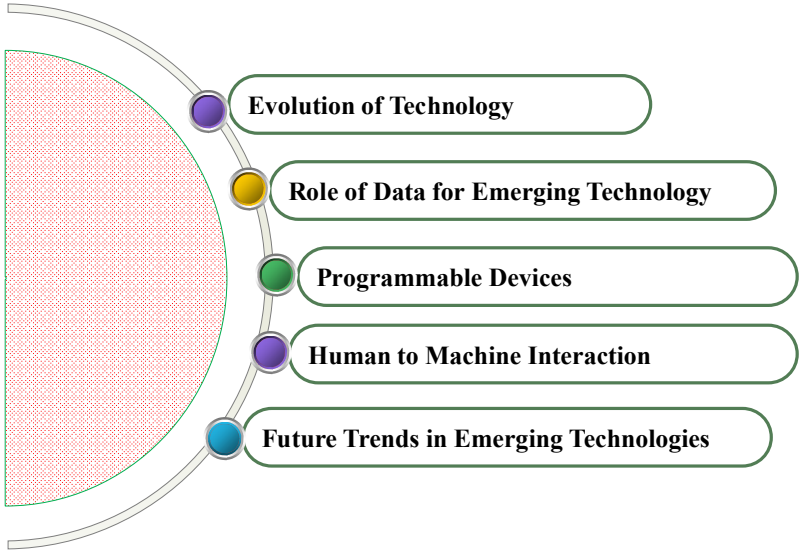
CHAPTER ONE

Introduction to

Emerging Technology

Andualem T.

Contents



Emerging Technology

- Is a term generally used to describe a new technology
- It may also refer to the continuing development of existing technology
- The term commonly refers to technologies that are currently developing, or that are expected to be available within the next five to ten years
- The term is usually reserved for technologies that are creating or are expected to create significant social or economic effects.

What is the root word of Technology and Evolution?

Technology

- 1610s, "discourse or treatise on an art or the arts," from Greek tekhnologia "systematic treatment of an art, craft, or technique,"
- Originally referring to grammar, from tekhno- (see techno-) + -logy.
- The meaning "science of the mechanical and industrial arts" is first recorded in 1859.

Evolution

- Evolution means the process of developing by gradual changes.
- This noun is from Latin evolutio, "an unrolling or opening," combined from the prefix e-, "out," plus volvere, "to roll."

List of some currently available Emerged Technologies

- Artificial Intelligence
- Blockchain
- Augmented Reality and Virtual Reality
- Cloud Computing
- Angular and React
- DevOps
- Internet of Things (IoT)
- Intelligent Apps (I-Apps)
- Big Data
- Robotic Processor Automation (RPA)

Introduction to the Industrial Revolution (IR)

- A period of major industrialization and innovation that took place during the late 1700s and early 1800s.
- IR occurs when a society shifts from using tools to make products to use new sources of energy, such as coal, to power machines in factories.
- The revolution started in England, with a series of innovations to make labor more efficient and productive.
- IR was a time when the manufacturing of goods moved from small shops and homes to large factories.
- This shift brought about changes in culture as people moved from rural areas to big cities in order to work.

Introduction to the Industrial Revolution (IR)

- The American Industrial Revolution commonly referred to as the Second Industrial Revolution, started sometime between 1820 and 1870.
- Industries such as textile manufacturing, mining, glass making, and agriculture all had undergone changes.
- For example, prior to the Industrial Revolution, textiles were primarily made of wool and were handspun.
- From the first industrial revolution (mechanization through water and steam power) to the mass production and assembly lines using electricity in the second, the fourth industrial revolution will take what was started in the third with the adoption of computers and automation and enhance it with smart and autonomous systems fueled by data and machine learning.

Introduction to the Industrial Revolution (IR)

- Generally, the following industrial revolutions fundamentally changed and transfer the world around us into modern society.
  - The steam engine,
  - The age of science and mass production, and
  - The rise of digital technology
  - Smart and autonomous systems fueled by data and machine learning.

Introduction to the Industrial Revolution (IR)

- The Most Important Inventions of the Industrial Revolution
  - **Transportation**: The Steam Engine, The Railroad, The Diesel Engine, The Airplane.
  - **Communication**.: The Telegraph, Transatlantic Cable, Phonograph, the Telephone.
  - **Industry**: The Cotton Gin. The Sewing Machine. Electric Lights.

Historical Background (IR 1.0, IR 2.0, IR 3.0)

- The industrial revolution began in Great Britain in the late 1770s before spreading to the rest of Europe.
- The first European countries to be industrialized after England were Belgium, France, and the German states.
- The final cause of the Industrial Revolution was the effects created by the Agricultural Revolution.
- As previously stated, the Industrial Revolution began in Britain in the 18th century due in part to an increase in food production, which was the key outcome of the Agricultural Revolution.

Historical Background (IR 1.0, IR 2.0, IR 3.0)

- The four types of industries are:
  - Primary industry involves getting raw materials e.g. mining, farming, and fishing.
  - Secondary industry involves manufacturing e.g. making cars and steel.
  - Tertiary industries provide a service e.g. teaching and nursing.
  - Quaternary industry involves research and development industries e.g. IT.

Historical Background (IR 1.0, IR 2.0, IR 3.0)

- Industrial Revolution (IR 1.0)
  - The Industrial Revolution (IR) is described as a transition to new manufacturing processes.
  - IR was first coined in the 1760s, during the time where this revolution began.
  - The transitions in the first IR included going from hand production methods to machines, the increasing use of steam power, the development of machine tools and the rise of the factory system.

Historical Background (IR 1.0, IR 2.0, IR 3.0)

- Industrial Revolution (IR 2.0)
  - Also known as the Technological Revolution, began somewhere in the 1870s.
  - The advancements in IR 2.0 included the development of methods for manufacturing interchangeable parts and widespread adoption of pre-existing technological systems such as telegraph and railroad networks.
  - This adoption allowed the vast movement of people and ideas, enhancing communication.
  - Moreover, new technological systems were introduced, such as electrical power and telephones.

Historical Background (IR 1.0, IR 2.0, IR 3.0)

- Industrial Revolution (IR 3.0)
  - Introduced the transition from mechanical and analog electronic technology to digital electronics which began from the late 1950s.
  - Due to the shift towards digitalization, IR 3.0 was given the nickname, "Digital Revolution".
  - The core factor of this revolution is the mass production and widespread use of digital logic circuits and its derived technologies such as the computer, handphones and the Internet.
  - These technological innovations have arguably transformed traditional production and business techniques enabling people to communicate with another without the need of being physically present.
  - Certain practices that were enabled during IR 3.0 is still being practiced until this current day, for example – the proliferation of digital computers and digital record.

Historical Background (IR 1.0, IR 2.0, IR 3.0, IR 4.0)

- Industrial Revolution (IR 4.0)
  - Now, with advancements in various technologies such as robotics, Internet of Things (IoT), additive manufacturing and autonomous vehicles, the term "Fourth Industrial
  - Revolution" or IR 4.0 was coined by Klaus Schwab, the founder and executive chairman of World Economic Forum, in the year 2016.
  - The technologies mentioned above are what you call – cyber physical systems.
  - A cyber-physical system is a mechanism that is controlled or monitored by computer-based algorithms, tightly integrated with the Internet and its users.
  - ***Examples***: Computer Numerical Control (CNC) machines and Artificial Intelligence (AI).
  - CNC Machines: operated by giving it instructions using a computer
  - AI: one of the main elements that give life to Autonomous Vehicles and Automated Robots.

Role of Data for Emerging Technology

- Data is regarded as the new oil and strategic asset since we are living in the age of big data, and drives or even determines the future of science, technology, the economy, and possibly everything in our world today and tomorrow.
- Data have not only triggered tremendous hype and buzz but more importantly, presents enormous challenges that in turn bring incredible innovation and economic opportunities.
- This reshaping and paradigm-shifting are driven not just by data itself but all other aspects that could be created, transformed, and/or adjusted by understanding, exploring, and utilizing data.

Role of Data for Emerging Technology

- The preceding trend and its potential have triggered new debate about data-intensive scientific discovery as an emerging technology, the so-called "fourth industrial revolution," There is no doubt, nevertheless, that the potential of data science and analytics to enable data-driven theory, economy, and professional development is increasingly being recognized.
- This involves not only core disciplines such as computing, informatics, and statistics, but also the broad-based fields of business, social science, and health/medical science.

Enabling Devices & Network (Programmable Devices)

- In the world of digital electronic systems, there are four basic kinds of devices: **memory**, **microprocessors**, **logic**, and **networks**.
- Memory devices store random information such as the contents of a spreadsheet or database.
- Microprocessors execute software instructions to perform a wide variety of tasks such as running a word processing program or video game.
- Logic devices provide specific functions, including device-to-device interfacing, data communication, signal processing, data display, timing and control operations, and almost every other function a system must perform.
- Network is a collection of computers, servers, mainframes, network devices, peripherals, or other devices connected to one another to allow the sharing of data.
- Example of a network is the Internet, which connects millions of people all over the world Programmable devices usually refer to chips that incorporate field programmable logic devices (FPLDs), complex programmable logic devices (CPLD) and programmable logic devices (PLD).
- There are also devices that are the analog equivalent of these called field programmable analog arrays.

Enabling Devices & Network (Programmable Devices)

- **Why is a computer referred to as a programmable device?**
  - Because a computer follows a set of instructions.
  - Many electronic devices are computers that perform only one operation, but they are still following instructions that reside permanently in the unit.
- **List of some Programmable devices**
  - Achronix Speedster SPD60
  - Actel**'s**
  - Altera Stratix IV GT **and Arria II GX**
  - Atmel's AT91CAP7L
  - Cypress Semiconductor's programmable system-on-chip (PSoC) family
  - Lattice Semiconductor's ECP3
  - Lime Microsystems' LMS6002
  - Silicon Blue Technologies
  - Xilinx Virtex 6 and Spartan 6
  - Xmos Semiconductor L series

Enabling Devices & Network (Programmable Devices)

- **Service Enabling Devices (Network Related Equipment)**
  - Traditional channel service unit (CSU) and data service unit (DSU)
  - Modems
  - Routers
  - Switches
  - Conferencing equipment
  - Network appliances (NIDs and SIDs)
  - Hosting equipment and servers

Human to Machine Interaction(HMI)

- HMI refers to the communication and interaction between a human and a machine via a user interface.
- Nowadays, natural user interfaces such as gestures have gained increasing attention as they allow humans to control machines through natural and intuitive behaviors.

1. What is interaction in human-computer interaction?

- HCI (human-computer interaction) is the study of how people interact with computers and to what extent computers are or are not developed for successful interaction with human beings.
- As its name implies, HCI consists of three parts: the **User**, the **Computer** itself, and the **ways they work together**.

2. How do users interact with computers?

- The user interacts directly with hardware for the human input and output such as displays, e.g. through a graphical user interface.
- The user interacts with the computer over this software interface using the given input and output (I/O) hardware.

Human to Machine Interaction(HMI)

3. How important is human-computer interaction?

- The goal of HCI is to improve the interaction between users and computers by making computers more user-friendly and receptive to the user's needs.

- The **main advantages of HCI** are
  - Simplicity
  - Ease of deployment & operations
  - Cost savings for smaller set-ups
  - Reduce solution design time and integration complexity.

Human to Machine Interaction(HMI)

- **Disciplines Contributing to Human-Computer Interaction (HCI)**
  - **Cognitive psychology**: Limitations, information processing, performance prediction, cooperative working, and capabilities.
  - **Computer science**: Including graphics, technology, prototyping tools, user interface management systems.
  - **Linguistics**
  - **Engineering and design**
  - **Artificial intelligence**
  - **Human factors**

Future Trends in Emerging Technologies

- **Emerging Technology trends in 2019**
  - **5G Networks**
  - **Artificial Intelligence (AI)**
  - **Autonomous Devices**
  - **Blockchain**
  - **Augmented Analytics**
  - **Digital Twins**
  - **Enhanced Edge Computing and**
  - **Immersive Experiences in Smart Spaces**

Future Trends in Emerging Technologies

- **Some emerging technologies that will shape the future of you and your business**
  - **The future is now or emerging technologies are taking over our minds more and more each day.**
  - **These are very high-level emerging technologies though.**
    - **Chatbots**
    - **Virtual/augmented reality**
    - **Blockchain**
    - **Ephemeral Apps and**
    - **Artificial Intelligence are already shaping your life whether you like it or not.**

CHAPTER TWO

Data Science

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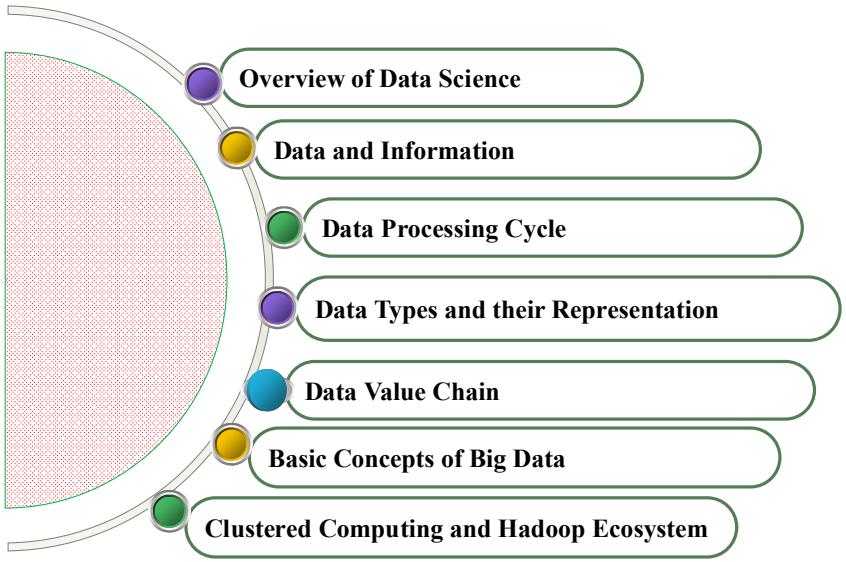
Contents



Overview of Data Science

- Data science is a multi-disciplinary field that uses scientific methods, processes, algorithms, and systems to extract knowledge and insights from structured, semi-structured and unstructured data.
- Data science is much more than simply analyzing data.
- Let's consider this idea by thinking about some of the data involved in buying a box of cereal from the store or supermarket:
  - Whatever your cereal preferences teff, wheat, or burly you prepare for the purchase by writing "cereal" in your notebook. This planned purchase is a piece of data though it is written by pencil that you can read.

Data and Information

Data

- Defined as a representation of facts, concepts, or instructions in a formalized manner, which should be suitable for communication, interpretation, or processing, by human or electronic machines.
- It can be described as unprocessed facts and figures.
- Represented with the help of characters such as alphabets (A-Z, a-z), digits (0-9) or special characters (+, -, /, *, <,>, =, etc.).

Information

- Is the processed data on which decisions and actions are based
- It is data that has been processed into a form that is meaningful to the recipient
- Information is interpreted data; created from organized, structured, and processed data in a particular context.

Data Processing Cycle

- Data processing is the re-structuring or re-ordering of data by people or machines to increase their usefulness and add values for a particular purpose.
- Data processing consists of the following basic steps - input, processing, and output.
- These three steps constitute the data processing cycle

Figure 2.1 Data Processing Cycle

Data Processing Cycle

- **Input**
  - In this step, the input data is prepared in some convenient form for processing.
  - The form will depend on the processing machine.
  - ***For example***, when electronic computers are used, the input data can be recorded on any one of the several types of storage medium, such as hard disk, CD, flash disk and so on.
- **Processing**
  - In this step, the input data is changed to produce data in a more useful form.
  - ***For example***, interest can be calculated on deposit to a bank, or a summary of sales for the month can be calculated from the sales orders.
- **Output**
  - At this stage, the result of the proceeding processing step is collected.
  - The particular form of the output data depends on the use of the data.
  - ***For example***, output data may be payroll for employees.

Data Types and their Representation

- Data types can be described from diverse perspectives.
- In computer science and computer programming, for instance, a data type is simply an attribute of data that tells the compiler or interpreter how the programmer intends to use the data.

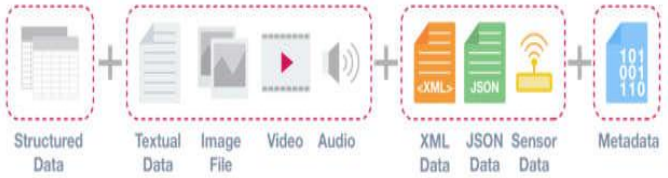
1. Data types from Computer programming perspective

- Almost all programming languages explicitly include the notion of data type.
- Common data types include
  - **Integers**(int)- is used to store whole numbers, mathematically known as integers
  - **Booleans**(bool)- is used to represent restricted to one of two values: true or false
  - **Characters**(char)- is used to store a single character
  - **Floating-point numbers**(float)- is used to store real numbers
  - Alphanumeric **strings**(string)- used to store a combination of characters and numbers

Data Types and their Representation

2. Data types from Data Analytics perspective

- From a data analytics point of view, it is important to understand that there are three common types of data types or structures:
  A. Structured
  B. Semi-structured, and
  C. Unstructured data types
- below describes the three types of data and metadata.



Structured Data

- Structured data is data that adheres to a pre-defined data model and is therefore straightforward to analyze.
- Structured data conforms to a tabular format with a relationship between the different rows and columns.
- ***Example***: Excel files or SQL databases.
- Each of these has structured rows and columns that can be sorted.

Semi-structured Data

- Semi-structured data is a form of structured data that does not conform with the formal structure of data models associated with relational databases or other forms of data tables, but nonetheless, contains tags or other markers to separate semantic elements and enforce hierarchies of records and fields within the data.
- Therefore, it is also known as a self-describing structure.
- ***Examples***: JSON and XML are forms of semi-structured data.

Unstructured Data

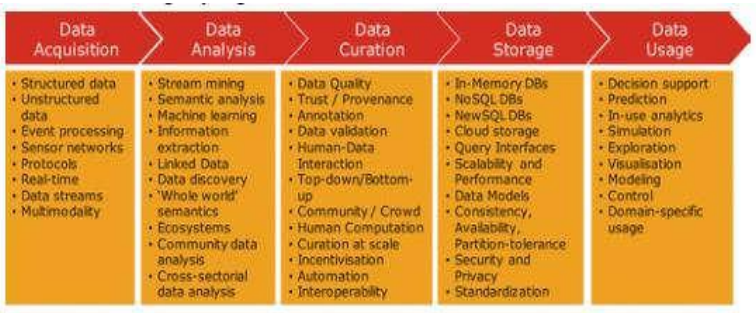
- Unstructured data is information that either does not have a predefined data model or is not organized in a pre-defined manner.
- Unstructured information is typically text-heavy but may contain data such as dates, numbers, and facts as well.
- This results in irregularities and ambiguities that make it difficult to understand using traditional programs as compared to data stored in structured databases.
- ***Example***: Audio, video files or NoSQL databases.

Metadata (Data about Data)

- From a technical point of view, this is not a separate data structure, but it is one of the most important elements for Big Data analysis and big data solutions.
- Metadata is data about data.
- It provides additional information about a specific set of data.
- metadata is frequently used by Big Data solutions for initial analysis.
- In a set of photographs, for example, metadata could describe when and where the photos were taken. The metadata then provides fields for dates and locations which, by themselves, can be considered structured data.

Data Value Chain

- The Data Value Chain is introduced to describe the information flow within a big data system as a series of steps needed to generate value and useful insights from data.
- The Big Data Value Chain identifies the following key high-level activities:



Data Acquisition

- It is the process of gathering, filtering, and cleaning data before it is put in a data warehouse or any other storage solution on which data analysis can be carried out.
- Data acquisition is one of the major big data challenges in terms of infrastructure requirements.
- The infrastructure required to support the acquisition of big data must deliver low, predictable latency in both capturing data and in executing queries; be able to handle very high transaction volumes, often in a distributed environment; and support flexible and dynamic data structures.

Data Analysis

- It is concerned with making the raw data acquired amenable to use in decision-making as well as domain-specific usage.
- Data analysis involves exploring, transforming, and modeling data with the goal of highlighting relevant data, synthesizing and extracting useful hidden information with high potential from a business point of view.
- Related areas include data mining, business intelligence, and machine learning.

Data Curation

- It is the active management of data over its life cycle to ensure it meets the necessary data quality requirements for its effective usage.
- Data curation processes can be categorized into different activities such as content creation, selection, classification, transformation, validation, and preservation.
- Data curation is performed by expert curators that are responsible for improving the accessibility and quality of data.
- Data curators (also known as scientific curators or data annotators) hold the responsibility of ensuring that data are trustworthy, discoverable, accessible, reusable and fit their purpose.
- A key trend for the duration of big data utilizes community and crowdsourcing approaches.

Data Storage

- It is the persistence and management of data in a scalable way that satisfies the needs of applications that require fast access to the data.
- Relational Database Management Systems (RDBMS) have been the main, and almost unique, a solution to the storage paradigm for nearly 40 years.
- However, the **ACID** (Atomicity, Consistency, Isolation, and Durability) properties that guarantee database transactions lack flexibility with regard to schema changes and the performance and fault tolerance when data volumes and complexity grow, making them unsuitable for big data scenarios.
- NoSQL technologies have been designed with the scalability goal in mind and present a wide range of solutions based on alternative data models.

Data Usage

- It covers the data-driven business activities that need access to data, its analysis, and the tools needed to integrate the data analysis within the business activity.
- Data usage in business decision-making can enhance competitiveness through the reduction of costs, increased added value, or any other parameter that can be measured against existing performance criteria.

Basic Concepts of Big Data

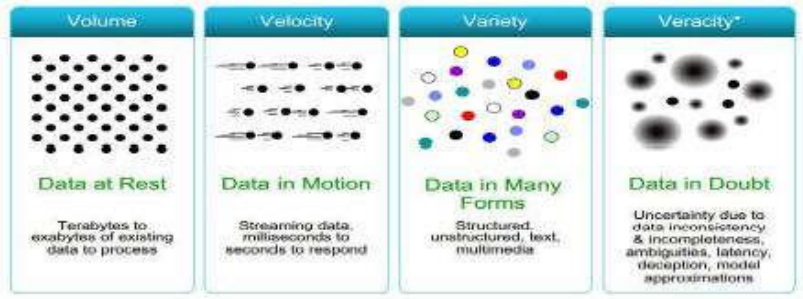
- Big data is a blanket term for the non-traditional strategies and technologies needed to gather, organize, process, and gather insights from large datasets.
- While the problem of working with data that exceeds the computing power or storage of a single computer is **not** new, the pervasiveness, scale, and value of this type of computing have greatly expanded in recent years.

What is Big Data?

- **Big data** is the term for a collection of data sets so large and complex that it becomes difficult to process using on-hand database management tools or traditional data processing applications.
- In this context, a "large dataset" means a dataset too large to reasonably process or store with traditional tooling or on a single computer.
- This means that the common scale of big datasets is constantly shifting and may vary significantly from organization to organization.
- Big data is characterized by 3V and more: Volume, Velocity, Variety and Veracity

What is Big Data?

- **Characteristics of Big Data**
  - **Volume**: large amounts of data Zeta bytes/Massive datasets
  - **Velocity**: Data is live streaming or in motion
  - **Variety**: data comes in many different forms from diverse sources
  - **Veracity**: can we trust the data? How accurate is it? etc.



Clustered Computing and Hadoop Ecosystem

- Clustered Computing
  - Because of the qualities of big data, individual computers are often inadequate for handling the data at most stages.
  - To better address the high storage and computational needs of big data, computer clusters are a better fit.
  - Big data clustering software combines the resources of many smaller machines, seeking to provide a number of benefits:
    - Resource Pooling
    - High Availability
    - Easy Scalability

Clustered Computing and Hadoop Ecosystem

- Resource Pooling
  - Combining the available storage space to hold data is a clear benefit, but CPU and memory pooling are also extremely important.
  - Processing large datasets requires large amounts of all three of these resources.
- High Availability
  - Clusters can provide varying levels of fault tolerance and availability guarantees to prevent hardware or software failures from affecting access to data and processing.
  - This becomes increasingly important as we continue to emphasize the importance of real-time analytics.
- Easy Scalability
  - Clusters make it easy to scale horizontally by adding additional machines to the group. This means the system can react to changes in resource requirements without expanding the physical resources on a machine.

Clustered Computing and Hadoop Ecosystem

- Using clusters requires a solution for managing cluster membership, coordinating resource sharing, and scheduling actual work on individual nodes.
- Cluster membership and resource allocation can be handled by software like **Hadoop's YARN** (which stands for Yet Another Resource Negotiator).
- The assembled computing cluster often acts as a foundation that other software interfaces with to process the data.
- The machines involved in the computing cluster are also typically involved with the management of a distributed storage system, which we will talk about when we discuss data persistence.

Clustered Computing and Hadoop Ecosystem

- Hadoop and its Ecosystem
  - Hadoop is an open-source framework intended to make interaction with big data easier.
  - It is a framework that allows for the distributed processing of large datasets across clusters of computers using simple programming models.
  - It is inspired by a technical document published by Google.
  - The four key characteristics of Hadoop are:
    - Economical
    - Reliable
    - Scalable
    - Flexible

Hadoop and its Ecosystem

- The four key characteristics of Hadoop are:
  - **Economical**: Its systems are highly economical as ordinary computers can be used for data processing.
  - **Reliable**: It is reliable as it stores copies of the data on different machines and is resistant to hardware failure.
  - **Scalable**: It is easily scalable both, horizontally and vertically. A few extra nodes help in scaling up the framework
  - **Flexible**: It is flexible and you can store as much structured and unstructured data as you need to and decide to use them later.

Hadoop and its Ecosystem

- Hadoop has an ecosystem that has evolved from its four core components: data management, access, processing, and storage.
- It is continuously growing to meet the needs of Big Data.
- It comprises the following components and many others:
  - **HDFS:** Hadoop Distributed File System
  - **YARN**: Yet Another Resource Negotiator
  - **MapReduce:** Programming based Data Processing
  - **Spark:** In-Memory data processing
  - **PIG, HIVE:** Query-based processing of data services
  - **HBase:** NoSQL Database
  - **Mahout, Spark MLLib**: Machine Learning algorithm libraries
  - **Solar, Lucene:** Searching and Indexing
  - **Zookeeper:** Managing cluster
  - **Oozie:** Job Scheduling

Hadoop and its Ecosystem

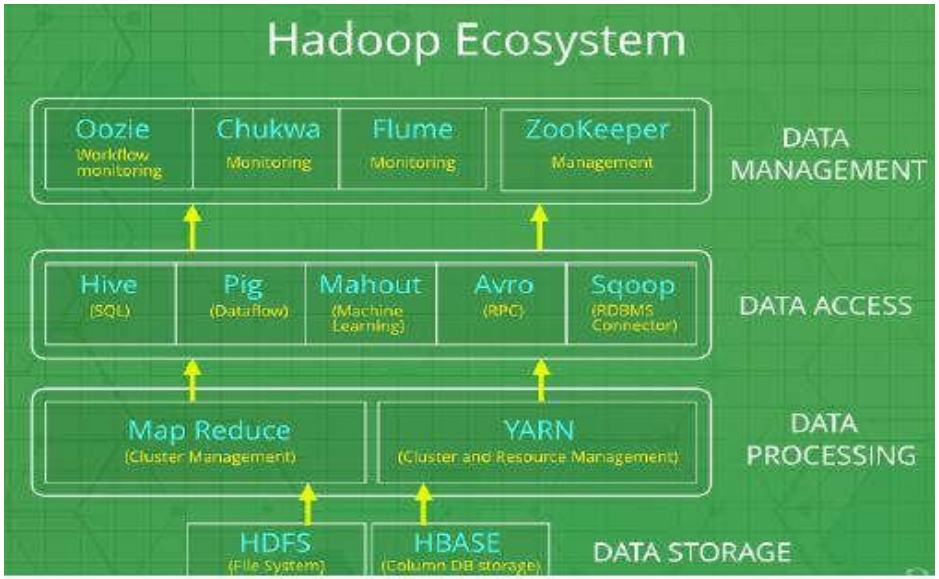


Figure 2.5 Hadoop Ecosystem

Big Data Life Cycle with Hadoop

- Ingesting data into the system
  - The first stage of Big Data processing is Ingest.
  - The data is ingested or transferred to Hadoop from various sources such as relational databases, systems, or local files.
  - Sqoop transfers data from RDBMS to HDFS, whereas Flume transfers event data.
- Processing the data in storage
  - The second stage is Processing.
  - In this stage, the data is stored and processed.
  - The data is stored in the distributed file system, HDFS, and the NoSQL distributed data, HBase.
  - Spark and MapReduce perform data processing.

Big Data Life Cycle with Hadoop

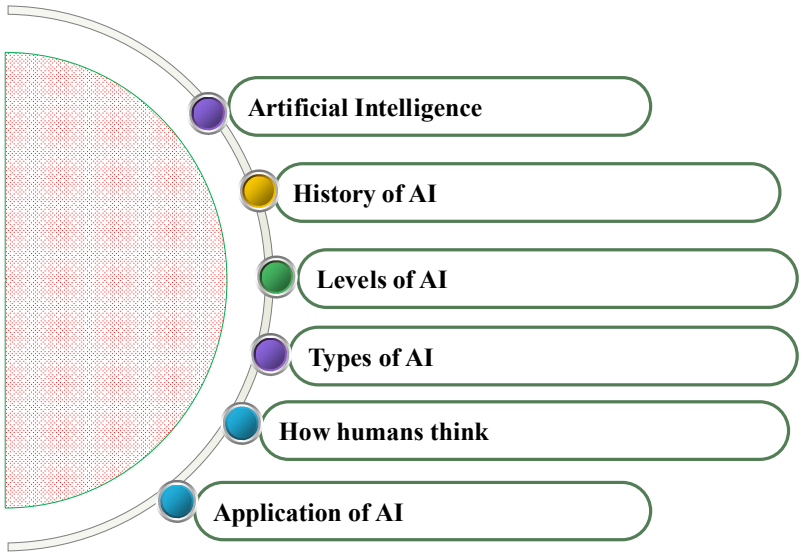
- Computing and analyzing data
  - The third stage is to Analyze.
  - Here, the data is analyzed by processing frameworks such as Pig, Hive, and Impala.
  - Pig converts the data using a map and reduce and then analyzes it.
  - Hive is also based on the map and reduce programming and is most suitable for structured data.
- Visualizing the results
  - The fourth stage is Access, which is performed by tools such as Hue and Cloudera Search.
  - In this stage, the analyzed data can be accessed by users.

CHAPTER THREE

Artificial Intelligence

Andualem T.

Contents



Artificial Intelligence (AI)

- **Artificial Intelligence** is composed of two words **Artificial** and **Intelligence**.
- Artificial defines "man-made," and intelligence defines "thinking power", or "the ability to learn and solve problems"
- Artificial Intelligence means "a man-made thinking power."
- Artificial Intelligence (AI) as the branch of computer science by which we can create intelligent machines which can behave like a human, think like humans, and able to make decisions.
- **Intelligence** is the ability to acquire and apply **knowledge**.

Artificial Intelligence (AI)

- **Knowledge** is the information acquired through experience.
- **Experience** is the knowledge gained through exposure (training).
- Therefore, artificial intelligence as the "copy of something natural (i.e., human beings) 'WHO' is capable of acquiring and applying the information it has gained through exposure."
- Artificial Intelligence exists when a machine can have human-based skills such as learning, reasoning, and solving problems.
- In Artificial Intelligence you **do not** need to preprogram a machine to do some work, despite that you can create a machine with programmed algorithms which can work with own intelligence.

Artificial Intelligence (AI)

- **Intelligence** is composed of:
  - Reasoning
  - Learning
  - Problem Solving
  - Perception and
  - Linguistic Intelligence
- **Artificial Intelligence system** is composed of
  - Agent and
  - Environment.

Artificial Intelligence (AI)

- **Artificial Intelligence system** is composed of **Agent** and its **Environment**.
  - An agent (e.g., human or robot) is anything that can perceive its environment through sensors and acts upon that environment through effectors.
  - Intelligent agents must be able to set goals and achieve them.
  - **Machine perception** is the ability to use input from sensors (such as cameras, microphones, sensors, etc.) to deduce aspects of the world. e.g., Computer Vision.

Artificial Intelligence (AI)

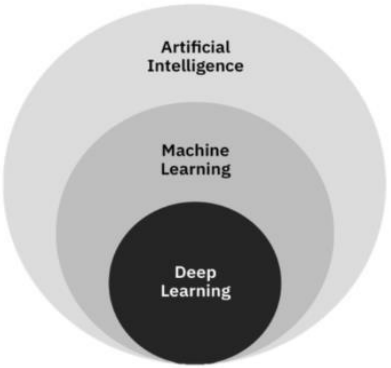
- **High-profile Examples of AI include**
  - Autonomous vehicles (such as drones and self-driving cars)
  - Medical diagnosis
  - Creating art (such as poetry)
  - Proving mathematical theorems
  - Playing games (such as Chess or Go)
  - Search engines (such as Google search)
  - Online assistants (such as Siri)
  - Image recognition in photographs
  - Spam filtering
  - Prediction of judicial decisions and
  - Online advertisements

Artificial Intelligence (AI)

- AI deals with the area of developing computing systems that are capable of performing tasks that humans are very good at.
  - Example: recognizing objects, recognizing and making sense of speech, and decision making in a constrained environment.
- **Machine Learning** is an advanced form of AI where the machine can learn as it goes rather than having every action programmed by humans.
- Machine learning, a fundamental concept of AI research since the field's inception, is the study of computer algorithms that improve automatically through experience.

Artificial Intelligence (AI)

- The term machine learning was introduced by Arthur Samuel in 1959.
- Neural networks are biologically inspired networks that extract features from the data in a hierarchical fashion.
- The field of neural networks with several hidden layers is called **deep learning.**



Need for Artificial Intelligence

- **Why we need AI at this time?**
  1. To create expert systems that exhibit intelligent behavior with the capability to learn, demonstrate, explain and advice its users.
  2. Helping machines find solutions to complex problems like humans do and applying them as algorithms in a computer-friendly manner.

Goals of Artificial Intelligence

- **Following are the main goals of Artificial Intelligence:**
  1. Replicate human intelligence
  2. Solve Knowledge-intensive tasks
  3. An intelligent connection of perception and action
  4. Building a machine which can perform tasks that requires human intelligence such as:
     - Proving a theorem
     - Playing chess
     - Plan some surgical operation
     - Driving a car in traffic
  5. Creating some system which can exhibit intelligent behavior, learn new things by itself, demonstrate, explain, and can advise to its user.

What Comprises to Artificial Intelligence?

- To create the AI-first we should know that how intelligence is composed, so **Intelligence** is an intangible part of our brain which is a combination of Reasoning, learning, problem-solving, perception, language understanding, etc
- To achieve the above factors for a machine or software Artificial Intelligence requires the following **disciplines**

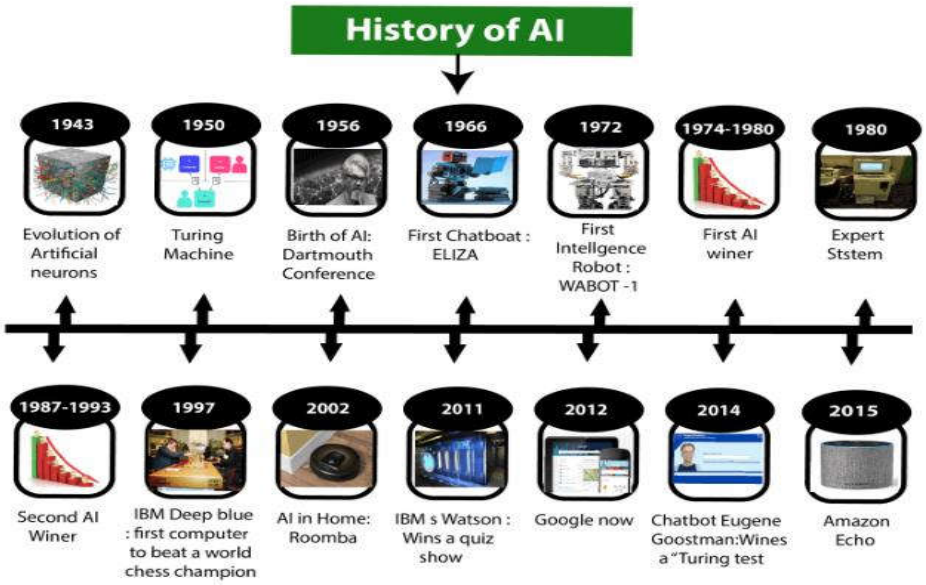
Advantages of Artificial Intelligence

- **High Accuracy with fewer errors:** AI machines or systems are prone to fewer errors and high accuracy as it takes decisions as per pre-experience or information.
- **High-Speed:** AI systems can be of very high-speed and fast-decision making, because of that AI systems can beat a chess champion in the Chess game.
- **High reliability:** AI machines are highly reliable and can perform the same action multiple times with high accuracy.
- **Useful for risky areas:** AI machines can be helpful in situations such as defusing a bomb, exploring the ocean floor, where to employ a human can be risky.
- **Digital Assistant:** AI can be very useful to provide digital assistant to users such as AI technology is currently used by various E-commerce websites to show the products as per customer requirements.
- **Useful as a public utility:** AI can be very useful for public utilities such as a self driving car which can make our journey safer and hassle-free, facial recognition for security purposes, Natural language processing (for search engines, for spelling checker, for assistant like Siri, for translation like google translate), etc.

Disadvantages of Artificial Intelligence

- **High Cost:** The hardware and software requirement of AI is very costly as it requires lots of maintenance to meet current world requirements.
- **Can't think out of the box:** Even we are making smarter machines with AI, but still they cannot work out of the box, as the robot will only do that work for which they are trained, or programmed.
- **No feelings and emotions:** AI machines can be an outstanding performer, but still it does not have the feeling so it cannot make any kind of emotional attachment with humans, and may sometime be harmful for users if the proper care is not taken.
- **Increase dependence on machines:** With the increment of technology, people are getting more dependent on devices and hence they are losing their mental capabilities.
- **No Original Creativity:** As humans are so creative and can imagine some new ideas but still AI machines cannot beat this power of human intelligence and cannot be creative and imaginative.

History of AI [Reading Assignment]



History of AI

A. **Maturation of Artificial Intelligence (1943-1952)**

- **The year 1943:** The first work which is now recognized as AI was done by Warren McCulloch and Walter pits in 1943. They proposed a model of artificial neurons.
- **The year 1949:** Donald Hebb demonstrated an updating rule for modifying the connection strength between neurons. His rule is now called Hebbian learning.
- **The 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.

History of AI

B. The birth of Artificial Intelligence (1952-1956)

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

History of AI

C. The golden years-Early enthusiasm (1956-1974)

- **The year 1966:** The researchers emphasized developing algorithms that can solve mathematical problems. Joseph Weizenbaum created the first chatbot in 1966, which was named as ELIZA.
- **The year 1972:** The first intelligent humanoid robot was built in Japan which was named WABOT-1.

D. The first AI winter (1974-1980)

- The duration between the years 1974 to 1980 was the first AI winter duration. AI winter refers to the time period where computer scientists dealt with a severe shortage of funding from the government for AI researches.
- During AI winters, an interest in publicity on artificial intelligence was decreased.

History of AI

E. A boom of AI (1980-1987)

- **The 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.

F. 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 due to high cost but not efficient results. The expert system such as XCON was very cost-effective.

History of AI

G. The emergence of intelligent agents (1993-2011)

- **The 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
- **The year 2002:** for the first time, AI entered the home in the form of Roomba, a vacuum cleaner.
- **The year 2006:** AI came into the Business world until the year 2006. Companies like Facebook, Twitter, and Netflix also started using AI.

History of AI

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

- **The year 2011:** In the year 2011, IBM's Watson won jeopardy, a quiz show, where it had to solve complex questions as well as riddles.
- Watson had proved that it could understand natural language and can solve tricky questions quickly.
- **The year 2012:** Google has launched an Android app feature "Google now", which was able to provide information to the user as a prediction.

History of AI

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

- **The year 2014:** In the year 2014, Chatbot "Eugene Goostman" won a competition in the infamous "Turing test"
- **The 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 hair dresser appointment on call, and the lady on the other side didn't notice that she was talking with the machine.

Levels of AI

- **Stage 1 – Rule-Based Systems**
  - Uses rules as the knowledge representation
  - Is a system that applies human-made rules to store, sort and manipulate data. In doing so, it mimics human intelligence.
  - It's a logical program that uses pre-defined rules to make deductions and choices to perform automated actions.
- **Stage 2 – Context Awareness and Retention**
  - Algorithms that develop information about the specific domain they are being applied in.
  - They are trained on the knowledge and experience of the best humans, and their knowledge base can be updated as new situations and queries arise.
  - Eg. chatbots and "robo advisors"

Levels of AI

- **Stage 3 – Domain-Specific Expertise**
  - **Expertise** and **Domain Specific Knowledge**.
  - These systems build up expertise in a specific context taking in massive volumes of information which they can use for decision making.
  - Eg. AlphaGo
- **Stage 4 – Reasoning Machines**
  - These algorithms have some ability to attribute mental states to themselves and others – they have a sense of beliefs, intentions, knowledge, and how their own logic works.
  - This means they could reason or negotiate with humans and other machines.
  - At the moment these algorithms are still in development, however, commercial applications are expected within the next few years

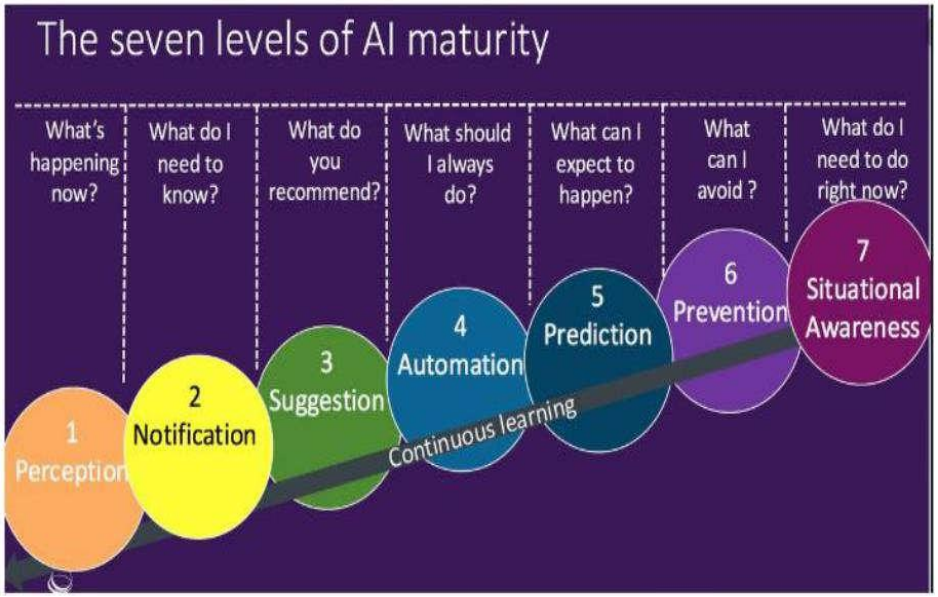
Levels of AI

- **Stage 5 – Self Aware Systems / Artificial General Intelligence (AGI)**
  - These systems have human-like intelligence
  - **AGI** is the **intelligence** of a machine that has the capacity to understand or learn any intellectual task that a human being can.
- **Stage 6 – Artificial Superintelligence (ASI)**
  - AI algorithms can outsmart even the most intelligent humans in every domain.
  - Logically it is difficult for humans to articulate what the capabilities might be, yet we would hope examples would include solving problems we have failed to so far, such as world hunger and dangerous environmental change.
  - A few experts who claim it can be realized by 2029.
  - Fiction has tackled this idea for a long time, for example in the film Ex Machina or Terminator.

Levels of AI

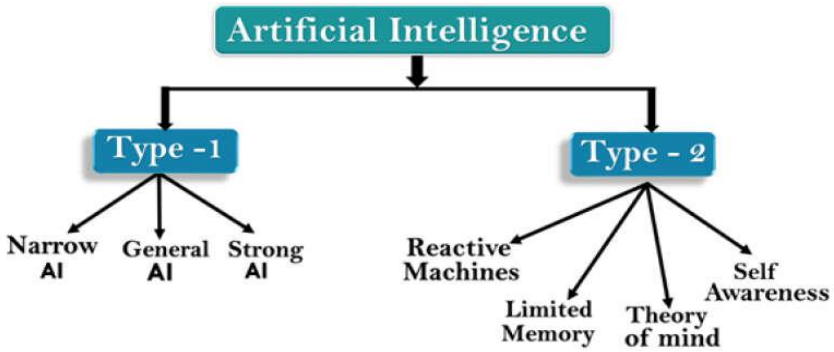
- **Stage 7 –Singularity and Transcendence**
  - This leads to a massive expansion in human capability.
  - Human augmentation could connect our brains to each other and to a future successor of the current internet, creating a "hive mind" that shares ideas, solves problems collectively, and even gives others access to our dreams as observers or participants.
  - Pushing this idea further, we might go beyond the limits of the human body and connect to other forms of intelligence on the planet – animals, plants, weather systems, and the natural environment.
  - Some proponents of singularity such as Ray Kurzweil, Google's Director of Engineering, suggest we could see it happen by 2045 as a result of exponential rates of progress across a range of science and technology disciplines.
  - The other side of the fence argues that singularity is impossible and human consciousness could never be digitized

Levels of AI



Types of AI

- Artificial Intelligence can be divided into various types, these are
  - **Based on Capabilities and**
  - **Based on Functionality**



Based on Capabilities

1. Weak AI or Narrow AI:

- Is a type of AI which is able to perform a dedicated task with intelligence.
- cannot perform beyond its field or limitations, as it is only trained for one specific task.
- Also called as **Weak AI.**
- Is the most common and currently available AI in the world
- Can fail in unpredictable ways if it goes beyond its limits.
- E.g. Apple Siri , IBM's Watson supercomputer ,Google translate, playing chess, purchasing suggestions on e-commerce sites, self-driving cars, speech recognition, and image recognition.

Based on Capabilities

2. General AI

- Is a type of intelligence that could perform any intellectual task with efficiency like a human.
- The idea behind the general AI to make such a system that could be smarter and think like a human on its own.
- Currently, there is no such system exists which could come under general AI and can perform any task as perfect as a human.
- As systems with general AI are still under research, and it will take lots of effort and time to develop such systems.

Based on Capabilities

3. Super AI

- Is a level of Intelligence of Systems at which machines could surpass human intelligence, and can perform any task better than a human with cognitive properties.
- This refers to aspects like general wisdom, problem solving and creativity.
- It is an outcome of general AI.
- Some key characteristics of strong AI include capability include the ability to think, to reason solve the puzzle, make judgments, plan, learn, and communicate on its own.
- Super AI is still a hypothetical concept of Artificial Intelligence.
- The development of such systems in real is still a world-changing task.

Based on Functionality

1. Reactive Machines:

- The most basic types of Artificial Intelligence
- Do not store memories or past experiences for future actions
- Only focus on current scenarios and react on it as per possible best action.
- Eg. IBM's Deep Blue system and Google's AlphaGo

Based on Functionality

2. Limited Memory

- Can store past experiences or some data for a short period of time.
- These machines can use stored data for a limited time period only.
- As the name suggests they have limited memory or short-lived memory
- Eg. **Self-driving cars** : can store the recent speed of nearby cars, the distance of other cars, speed limits, and other information to navigate the road.

Based on Functionality

3. Theory of Mind

- Understand human emotions, people, beliefs, and be able to interact socially like humans.
- Still not developed

4. Self Awareness

- is the future of Artificial Intelligence
- will be super intelligent and will have their own consciousness, sentiments, and self-awareness.
- These machines will be smarter than the human mind.
- does not exist in reality still and it is a hypothetical concept.

How Humans Think

- Intelligence or the cognitive process is composed of three main stages:
  - Observe and input the information or data in the brain.
  - Interpret and evaluate the input that is received from the surrounding environment.
  - Make decisions as a reaction towards what you received as input and interpreted and evaluated.

Mapping Human Thinking to AI Components

- Because AI is the science of simulating human thinking, it is possible to map the human thinking stages to the layers or components of AI systems.
- In the first stage, humans acquire information from their surrounding environments through human senses, such as sight, hearing, smell, taste, and touch, through human organs, such as eyes, ears, and other sensing organs, for example, the hands.
- In AI models, this stage is represented by the sensing layer, which perceives information from the surrounding environment.
- Eg: Sensors like voice recognition and visual imaging recognition

Influencers of Artificial Intelligence

- Influencers of AI includes:
  - **Big data:** Structured data versus unstructured data
  - **Advancements** in computer processing speed and **New chip** architectures
  - **Cloud computing and Application Program Interfaces**
    - Cloud computing is a general term that describes the delivery of on-demand services, usually through the internet, on a pay-per-use basis.
  - **The emergence of data science**
    - The goal of data science is to extract knowledge or insights from data in various forms, either structured or unstructured, which is like data mining.

Applications of Artificial Intelligence

- AI in agriculture
  - Very helpful for farmers
  - As agriculture robotics, solid and crop monitoring
- AI in Healthcare
  - to make a better and faster diagnosis than humans.
- AI in education
  - as a teaching assistant
  - Eg: chatbot
- AI in Finance and E-commerce
- AI in Gaming : eg chess
- AI in Social Media
  - To organize and manage massive amounts of data
- AI in Data Security
  - used to make your data more safe and secure.
- AI in Travel &Transport
  - Use chatbots which can make human-like interaction with customers
- AI in Robotics
- AI in Entertainment
- AI in the Automotive Industry

AI Tools and Platforms

- AI has developed a large number of tools to solve the most difficult problems in computer science, like:
  - Search and optimization
  - Logic
  - Probabilistic methods for uncertain reasoning
  - Classifiers and statistical learning methods
  - Neural networks
  - Control theory
  - Languages
- Most common artificial intelligence platforms include Microsoft AZURE Machine Learning, Google Cloud Prediction API, IBM Watson, TensorFlow, Infosys Nia, Wipro HOLMES, API.AI, Premonition, Rainbird, Ayasdi, MindMeld, and Meya.

Sample AI Application

- Commuting
  - Googles AI-powered predictions
  - Ridesharing Apps like Uber
- E-mail
  - Spam filters
  - Smart e-mail categorization
- AI in education
  - As a teaching assistant
  - Eg: chatbot
- Social Networking
  - Facebook
  - Instagram
- Online Shopping
  - Search (Amazon)
  - recommendations for products
- Mobile Use
  - Voice-to-text
  - Smart personal Assistants (Siri)

CHAPTER FOUR

Internet of Things

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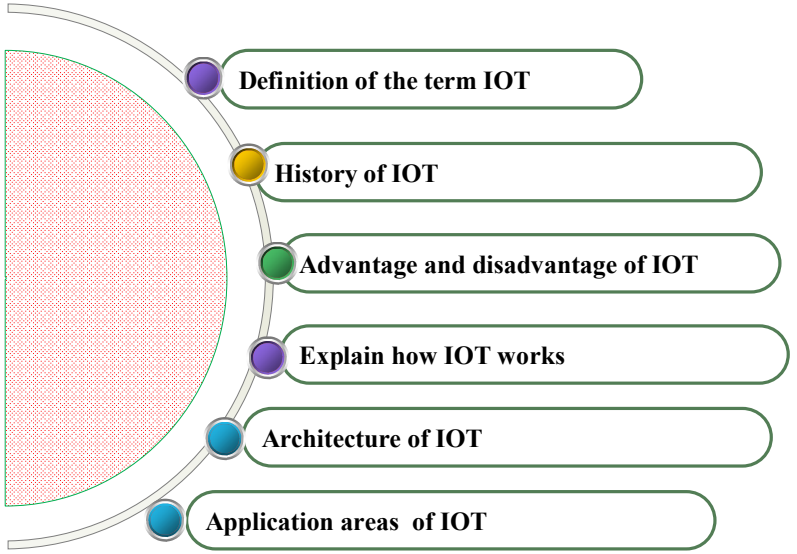
Contents



Overview of Internet of Things

- The most important features of internet of things (IoT) include:
  - Artificial intelligence
  - Connectivity
  - Sensors
  - Active engagement and
  - Small device

Overview of Internet of Things

- **Artificial intelligence**
  - IoT makes anything virtually "smart", meaning it enhances every aspect of life with the power of data collection, artificial intelligence algorithms, and networks
- **Connectivity**
  - new enabling technologies for networking and specially IOT networking , mean networks are no longer exclusively tied to major provides therefore IOT creates these small networks between its system devices.
- **Sensors**
  - IOT loses its distinction without sensors
  - They act as defining instruments that transform from standard passive network of device in to an active system cabling of real world integration.

Overview of Internet of Things

- **Active engagement**
  - IOT introduce a new paradigm for active content , product ,or service engagement rather than passive engagement.
- **Small device**
  - Those devices has become smaller, cheaper and more powerful over time so IOT exploits purpose built small devices to deliver its precision, scalability, and versatility.

Definitions of IOT

- Several groups defined IOT using different definitions

1. According to the internet architecture boards definition :-

- IOT is networking of smart objects, means a huge number of devices intelligently communicating in the presence of internet protocol that cannot be directly operated by human beings but exist as components in building vehicles or the environment.

2. According to the internet engineering task force (IETF) organizations

- IOT is the networking of smart objects in which smart objects have some constraints such as limited bandwidth ,power, and processing accessibility for achieving interoperability among smart objects.

Definitions of IOT

3. According to the IEEE communications category magazines definition:-

- IOT is framework of all things that have a representation of the presence of the internet in such a way that new applications and services enable the interaction in the physical and virtual world in the form of machine to machine (M2M)communication in the cloud.

4. According to the oxfords definition

- IOT is the interaction of everyday objects computing devices through the internet that enables the sending and receiving of useful data.
- The term Internet of things defines according to the 2020 conceptual frame work is expressed through simple formula such as:-

IOT=services + data +networks + sensors

Definitions of IOT

- Generally, IOT is the network of physical objects or “things” embedded with electronics , software and network connectivity , which enables these to collect and exchange data.
- Is also a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction
- IOT is a network of devices that can sense, accumulate and transfer data over the internet without any human intervention.

Definitions of IOT

- Simply stated, the Internet of Things consists of any device with an on/off switch connected to the Internet including anything such as:-
- Ranging from cellphones to building maintenance to the jet engine of an airplane
- Medical devices, such as a heart monitor implant or a biochip transponder in a farm animal can transfer data over a network and are members of the IOT.
- The IOT consists of a gigantic network of internet-connected "things" and devices.
- E.g. Ring, a doorbell that links to your smartphone, provides an excellent example of a recent addition to the Internet of Things means Ring signals you when the doorbell is pressed and lets you see who it is and to speak with them.

Areas where IOT is applicable

- In connected industry
- In smart-city
- In using smart-home
- In smart-energy
- In connected car
- In the smart agriculture
- In connected building and campus
- In the health care
- In Logistics and other domains

- IOT systems allow users to achieve deeper automation, analysis, and integration within a system.
- It also improve the reach of these areas and their accuracy.
- IOT utilizes existing and emerging technology for sensing, networking, and robotics.
- IOT exploits recent advances in software, falling hardware prices, and modern attitudes towards technology
- Its new and advanced elements bring major changes in the delivery of products, goods, and services; and the social, economic, and political impact of those changes.

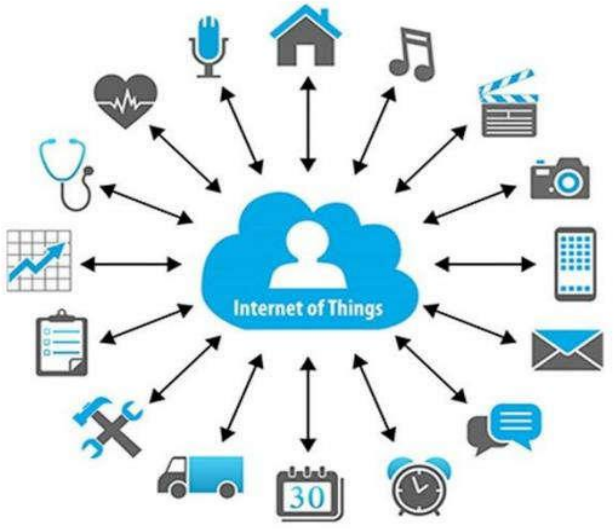


Figure 4.1 IoT in Different Domains

History of IOT

- The Internet of Things has not been around for very long.
- since the early 1800s there have been visions of machines communicating with one another.
- In 1830s and 1840s Machines have been providing direct communications since the telegraph (the first landline) was developed.
- In June 3, 1900, Described as "wireless telegraphy," the first radio voice transmission took place, providing another necessary component for developing the Internet of Things.
- In 1950s The development of computers began .
- In 1962 The Internet, itself a significant component of the IOT, started out as part of DARPA (Defense Advanced Research Projects Agency).
- In 1969 evolved into ARPANET.

History of IOT

- The traditional fields of automation (including the automation of buildings and homes), wireless sensor networks, GPS, control systems, and others, all support the IoT.
- Kevin Ashton, the Executive Director of Auto-ID Labs at MIT, was the first to describe the Internet of Things, during his 1999 speech.
- Kevin Ashton stated that Radio Frequency Identification (RFID) was a prerequisite for the Internet of Things. He concluded if all devices were "tagged," computers could manage, track, and inventory them.
- To some extent, the tagging of things has been achieved through technologies such as digital watermarking, barcodes, and QR codes.

Advantages of IOT

- Advantages of IoT span across every area of lifestyle and business Here is a list of some of the advantages that IoT has to offer:
- **Improved Customer Engagement** − Current analytics suffer from blind-spots and significant flaws inaccuracy; and as noted, engagement remains passive. IoT completely transforms this to achieve richer and more effective engagement with audiences
- **Technology Optimization** − The same technologies and data which improve the customer experience also improve device use, and aid in more potent improvements to technology. IoT unlocks a world of critical functional and field data.

Advantages of IOT

- **Reduced Waste** − IoT makes areas of improvement clear. Current analytics give us superficial insight, but IoT provides real-world information leading to the more effective management of resources.
- **Enhanced Data Collection** − Modern data collection suffers from its limitations and its design for passive use. IoT breaks it out of those spaces and places it exactly where humans really want to go to analyze our world. It allows an accurate picture of everything.

Disadvantage of IOT

- As the number of connected devices increases and more information is shared between devices, the potential that a hacker could steal confidential information also increases.
- If there's a bug in the system, it's likely that every connected device will become corrupted.
- Since there's no international standard of compatibility for IoT, it's difficult for devices from different manufacturers to communicate with each other.
- Enterprises may eventually have to deal with massive numbers maybe even millions of IoT devices and collecting and managing the data from all those devices will be challenging.

Challenges of IOT

- **Security** – IoT creates an ecosystem of constantly connected devices communicating over networks. The system offers little control despite any security measures. This leaves users exposed to various kinds of attackers.
- **Privacy** – The sophistication of IoT provides substantial personal data in extreme detail without the user's active participation.
- **Flexibility** – Many are concerned about the flexibility of an IoT system to integrate easily with another. They worry about finding themselves with several conflicting or locking systems.

Challenges of IOT

- **Complexity** – Some find IoT systems complicated in terms of design, deployment, and maintenance given their use of multiple technologies and a large set of new enabling technologies.
- **Compliance** – IoT, like any other technology in the realm of business, must comply with regulations. Its complexity makes the issue of compliance seem incredibly challenging when many consider standard software compliance a battle.

How does it work

- An IoT ecosystem consists of web-enabled smart devices that use embedded processors, sensors and communication hardware to collect, send and act on data they acquire from their environments.
- IoT devices share the sensor data they collect by connecting to an IoT gateway or another edge device where data is either sent to the cloud to be analyzed or analyzed locally.
- Sometimes, these devices communicate with other related devices and act on the information they get from one another Those devices do most of the work without human intervention, although people can interact with the devices.
- For instance, to set them up, give them instructions or access the data.
- The connectivity, networking and communication protocols used with these web-enabled devices largely depend on the specific IoT applications deployed.

Architecture of IoT

- In general, an IoT device can be explained as a **network of things** that consists of hardware, software, network connectivity, and sensors.
- The **architecture of IoT devices comprises four major components**
  - **Sensing**
  - **Network**
  - **Data processing and**
  - **Application layers**

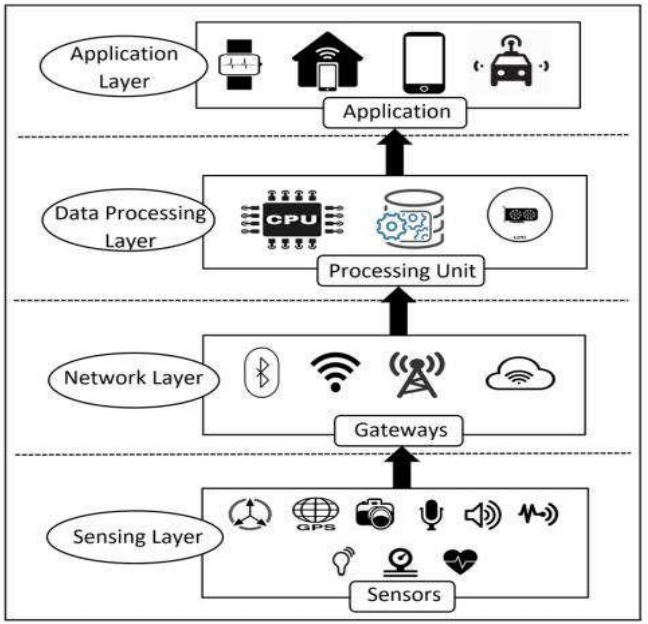


Figure 4.2 Architecture of IoT

1. Sensing Layer

- The main purpose of the sensing layer is
  - To identify any phenomena in the devices
  - To obtain data from the real world.
- This layer consists of several sensors.
- Sensors in IoT devices are usually integrated through **sensor hubs**.
- A sensor hub is a common **connection point for multiple sensors** that accumulate and forward sensor data to the processing unit of a device.
- **Actuators** can also interfere to change the physical conditions that generate the data.
- Example on actuator is shut off a power supply, adjust an airflow valve, or move a robotic gripper in an assembly process.

- There are three kinds of sensors in IOT device they are

A. Motion Sensors

- They can measure the change in motion as well as the orientation of the devices.
- There are two types of motions one can observe in a device: linear and angular
  - **Linear motion** refers to the linear displacement of an IoT device
  - **Angular motion** refers to the rotational displacement of the device.

B. Environmental Sensors

- Sensors such as light sensors, pressure sensors etc are embedded in IoT devices to sense the change in environmental parameters in the devices peripheral.
- Its primary purpose is to help the devices to take autonomous decisions according to the changes of a device's peripheral
- For instance, environment sensors are used in many applications to improve user experience, home automation systems, smart locks, smart lights,

C. Position sensors

- Deal with the physical position and location of the device.
- The most common position sensors used in IoT devices are Magnetic sensors and Global Positioning System (GPS) sensors.
- **Magnetic sensors** are usually used as digital compass and help to fix the orientation of the device display
- **Global Positioning System** is used for navigation purposes in IoT devices.

2. Network Layer

- Acts as a communication channel to transfer data, collected in the sensing layer, to other connected devices.
- In IoT devices, the network layer is implemented by using diverse communication technologies to allow data flow between other devices within the same network.
- e.g. Wi-Fi, Bluetooth, Zigbee, ZWAVE, LoRa, cellular network, etc.

3. Data Processing Layer

- Consists of the main data processing unit of IoT devices
- It takes data collected in the sensing layer and analyses the data to make decisions based on the result.
- In some IoT devices (e.g., smartwatch, smart home hub, etc.), the data processing layer also saves the result of the previous analysis to improve the user experience.
- This layer may share the result of data processing with other connected devices via the **network layer**.

4. Application Layer

- Implements and presents the results of the data processing layer to accomplish different applications of IoT devices.
- It's a user-centric layer that executes various tasks for the users.
- There exist diverse IoT applications, which includes
  - Smart transportation
  - Smart home
  - Personal care
  - Healthcare, etc.

Device and Network

- Connected devices are part of a scenario in which every device talks to other related devices in an environment to automate home and industrial tasks, and to communicate usable sensor data to users, businesses and other interested parties.
- IoT devices are meant to work in concert for people at home, in industry or in the enterprise.
- The devices can be **categorized into three** main groups: **Consumer**, **Enterprise** and **Industrial**.
- **Consumer connected devices** include smart TVs, smart speakers, toys, wearables, and smart appliances.
- **Industrial and Enterprise** IoT devices include smart meters, commercial security systems and smart city technologies such as those used to monitor traffic and weather conditions

IOT tools and platforms

- There are many vendors in the industrial IoT platform marketplace, offering remarkably similar capabilities and methods of deployment
- These IoT platform solutions are based on IoT and cloud technology.
- They can be used in areas of smart home, city, enterprise, home automation, healthcare or automotive.
- IoT Platform includes:
  - **KAA**: Manage unlimited number of connected devices
  - **SiteWhere**: run any number of IoT applications on single SiteWhere instance
  - **ThingSpeak**: collect data in private channels
  - **Zetta**: supports a wide rage of hacker boards

Applications of IOT

- Agriculture
- Consumer Use
- Insurance
- Healthcare
- Manufacturing
- Retail
- Transportation
- Utilities

1. IoT Based Smart Home

- Smart Home initiative allows subscribers to remotely manage and monitor different home devices from anywhere via smartphones or over the web with no physical distance limitations.
- These "smart" devices have the potential to share information with each other given the permanent availability to access the broadband internet connection.
- Components those are included in smart home development
- **Remote Control Appliances**: Switching on and off remotely appliances to avoid accidents and save energy.
- **Weather**: Displays outdoor weather conditions such as humidity, temperature, pressure, wind speed and rain levels with the ability to transmit data over long distances.

- **Smart Home Appliances**: Refrigerators with LCD screen telling what's inside, food that's about to expire, ingredients you need to buy and with all the information available on a smartphone app and also washing machine.
- **Safety Monitoring**: cameras, and home alarm systems making people feel safe in their daily life at home.
- **Intrusion Detection Systems**: Detection of window and door openings and violations to prevent intruders.
- **Energy and Water Use**: Energy and water supply consumption monitoring to obtain advice on how to save cost and resources, & many more.

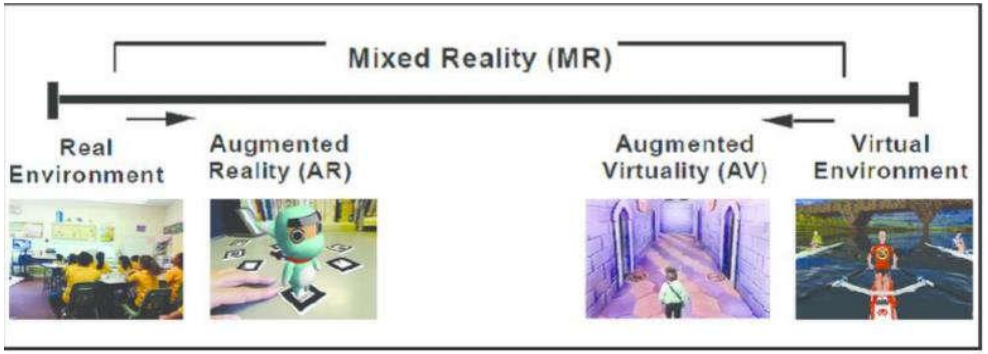
2. IOT based smart city

- The development of smart grids, data analytics, and autonomous vehicles will provide an intelligent platform to deliver innovations in energy management, traffic management, and security, sharing the benefits of this technology throughout society.
- Components those are included in smart city development
- **Structural Health**: Monitoring of vibrations and material conditions in buildings, bridges and historical monuments.
- **Lightning**: intelligent and weather adaptive lighting in street lights.
- **Smart Parking**: Real-time monitoring of parking spaces available in the city making residents able to identify and reserve the closest available spaces
- **Waste Management**: Detection of rubbish levels in containers to optimize the trash collection routes. Garbage cans and recycle bins with RFID tags allow the sanitation staff to see when garbage has put out.

3. IOT based smart Farming

- **Green Houses**: Control micro-climate conditions to maximize the production of fruits and vegetables and its quality.
- **Compost**: Control of humidity and temperature levels in alfalfa, hay, straw, etc. to prevent fungus and other microbial contaminants.
- **Offspring Care**: Control of growing conditions of the offspring in animal farms to ensure its survival and health.
- **Field Monitoring**: Reducing spoilage and crop waste with better monitoring, accurate ongoing data obtaining, and management of the agriculture fields, including better control of fertilizing, electricity and watering.
- **Animal Farming/Tracking**: Location and identification of animals grazing in open pastures or location in big stables, Study of ventilation and air quality in farms and detection of harmful gases from excrements.

CHAPTER 5
AUGMENTED REALITY (AR)



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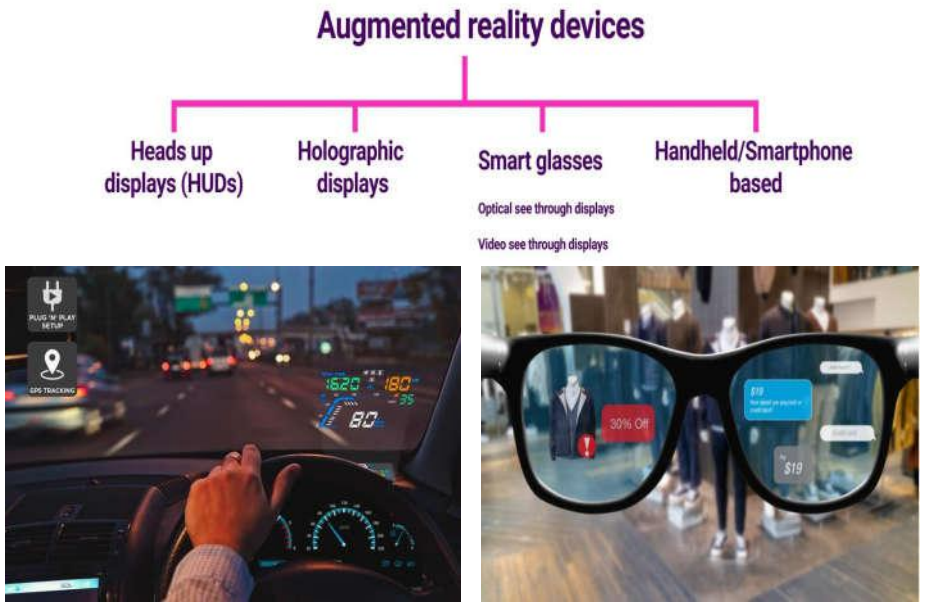
Introduction to AR

- The idea of AR is to combine or mix the view of the real environment with additional virtual content that is presented through computer graphics.
- Augmented reality (AR) is a form of emerging technology that allows users to overlay computer generated virtual graphical content in the real world.
- AR refers to a live view of a physical real-world environment whose elements are merged with augmented computer-generated images creating a mixed reality.

Introduction to AR

- Through augmented vision, the information about the surrounding real world helps the user can digitally interact with and adjust information about their surrounding environment.
- Augmented reality is the integration of digital information with the user's environment in real time.
- Example: Snapchat



And what is VR?

- VR tricks your senses into thinking you are in different environment or world apart from real world
- VR is a general term for immersive experiences and content via a VR headset or HMD (head-mounted display).
- It refers to computer technologies using reality headsets to generate realistic sounds, images and other sensations that replicate a real environment or create an imaginary world.
- The content is 100% digital and computer-generated. It is also called a **computer-simulated reality.**

And what is VR?

- Advanced VR environment engage all five senses (**taste**, **sight**, **smell**, **touch**, **sound**), but it is important to say that this is not always possible
- Most VR Devices **tethered** which are connected to a computer and some of them are **standalone** devices like Google Cardboard is among the most popular) and the remaining's are **Smartphone VR**.
- Using VR devices such as HTC Vive, Oculus Rift or Google Cardboard, users can be transported into a number of real-world and imagined environments

And what is VR?

- VR technology creates an environment in which the user feels and seems to be moving inside a computer-created virtual world in the same way people move inside the natural environment.
- Example: dragons

VR devices

Standalone

smartphone

tethered

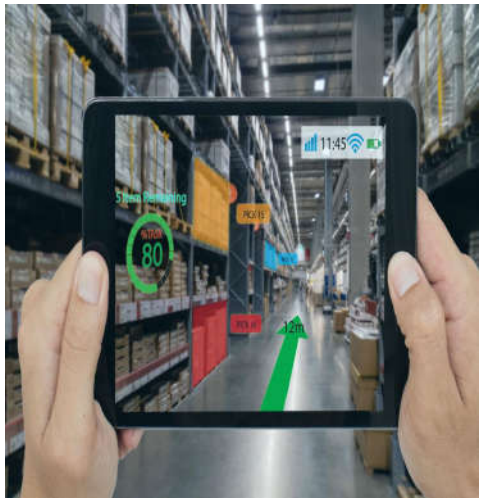
Mixed Reality

- Mixed Reality (MR), referred to as hybrid reality, is the merging of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real-time.
- It allows for digital content to integrate, enrich and interact with the user's real-world environment.
- MR lenses or headsets present an overlay of digital content that interacts with objects in the real world in real-time.

Mixed Reality

- The key characteristic of MR is that the synthetic content and the real-world content are able to react to each other in real-time.
- The products are, in most cases, in the research and development phase, but MR is viewed through transparent wearable glasses.
- Mixed Reality removes the boundaries between real and virtual worlds using **occlusion**: the computer-generated objects can be visibly obscured by objects in the physical environment from the user's point of view.

Mixed Reality Examples



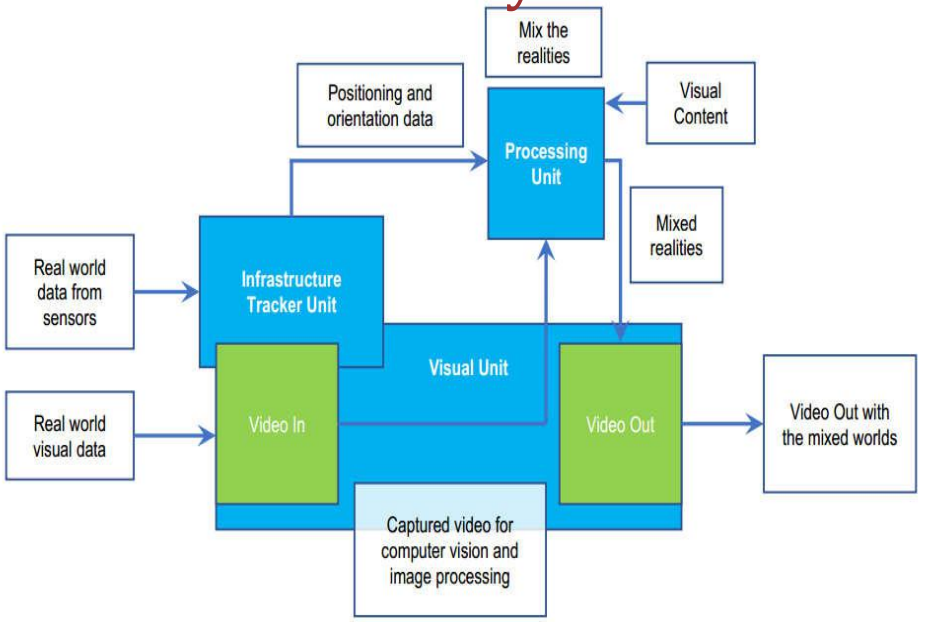
AR vs VR vs MR

- **Virtual Reality:** VR is content which is 100% digital and can be enjoyed in a fully immersive environment.
- **Augmented Reality:** AR overlays digital content on top of the real-world.
- **Mixed Reality:** MR is a digital overlay that allows interactive virtual elements to integrate and interact with the real-world environment.

Architecture of AR Systems

- The first Augmented Reality Systems (ARS) were usually designed with a basis on **three main blocks**.
  - **Infrastructure Tracker Unit**
  - **Processing Unit**
  - **Visual Unit**

Architecture of AR Systems

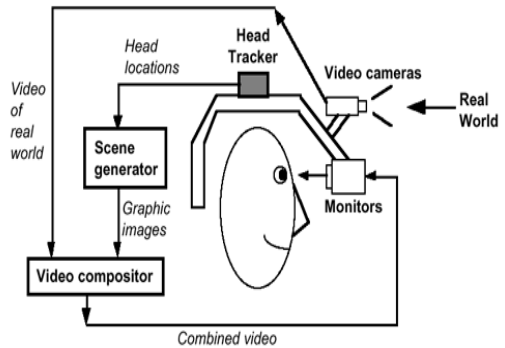


Architecture of AR Systems

- **Infrastructure Tracker Unit**: is responsible for collecting data from the real world, sending them to the Processing Unit.
- **Processing Unit:** which mix the virtual content with the real content and sent the result to the Video Out module of the Visual Unit.
- **Visual Unit:** the Visual Unit can be classified into two types of system, depending on the followed visualization technology: **video see through** and **optical see through**

Architecture of AR Systems

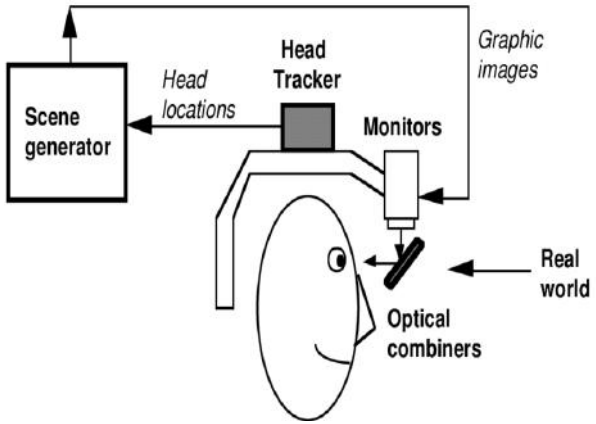
1. Video see-through: It uses a Head-Mounted Display (HMD) that employs a video-mixing and displays the merged images on a closed-view HMD.



Video see-through HMD conceptual diagram

Architecture of AR Systems

2. Optical see-through: It uses an HMD that employs optical combiners to merge the images within an open-view HMD.



Applications of AR Systems

1. **Educational Purpose:** AR supplements educational sector the following benefits:
   - Affordable learning materials
   - Interactive lessons
   - Higher engagement
   - Higher retention
   - Boost intellectual curiosity

Applications of AR Systems

2. Medical Purpose: AR provides Health and medical sector the following benefits:

- Describing symptoms
- Nursing care
- Surgery
- Ultrasounds
- Diabetes management
- Navigation

Applications of AR Systems

3. AR in Entertainment: AR could be used in various entertainment activities.

- Games
- Music
- Tv
- esports
- theater

CHAPTER 6

ETHICS AND PROFESSIONALISM OF EMERGING TECHNOLOGIES

Outline

- ***Technology and ethics***
- ***New ethical questions***
- ***General ethical principles***
- ***Professional responsibilities.***
- ***Professional leadership principles.***
- ***Digital privacy***
- ***Accountability and trust***
- ***Ethical and regulatory challenge***
- ***Treats***

Technology and ethics

- Technology can serve to promote or restrict human rights. The Information Society should foster the use of emerging technologies in such a way as to maximize the benefits that they provide while minimizing the harms.
- Ethics is particularly important for the accountancy profession, with a code for professional ethics based on five basic principles –
  - ✓ Integrity
  - ✓ Objectivity
  - ✓ Competence and due care
  - ✓ Confidentiality
  - ✓ Professional behavior
- However, the emergence of new technologies raises some new challenges for the profession to address.

New ethical questions

- The increasing use of big data, algorithmic decision-making, and artificial intelligence can enable more consistent, evidence-based and accurate judgments or decisions, often more quickly and efficiently. However, these strengths can potentially have a darker side too, throwing up questions around the ethical use of these fairly new technologies.
- questions are being asked regarding the interaction between computers and humans.
  - ✓ How much reliance can we place on data and models?
  - ✓ What is the role of human judgment ?
  - ✓How do we ensure that we understand the decision-making process?
- Whatever the power of the machine, humans will still need to be involved, so that people can be held accountable, or explain the reasons behind a decision.

General ethical principles

1. Contribute to society and to human well-being, acknowledging that all people are stakeholders in computing.

2. Avoid harm.

3. Be honest and trustworthy.

4. Be fair and take action not to discriminate

5. Respect the work required to produce new ideas, inventions, creative works, and computing artifacts.

6. Respect privacy.

7. Honor confidentiality

Professional responsibilities

1. Strive to achieve high quality in both the processes and products of professional work.

2. Maintain high standards of professional competence, conduct, and ethical practice.

3. Know and respect existing rules pertaining to professional work.

4. Accept and provide appropriate professional review.

5.Give comprehensive and thorough evaluations of computer systems and their impacts, including analysis of possible risks.

6. Perform work only in areas of competence.

7. Foster public awareness and understanding of computing, related technologies, and their consequences.

Cont...

8.Access computing and communication resources only when authorized or when compelled by the public good.

9. Design and implement systems that are robustly and usably secure.

Professional leadership principles

1. Ensure that the public good is the central concern during all professional computing work.

2. Articulate, encourage acceptance of and evaluate fulfillment of social responsibilities by members of the organization or group.

3. Manage personnel and resources to enhance the quality of working life.

4. Articulate, apply, and support policies and processes that reflect the principles of the Code.

5. Create opportunities for members of the organization or group to grow as professionals.

6. Use care when modifying or retiring systems. Interface changes, the removal of features, and even software updates have an impact on the productivity of users and the quality of their work.

7. Recognize and take special care of systems that become integrated into the infrastructure of society.

Digital privacy

- Digital Privacy is the protection of personally identifiable or business identifiable information that is collected from respondents through information collection activities or from other sources.
- It is a collective definition that encompasses three sub-related categories; information privacy, communication privacy, and individual privacy.
- It is often used in contexts that promote advocacy on behalf of individual and consumer privacy rights in digital spheres, and is typically used in opposition to the business practices of many e-marketers/businesses/companies to collect and use such information and data.

Information Privacy

- Information privacy is the notion that individuals should have the freedom, or right, to determine how their digital information, mainly that pertaining to personally identifiable information, is collected and used.
- Every country has various laws that dictate how information may be collected and used by companies. Some of those laws are written to give agency to the preferences of individuals/consumers in how their data is used.
- In other places, like in the United States, privacy law is argued by some to be less developed in this regard,
- For example, some legislation, or lack of, allows companies to self-regulate their collection and dissemination practices of consumer information.

Communication Privacy

- Communication privacy is the notion that individuals should have the freedom, or right, to communicate information digitally with the expectation that their communications are secure; meaning that messages and communications will only be accessible to the sender's original intended recipient.
- However, communications can be intercepted or delivered to other recipients without the sender's knowledge, in a multitude of ways.
- Communications can be intercepted directly through various hacking methods; this is expanded upon further below.
- Communications can also be delivered to recipients unbeknownst to the sender due to false assumptions made regarding the platform or medium which was used to send information.

Cont.…

- An example of this is a failure to read a company's privacy policy regarding communications on their platform could lead one to assume their communication is protected when it is in fact not.
- Additionally, companies frequently have been known to lack transparency in how they use information, this can be both intentional and unintentional.
- Discussion of communication privacy necessarily requires consideration of technological methods of protecting information/communication in digital mediums, the effectiveness, and ineffectiveness of such methods/systems, and the development/advancement of new and current technologies.

Individual Privacy

- Individual privacy is the notion that individuals have a right to exist freely on the internet, in that they can choose what types of information they are exposed to, and more importantly that unwanted information should not interrupt them.
- An example of a digital breach of individual privacy would be an internet user receiving unwanted ads and emails/spam, or a computer virus that forces the user to take actions they otherwise wouldn't.
- In such cases the individual, during that moment, doesn't exist digitally without interruption from unwanted information; thus, their individual privacy has been infringed upon.

Some digital privacy principles

- **Data Minimization**: collect the minimal amount of information necessary from individuals and businesses consistent with the Department's mission and legal requirements.
- **Transparency**: Notice covering the purpose of the collection and use of identifiable information will be provided in a clear manner. Information collected will not be used for any other purpose unless authorized or mandated by law.
- **Accuracy**: Information collected will be maintained in a sufficiently accurate, timely, and complete manner to ensure that the interests of the individuals and businesses are protected.
- **Security**: Adequate physical and IT security measures will be implemented to ensure that the collection, use, and maintenance of identifiable information are properly safeguarded and the information is promptly destroyed in accordance with approved records control schedules.

Accountability and trust

- Emerging technologies can provide improved accuracy, better quality and cost efficiencies for businesses in every sector.
- They can enhance trust in the organization's operations and financial processes, which is crucial for sustainable success. But this can produce a paradox: the very solutions that can be used to better manage risk, increase transparency and build confidence are often themselves the source of new risks, which may go unnoticed.
- The obligation of an individual or organization to account for its activities, accept responsibility for them, and to disclose the results in a transparent manner. It also includes the responsibility for money or other entrusted property.

Treats and challenges

Ethical and regulatory challenges

- As security professionals, we need to keep pace with ever-changing technology and be aware of the AI, IoT, Big Data, Machine Learning, etc.
- Growing needs Cyber & Data Security is getting prominence that requires security practitioners to focus on the business need for securing data, understanding security and risk from a business perspective by extensively interacting with the business community in understanding their requirements or what they want.
- Emerging technologies are already impacting how we live and work.
- They're also changing how we approach, plan, and integrate security operations.
- For security, both physical and cyber, the equation is the same catalyzing many new potential applications for emerging technologies.

Cont.…

Emerging technologies are making an impact include:

1. Counter-terrorism and law enforcement informatics via predictive analytics and artificial intelligence.
2. Real-time horizon scanning and data mining for threats and information sharing
3. Automated cyber security and information assurance
4. Enhanced Surveillance (chemical and bio-detection sensors, cameras, drones, facial recognition, license plate readers)
5. Simulation and augmented reality technologies for training and modeling
6. Safety and security equipment (including bullet and bomb proof) made with lighter and stronger materials
7. Advanced forensics enabled by enhanced computing capabilities (including future quantum computing)

Cont.…

8. Situational awareness capabilities via GPS for disaster response and crisis response scenarios
9. Biometrics: assured identity security screening solutions by bio-signature: (every aspect of your physiology can be used as a bio-signature. Measure unique heart/pulse rates, electrocardiogram sensor, blood oximetry, skin temperature)
10. Robotic Policing (already happening in Dubai!)

Challenges in using Artificial Intelligence

- AI is only as good as the data it is exposed to, which is where certain challenges may present themselves.
- Alternatively, AI also has the potential to take the burden of laborious and time-consuming tasks from these people, freeing up their time and brainpower for other things e.g. doctors using diagnostic AI to help them diagnose patients will analyze the data presented by the AI and make the ultimate decision.
- Managing the challenges posed by AI will require careful planning to ensure that the full benefits are realized and risks are mitigated.

Challenges in using Robotics in manufacturing

- With automation and robotics moving from production lines out into other areas of work and business, the potential for humans losing jobs is great here too.
- As automation technologies become more advanced, there will be a greater capability for automation to take over more and more complex jobs.
- As robots learn to teach each other and themselves, there is the potential for much greater productivity but this also raises ethical and cyber security concerns.

Challenges in using the Internet of Things

- As more and more connected devices (such as smart watches and fitness trackers) join the Internet of Things (IoT) the amount of data being generated is increasing.
- Companies will have to plan carefully how this will affect the customer-facing application and how to best utilize the masses of data being produced.
- There are also severe security implications of mass connectivity that need to be addressed.

Challenges in Big Data

- Almost all the technologies mentioned above have some relation to Big Data.
- The huge amount of data being generated on a daily basis has the potential to provide businesses with better insight into their customers as well as their own business operations.
- Although data can be incredibly useful for spotting trends and analyzing impacts, surfacing all this data to humans in a way that they can understand can be challenging. AI will play a role here.

Treats

- New and emerging technologies pose significant opportunities for businesses if they utilize them well and understand their true value early on.
- They also pose risks and questions not only to business but to society as a whole.
- Planning for how to deal with these emerging technologies and where value can be derived while assessing potential risks before they become a fully-fledged reality is essential for businesses that want to thrive in the world of AI, Big Data and IoT.

Some risks of emerging technology are:

- **Driverless car**:
  - ✓while a compelling option for future fleer cars, companies could crash and burn from claims related to bodily injury and property damage.
- **Wearables**:
  - ✓Google glass, Fitbit and other wearables can expose companies to the invasion of privacy claims that may not be covered by general liability or personal injury claims that weren't foreseen.
- **Drones**:
  - ✓Turbulence is in the offing for manufacturers and organizations that fail to protect themselves for property damage and bodily injury, as well as errors and omissions.
- **Internet of things**:
  - ✓The proliferation of sensors and cross-platform integration creates potential exposure from privacy invasion, bodily injury and property damage that may connect an organization to huge liabilities.

Chapter Seven
Other Emerging Technologies

Outline

- Other emerging technologies
  - Nanotechnology
  - Biotechnology
  - Blockchain technology
  - Cloud and quantum computing
  - Autonomic computing
  - Computer vision
  - Embeded systems
  - Cyber security
  - Additive manufacturing (3D Printing)

Nanotechnology

- Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers.
- Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering

How is it started?

- Started by physicist Richard Feynman on his famous talk entitled “There’s Plenty of Room at the Bottom” on December 29, 1959.
  - Long before the term nanotechnology was used
- Feynman described a process in which scientists would be able to manipulate and control individual atoms and molecules.
  - Feynman is called the father of nanotechnology
- A decade later, Professor Norio Taniguchi coined the term **nanotechnology** in his explorations of ultraprecision machining.
- It wasn't until 1981, with the development of the scanning tunneling microscope that could "see" individual atoms, that modern nanotechnology begun

Fundamental concepts in nanoscience and nanotechnology

- It's hard to imagine just how small nanotechnology is.
- One nanometer is a billionth of a meter or 10^9 of a meter.
- Here are a few illustrative examples:
  - There are 25,400,000 nanometers in an inch
  - A sheet of newspaper is about 100,000 nanometers thick
  - On a comparative scale, if a marble were a nanometer, then one meter would be the size of the Earth
- Nanoscience and nanotechnology involve the ability to see and to control individual atoms and molecules.
  - But impossible to see atom with the naked eye. Not even with high school microscopes.
  - The microscopes needed to see things at the nanoscale were invented relatively recently—about 30 years ago

Cont...

- As small as a nanometer is, it's still large compared to the atomic scale.
  - An atom has a diameter of about 0.1 nm.
  - An atom's nucleus is much smaller -- about 0.00001 nm.
- Atoms are the building blocks for all matter in our universe.
  - You and everything around you are made of atoms.
- At the atomic scale, elements are at their most basic level.
- On the nanoscale, we can potentially put these atoms together to make almost anything

Cont...

- Nobel Prize winner Dr. Horst Störmer In his lecture called "Small Wonders:The World of Nanoscience" said that
  - The nanoscale is more interesting than the atomic scale because the nanoscale is the first point where we can assemble something -- it's not until we start putting atoms together that we can make anything useful

Cont...

- People are interested in the nanoscale – which we define to be from 100nm down to the size of atoms (approximately 0.2nm)
  - because at this scale the properties of materials can be very different from those at a larger scale.
- We define nanoscience as the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale
- nanotechnologies as the design, characterisation, production and application of structures, devices and systems by controlling shape and size at the nanometer scale

Properties of materials at nanoscale

The properties of materials can be different at the nanoscale for two main reasons:

1. Nanomaterials have a relatively larger surface area when compared to the same mass of material produced in a larger form.
   - This can make materials more chemically reactive (in some cases materials that are inert in their larger form are reactive when produced in their nanoscale form), and affect their strength or electrical properties.
2. Quantum effects can begin to dominate the behavior of matter at the nanoscale – particularly at the lower end – affecting the optical, electrical and magnetic behavior of materials.

Cont..

- Scients are trying to make materials at the nanoscale to take advantage of their enhanced properties such as higher strength, lighter weight, increased control of light spectrum, and greater chemical reactivity than their larger-scale counterparts

Applications of nanotechnology

- Medicine
  - Researchers are developing customized nanoparticles the size of molecules that can deliver drugs directly to diseased cells in your body.
  - When it's perfected, this method should greatly reduce the damage treatment such as chemotherapy does to a patient's healthy cells
- Electronics
  - Nanotechnology holds some answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption

Applications of nanotechnology

- Food
  - Nanotechnology is having an impact on several aspects of food science, from how food is grown to how it is packaged.
  - Companies are developing nanomaterials that will make a difference not only in the taste of food but also in food safety and the health benefits that food delivery
- Space
  - Nanotechnology may hold the key to making space-flight more practical. Advancements in nanomaterials make lightweight spacecraft and a cable for the space elevator possible. By significantly reducing the amount of rocket fuel required, these advances could lower the cost of reaching orbit and traveling in space

Applications of nanotechnology

- Agriculture
  - Uses of nanotechnology can possibly change the whole agriculture part and nourishment industry anchor from generation to preservation, handling, bundling, transportation, and even waste treatment.
- Vehicle manufacturers
  - Much like aviation, lighter and stronger materials will be valuable for making vehicles that are both quicker and more secure. Burning motors will likewise profit from parts that are all the more hardwearing and higher temperature safe

Applications of nanotechnology

- Construction
  - Nanotechnology can possibly make development quicker, less expensive, more secure, and more changed. Computerization of nanotechnology development can take into account the formation of structures from cutting edge homes to enormous high rises substantially more rapidly and at much lower expense
- Information and communication
  - Current high-innovation generation techniques are in view of customary top-down procedures, where nanotechnology has as of now been presented noiselessly. The basic length size of incorporated circuits is as of now at the nanoscale (50 nm and underneath) with respect to the entryway length of transistors in CPUs or DRAM gadgets

Applications of nanotechnology

- medicine
  - The scientific and scientific analysis areas have utilized the exclusive qualities of nanomaterials for various programs (e.g., comparison providers for mobile pictures and therapeutics for the treatment of cancer).

Biotechnology

Introduction

- Defination
  - "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use"
- Biotechnology is technology based on biology
- Example
  - ***Brewing*** and ***baking bread*** are examples of processes that fall within the concept of biotechnology (use of yeast (= living organism) to produce the desired product).

Introduction(2)

- The traditional process like baking bread usually utilize the living organisms in their natural form
- However, modern biotechnology involve advanced modification of the biological system or organism
  - Example: Genetic engineering
- Genetic Engineering is the process of transferring individual genes between organisms or modifying the genes in an organism to remove or add a desired trait or characteristic

Introduction(3)

- Biotechnology covers many different disciplines
  - (eg. genetics, biochemistry, molecular biology, etc.).
- New technologies and products are developed every year within the areas of eg.
  - medicine (development of new medicines and therapies),
  - agriculture (development of genetically modified plants, biofuels, biological treatment) or
  - industrial biotechnology (production of chemicals, paper, textiles, and food)

History

- The agriculturalist Karl Ereky coined the term biotechnilogy in 1919.
  - He described 'biotechnology' as "all lines of work by which products are produced from raw materials with the aid of living things."
- In modern biotechnology, researchers modify DNA and proteins to shape the capabilities of living cells, plants, and animals into something useful for humans.
- Biotechnologists do this by sequencing or reading, the DNA found in nature, and then manipulating it in a test tube – or, more recently, inside of living cells

Application of biotechnology

1.Agriculture

- Biotechnology had contributed a lot towards the upliftment of agriculture.
- The organisms formed after manipulation of genes is known as Genetically Modified Organisms such as Crops, Animals, Plants, Fungi, Bacteria, etc.
- Genetically modified crops are formed by the manipulation of DNA to introduce a new trait into the crops.
- These manipulations are done to introduce traits such as pest resistance, insect resistance, weed resistance, etc

Application of biotechnology(2)

2.Medicine

- The use of biotechnology in medicine is known as Medicinal Biotechnology.
- This helps in the formation of genetically modified insulin known as humulin.
  - Used for the treatment of a large number of diabetes patients
- Biotechnology has given rise to a technique known as gene therapy.
- Gene therapy is a technique to remove the genetic defect in an embryo or child.
  - Transfer of a normal gene that works over the non-functional gene

Application of biotechnology(3)

3.Aquaculture Fisheries

- It helps in improving the quality and quantity of fishes.
- Through biotechnology, fishes are induced to breed via gonadotropin-releasing hormone

4.Production of Antibiotics

- Plants are used to develop antibiotics for Humans as well as for Animal use. It helps in the production of antibiotics, vaccines and artificial hormones for hormone therapies

5.Environment

- Environmental biotechnology is used in waste treatment and pollution prevention. Environmental biotechnology can more efficiently clean up many wastes than conventional methods and greatly reduce our dependence on methods for land-based disposal

Autonomic computing (AC)

Autonomic computing (AC)

- A software system that operates on its own or with a minimum of human interference according to a set of rules is called autonomic
  - The term autonomic derives from the human body's autonomic nervous system, which controls key functions without conscious awareness or involvement
- It refers to the self-managing characteristics of distributed computing resources, adapting to unpredictable changes while hiding intrinsic complexity to operators and users.

Cont...

- Initiated by IBM in 2001
- Aim was to develop computer systems capable of self-management, to overcome the rapidly growing complexity of computing systems management, and to reduce the barrier that complexity poses to further growth
- An AC system would control the functioning of computer applications and systems without input from the user, in the same way, that the autonomic nervous system regulates body systems without conscious input from the individual.
- The goal of autonomic computing is to create systems that run themselves, capable of high-level functioning while keeping the system's complexity invisible to the user

Characteristics of Autonomic Systems

Autonomic systems/applications eight defining characteristics:

1.Self Awareness: An autonomic application/system "knows itself" and is aware of its state and its behaviors.

2.Self Configuring: An autonomic application/system should be able to configure and reconfigure itself under varying and unpredictable conditions.

3.Self Optimizing: An autonomic application/system should be able to detect suboptimal behaviors and optimize itself to improve its execution.

4.Self-Healing: An autonomic application/system should be able to detect and recover from potential problems and continue to function smoothly.

Characteristics of Autonomic Systems(2)

- ***5.Self Protecting:*** An autonomic application/system should be capable of detecting and protecting its resources from both internal and external attacks and maintaining overall system security and integrity.
- ***6.Context-Aware:*** An autonomic application/system should be aware of its execution environment and be able to react to changes in the environment.
- ***7.Open:*** An autonomic application/system must function in a heterogeneous world and should be portable across multiple hardware and software architectures. Consequently, it must be built on standard and open protocols and interfaces.
- ***8.Anticipatory:*** An autonomic application/system should be able to anticipate to the extent possible, its needs and behaviors and those of its context, and be able to manage itself proactively

Computer vision

History

- It is started as MIT undergraduate summer project in 1966
  - believed at the time that computer vision could be solved in one summer
  - it is 50-year old scientific field but still far from being solved
- Early experiments in computer vision took place in the 1950s
  - detect the edges of an object
  - to sort simple objects into categories like circles and squares.

History(2)

- In the 1970s, the first commercial use of computer vision interpreted typed or handwritten text using optical character recognition.
  - This advancement was used to interpret written text for the blind.
- In the 1990s, given large sets of images available online for analysis, facial recognition programs flourished.
  - make it possible for machines to identify specific people in photos and videos

Introduction

Definition

- Computer vision is an interdisciplinary scientific field(geometry, physics, statistics, and learning theory) that deals with how computers can be made to gain a high-level understanding of digital images or videos.
  - From the perspective of engineering, it seeks to automate tasks that the human visual system can do
- Computer vision is building algorithms that can understand the content of images and use it for other applications
  - Example: authentication

Application of computer vision

1.Optical character recognition (OCR): reading handwritten postal codes on letters and automatic number plate recognition (ANPR);

2.Machine inspection: rapid parts inspection for quality assurance using stereo vision with specialized illumination to measure tolerances on aircraft wings or auto body parts or looking for defects in steel castings using X-ray vision;

3.Retail: object recognition for automated checkout lanes ;

Application of computer vision(2)

4.Medical imaging: registering pre-operative and intra-operative imagery (Figure 1.4d) or performing long-term studies of people's brain morphology as they age;

5.Automotive safety: detecting unexpected obstacles such as pedestrians on the street, under conditions where active vision techniques such as radar or lidar do not work well (Figure 1.4e;

6.Surveillance: monitoring for intruders, analyzing highway traffic (Figure 1.4f), and monitoring pools for drowning victims;

7.Fingerprint recognition and biometrics: for automatic access authentication as well as forensic applications

How computer vision works

1.Acquiring an image: Images, even large sets, can be acquired in real-time through video, photos or 3D technology for analysis.

2.Processing the image: Deep learning models automate much of this process, but the models are often trained by first being fed thousands of labeled or pre-identified images.

3.Understanding the image: The final step is the interpretative step, where an object is identified or classified.

Types of computer vision

1.Image segmentation partitions an image into multiple regions or pieces to be examined separately.

2.Object detection identifies a specific object in an image. Advanced object detection recognizes many objects in a single image: a football field, an offensive player, a defensive player, a ball and so on. These models use an X, Y coordinate to create a bounding box and identify everything inside the box.

3.Facial recognition is an advanced type of object detection that not only recognizes a human face in an image, but identifies a specific individual.

Types of computer vision(2)

4.Edge detection: is a technique used to identify the outside edge of an object or landscape to better identify what is in the image.

5.Pattern detection: is a process of recognizing repeated shapes, colors and other visual indicators in images.

6.Image classification: groups images into different categories.

7.Feature matching: is a type of pattern detection that matches similarities in images to help classify them.

Embedded systems

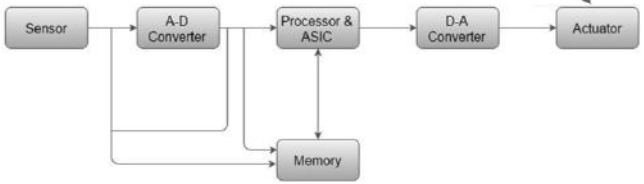
Embedded systems

- It is a controller with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints.
- It is embedded as part of a complete device often including hardware and mechanical parts.
- Embedded systems are often based on
  - microcontrollers (i.e. microprocessors with integrated memory and peripheral interfaces).
  - Ordinary microprocessors (using external chips for memory and peripheral interface circuits)
    - especially used by more complex systems.

Cont...

- The processor(s) may be
  - General-purpose to those specialized in a certain class of computations, or
  - Custom designed for the application at hand.
- Advantages of Embedded
  1. Easily Customizable
  2. Low power consumption
  3. Low cost
  4. Enhanced performance
- Disadvantages of Embedded systems
  1. High development effort
  2. Larger time to market

Basic Structure of an Embedded System



Sensor − It measures the physical quantity and converts it to an electrical signal
A sensor stores the measured quantity to the memory.

A-D Converter − An analog-to-digital converter converts the analog signal sent by the sensor into a digital signal

Processor & ASICs − Processors process the data to measure the output and store it to the memory.

D-A Converter − A digital-to-analog converter converts the digital data fed by the processor to analog data

Actuator − An actuator compares the output given by the D-A Converter to the actual (expected) output stored in it and stores the approved output

Cybersecurity

Cybersecurity

- Cybersecurity is the protection of computer systems from the theft of or damage to their hardware, software, or electronic data, as well as from the disruption or misdirection of the services they provide.
  - Protecting computer systems from unauthorized access or being otherwise damaged or made inaccessible.
- ***Information security*** is a broader category that looks to protect all information assets, whether in hard copy or in digital form
- **Cybercrime** describes an unlawful activity in which computer or computing devices which are stand-alone or a part of a network are used as a tool or/and target of criminal activity.
  - People do it for revenge, greed or adventure

- Combating cyber crime is a multi-disciplinary affair that spans hardware and software through to policy and people
  - aim is at both preventing cybercrimes occurring in the first place, or minimizing its impact when it does.

Cybersecurity checklist

Boost your cyber defenses with these must-have security measures

1.Staff awareness training:- Human error is the leading cause of data breaches

- show staff how security threats affect them and help them apply best-practice advice to real-world situations.

2.Application security:- Web application vulnerabilities are a common point of intrusion for cybercriminals. As applications play an increasingly critical role in business, it is vital to focus on web application security.

Cybersecurity checklist(2)

3.Network security:- It is the process of protecting the usability and integrity of your network and data. This is achieved by conducting a network penetration test, which scans your network for vulnerabilities and security issues.

4.Leadership commitment:- Top management must be prepared to invest in appropriate cybersecurity resources, such as awareness training.

5.Password management:- Almost half of the UK population uses 'password', '123456' or 'qwerty' as their password. You should implement a password management policy that provides guidance to ensure staff create strong passwords and keep them secure.

Types of cybersecurity threats

1.Ransomware:- It is a type of malicious software. It is designed to extort money by blocking access to files or the computer system until the ransom is paid. Paying the ransom does not guarantee that the files will be recovered or the system restored.

2.Malware:- itis a type of software designed to gain unauthorized access or to cause damage to a computer

3.Social engineering:- it is a tactic that adversaries use to trick you into revealing sensitive information. They can solicit a monetary payment or gain access to your confidential data. It can be combined with any of the threats listed above to make you more likely to click on links, download malware, or trust a malicious source.

Cont...

4.Phishing:- it is the practice of sending fraudulent emails that resemble emails from reputable sources.

- The aim is to steal sensitive data like credit card numbers and login information.
- It's the most common type of cyber attack.
- You can help protect yourself through education or a technology solution that filters malicious emails.

Benefits of cybersecurity

Benefits of utilizing cybersecurity include:

1.Business protection against malware, ransomware, phishing, and social engineering.

2.Protection for data and networks.

3.Prevention of unauthorized users.

4.Improves recovery time after a breach.

5.Protection for end-users.

6.Improved confidence in the product for both developers and customers.

Cybersecurity vendors

Vendors in cybersecurity fields will typically use endpoint, network and advanced threat protection security as well as data loss prevention.

Three commonly known cybersecurity vendors include Cisco, McAfee, and Trend Micro.

1.Cisco tends to focus on networks and allows its customers to utilize firewalls, VPNs and advanced malware protection along with supporting email and endpoint security. Cisco also supports real-time malware blocking.

2.McAfee makes cybersecurity products for consumers and enterprise users. McAfee supports mobile, enterprise clouds, network, web, and server-based security. Data protection and encryption are also offered.

3.Trend Micro is an anti-malware vendor which offers threat protection for mobile, hybrid clouds, SaaS and the IoT. Trend Micro provides users with endpoint, email and web security.

Additive manufacturing (3D Printing)

Introduction

- Are “3D printing” and “additive manufacturing” (AM) the same thing?
- **Different views**

1. ASTM International equates the two terms in their definition: “Additive manufacturing, also known as 3D printing, uses computer-aided design to build objects layer by layer.”

2.Wikipedia says, “today, the precision, repeatability, and material range has increased to the point that 3D printing is considered as industrial production technology, with the name of additive manufacturing.”

3.Author Dave Turbide puts it simply, suggesting that additive manufacturing is “the industrial version of 3D printing”.

3D Printing: It's All About the Printer

- When MIT invented binder jet printing in the 1980s, they wrote: “three-dimensional printing is a process under development at MIT for the rapid and flexible production of prototype parts, end-use parts, and tools directly from a CAD model.”
- Today our concept of “3D printing” is often associated with filament-based plastic printers, which are the pride and joy of many a hobbyist and self-described maker.
- But there are also binder jet printers, laser metal 3D printers, as well as glass and clay 3D printers.

Additive Manufacturing: A Bytes-to-Parts Supply Chain

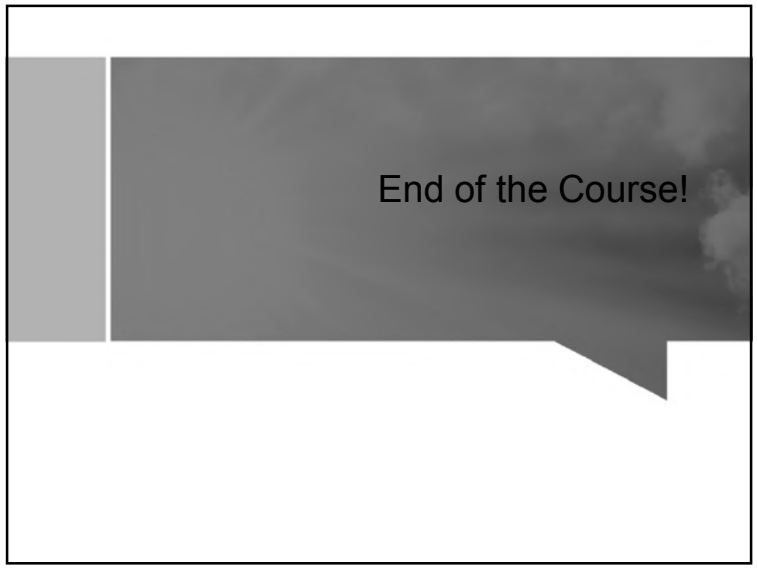
- “Additive manufacturing” (AM) is a big-picture term more at home in the boardroom than the factory floor or garage.
- Naturally, AM separates itself from older, subtractive technologies like milling.
- The term is less about the 3D printer itself, and more about the manufacturing process transformed by 3D printing
- What is that transformation?
  - AM changes the way we think about inventory and supply chain, taking parts from the point of manufacture to the point of use

Additive Manufacturing: A Bytes-to-Parts Supply Chain

- Additive manufacturing (AM) describes types of advanced manufacturing that are used to create threedimensional structures out of plastics, metals, polymers and other materials that can be sprayed through a nozzle or aggregated in a vat.
  - These constructs are added layer by layer in real-time based on digital design.

Additive Manufacturing: A Bytes-to-Parts Supply Chain

- The seven major additive manufacturing processes are:
  - material jetting, binder jetting, material extrusion, vat polymerization, powder bed fusion, direct energy deposition, sheet lamination.


End of the Course!