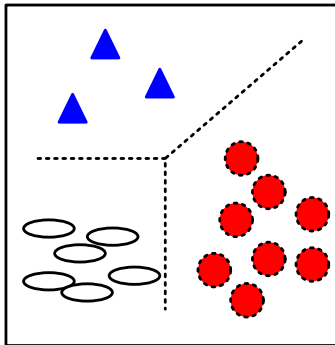
2: Information



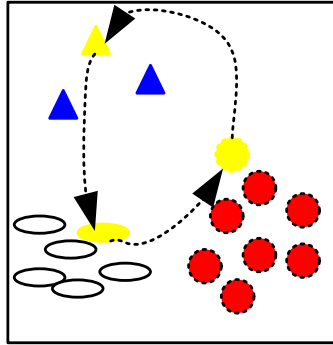
3 Knowledge



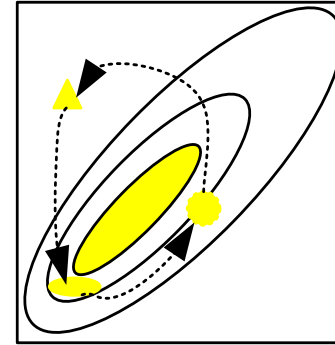
4 insight



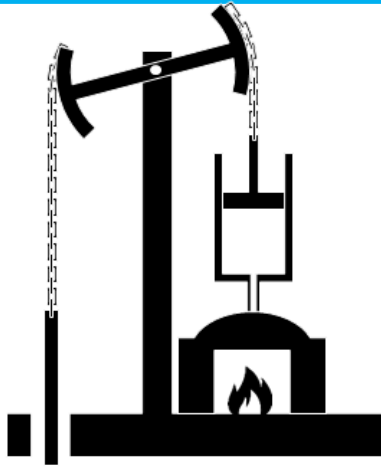
5 wisdom



6 Impact



Industry 4.0 (i4) What is i4? [KPMG\(3:54mins\)](#), [Essentra \(1:45mins\)](#)



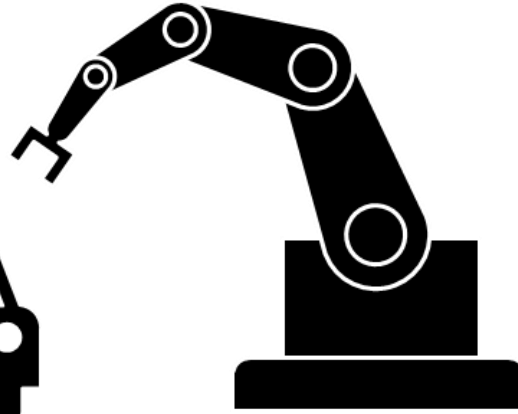
1st

Mechanization,
water power, steam
power



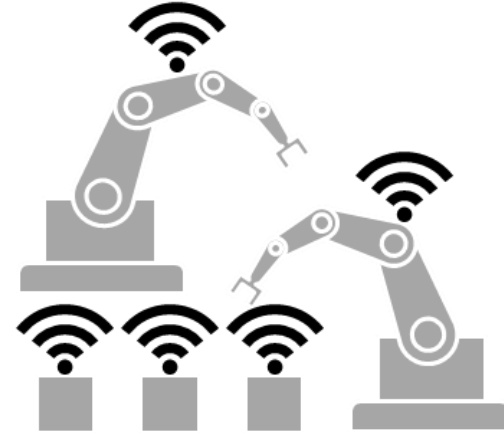
2nd

Mass production,
assembly line,
electricity



3rd

Computer and
automation

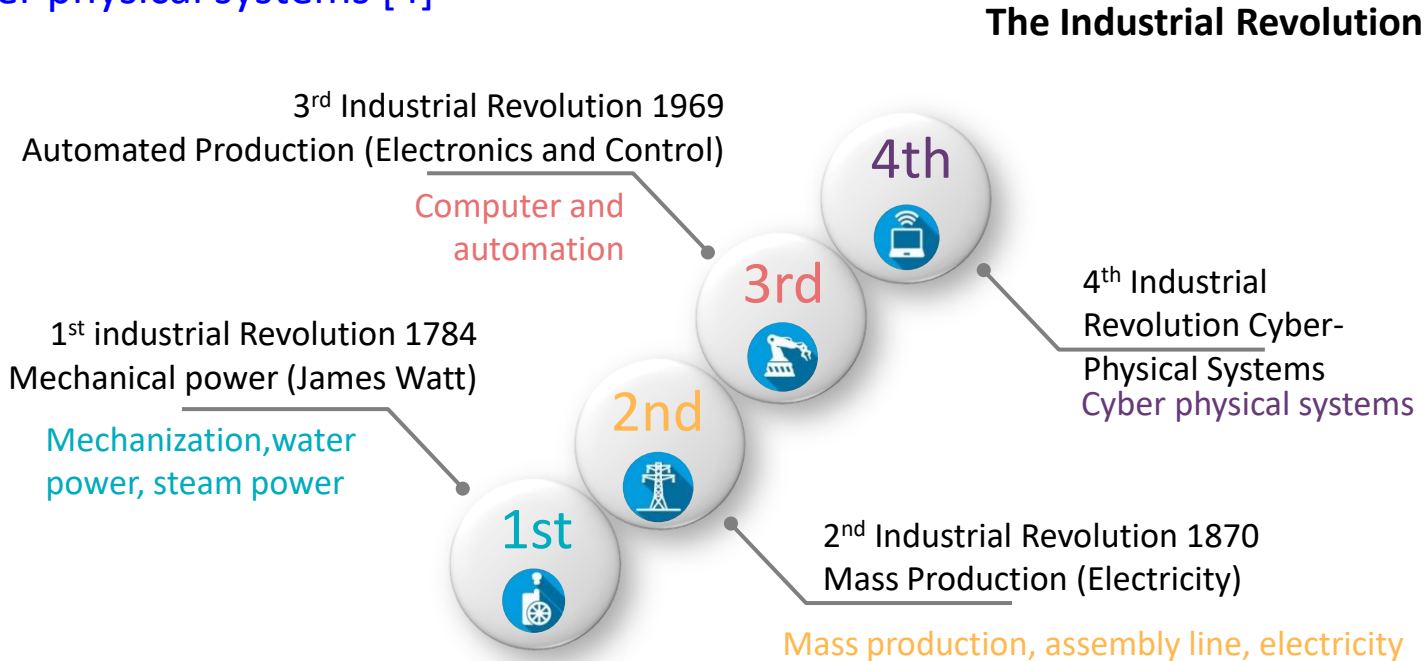


4th

Cyber Physical
Systems

From i1 to i4

- i1: Mechanisation, water power, steam power
- i2: Mass production, assembly line, electricity
- i3: Computer and automation
- i4: Cyber physical systems [4]



Blockchain

- A blockchain is a continuously growing list of records, called **blocks**, which are linked and secured using cryptography.
- What is Blockchain? [iftf\(2:25mins\)](#), [CN01\(4:12mins\)](#), [CN02\(3:45mins\)](#)

Cyber-physical System

- [What is CPS?\(1:06mins\)](#)
- Cyber-physical systems (CPS) are engineered systems that are built from, and depend upon, the seamless integration of **computation** and **physical** components.
- **Advances** in CPS will enable capability, adaptability, scalability, resiliency, safety, security, and usability that will expand the horizons of these critical systems.
- **Industry 4.0 = CPS + IoT + Services**

Digital Twins

- Digital twins (DT) is a **real-time mapping** of all **components** in the product life cycle using **physical** data, **virtual** data and **interaction data** between them.
- CPS provides an integrated and compatible **framework** with a comprehensive perspective
- DT can be considered as a focused **application** of it. [53]

See more in 06-02

The 4th Paradigm of Science

- The **1st** paradigm: **empirical** observation and experimentation
- The **2nd** paradigm: **analytical** or theoretical approaches
- The **3rd** paradigm: computational science or **simulation**
- The **4th** Paradigm: **data-intensive** scientific discovery
- What about the **5th** Paradigm?

AI-driven scientific discovery

Artificial Intelligence 2.0 (AI 2.0)^[56]

With the current popularisation of the following applications

- *the Internet*
- *universal existence of sensors*
- *emergence of big data*
- *development of e-commerce*
- *rise of the information community*
- *interconnection and fusion of data and knowledge in society, physical space, and cyberspace*

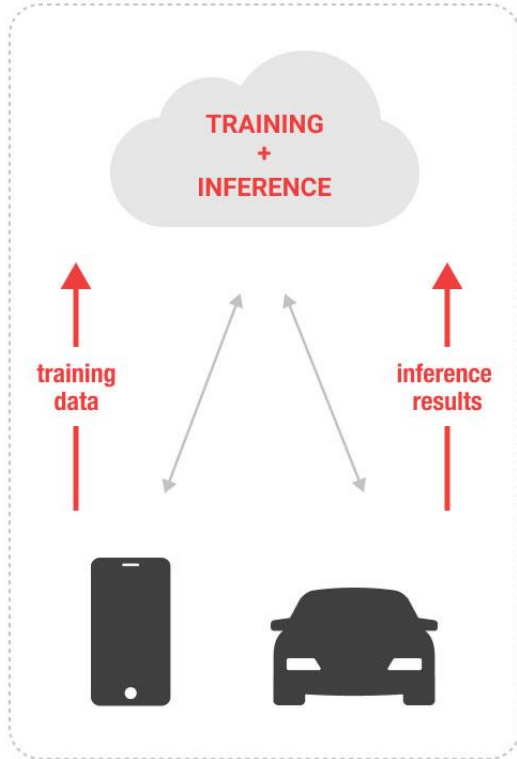
the information environment surrounding AI development has changed profoundly, leading to a new evolutionary stage: AI 2.0

- 1. Big-data-based AI*
- 2. Internet crowd intelligence*
- 3. Cross-media intelligence*
- 4. Human-machine hybrid-augmented intelligence*
- 5. Autonomous-intelligent systems*

Edge AI

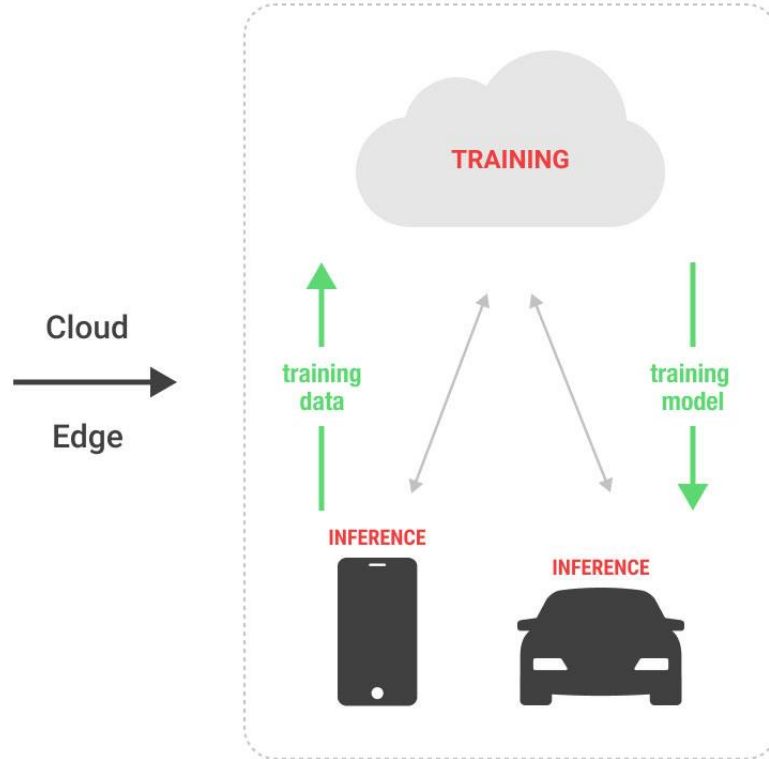
- Edge AI refers to AI algorithms that process locally on **hardware devices**, and can process data **without** a connection.
- This means operations such as data creation can occur without streaming or storing data in the cloud.
- This is important because there are an increasing number of cases where device data can't be handled via the cloud.
- Factory robots and cars, for example, need high-speed processing with minimal latency.

AI processing using only the cloud



- Increase in amount of data transmissions
- Large impact on data latency
- Large impact on transfer disconnections

Processing shared between cloud and edge



- Reduces amount of data transmission
- Lower impact on data latency
- Lower impact on transfer disconnections

Benefits of edge computing

- An efficient predictive maintenance and asset management
- Inspection span of less than one minute per product
- Reduces field issues
- Better customer satisfaction
- Ensure large-scale Edge AI infrastructure and edge device life-cycle management
- Improve traffic control measures in cities.

Advantages of Edge AI

- Privacy
- Reduced Latency
- Minimal Bandwidth (cloudlet)
- Low-Cost Digital Infrastructure



Challenges of Edge AI

- Poor Data Quality
- Vulnerable Security Feature
- Limited Machine Learning Power
- Pruning AI networks

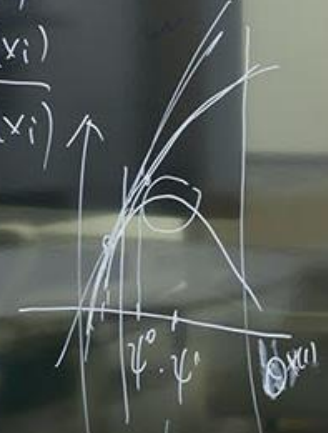


$$p_\theta(x) = \frac{1}{c_\theta} h_\theta(x)$$

$$\frac{c_\theta}{c_\psi} = \int \frac{h_\theta(x)}{h_\psi(x)} p_\psi(x) dx$$

$$\hat{r} = \frac{1}{n} \sum \frac{h_\theta(x_i)}{h_\psi(x_i)}$$

$\frac{\log}{\log}$

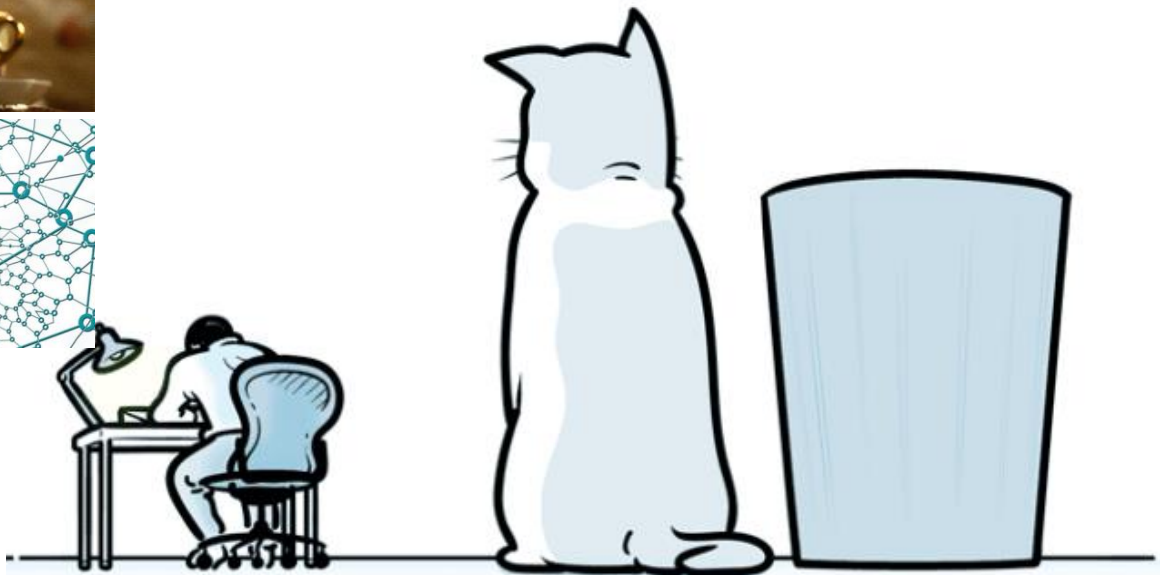
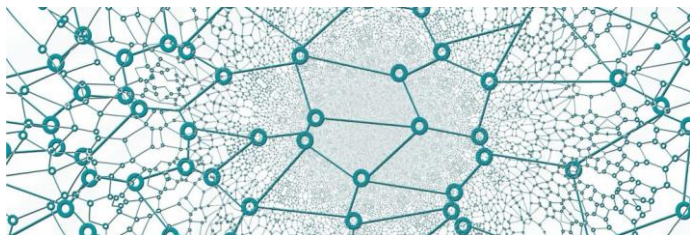




Thanks and Questions

Thanks and Questions

<https://github.com/LeoYiChen/Introduction2AI-202010>



Introduction to Artificial Intelligence

- 01 An Introduction

Dr Leo Chen

leo.chen@ieee.org

21/Feb/2024

Thanks and Questions