Unit-3

Syllabus:

1. Cyber Physical Systems
2. Robotics process System
3. Cobots
4. Mobile Computing
5. Cyber Security
6. Artificial Intelligence
7. Augmented Reality
8. Virtual reality
9. Support systems for Industry

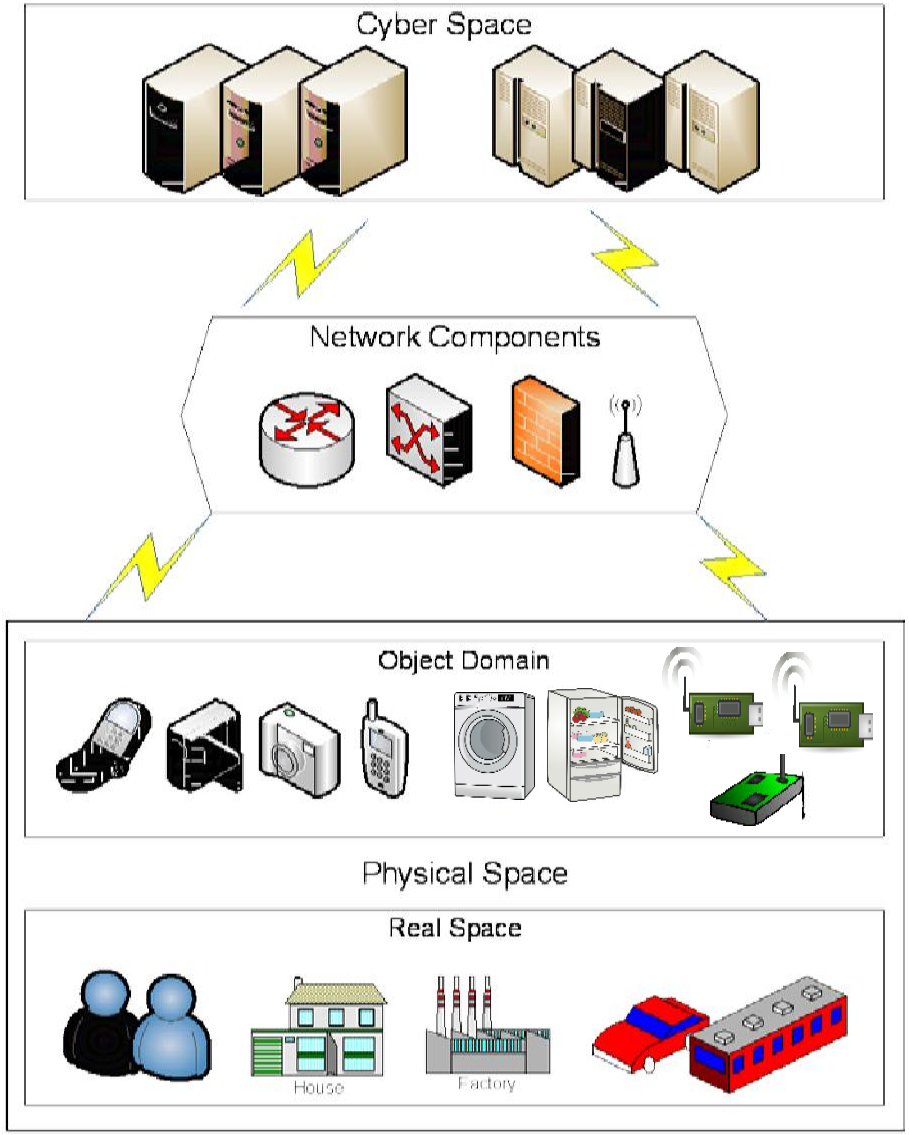
What are Cyber -Physical Systems?

- The term “Cyber -Physical Systems” emerged in 2006.
- Coined by national Science foundation in the USA
- “Cyber-Physical Systems or ‘smart’ systems are co-engineered interacting networks of physical and computational components. These systems will provide the foundation of our critical infrastructure, form the basis of emerging and future smart services, and improve our quality of life in many areas.” -- NIST, Engineering Laborator

  -- NIST, Engineering Laboratory
- Generalization of “embedded” systems
  - Possess compute, communicate and control capabilities
  - Interaction with the physical world through sensors and actuators.

- Examples:
  - Medical instruments
  - Transportation vehicles
  - Defense systems
  - Robotic equipment
  - Process monitoring and factory automation systems

Sensing



Actuation

Source: Ali et al., Sen. J., 2015

Embedded Systems	CPS
Devices having information processing systems embedded into them	Complete system having physical components and software
Typically confined to a single device	Networked set of embedded systems
Limited resources for performing limited number of tasks	Not resource constrained
Main issues are real-time response and reliability	Main issues are timing and concurrency

Source: Lee, IEEE ISORC, 2008

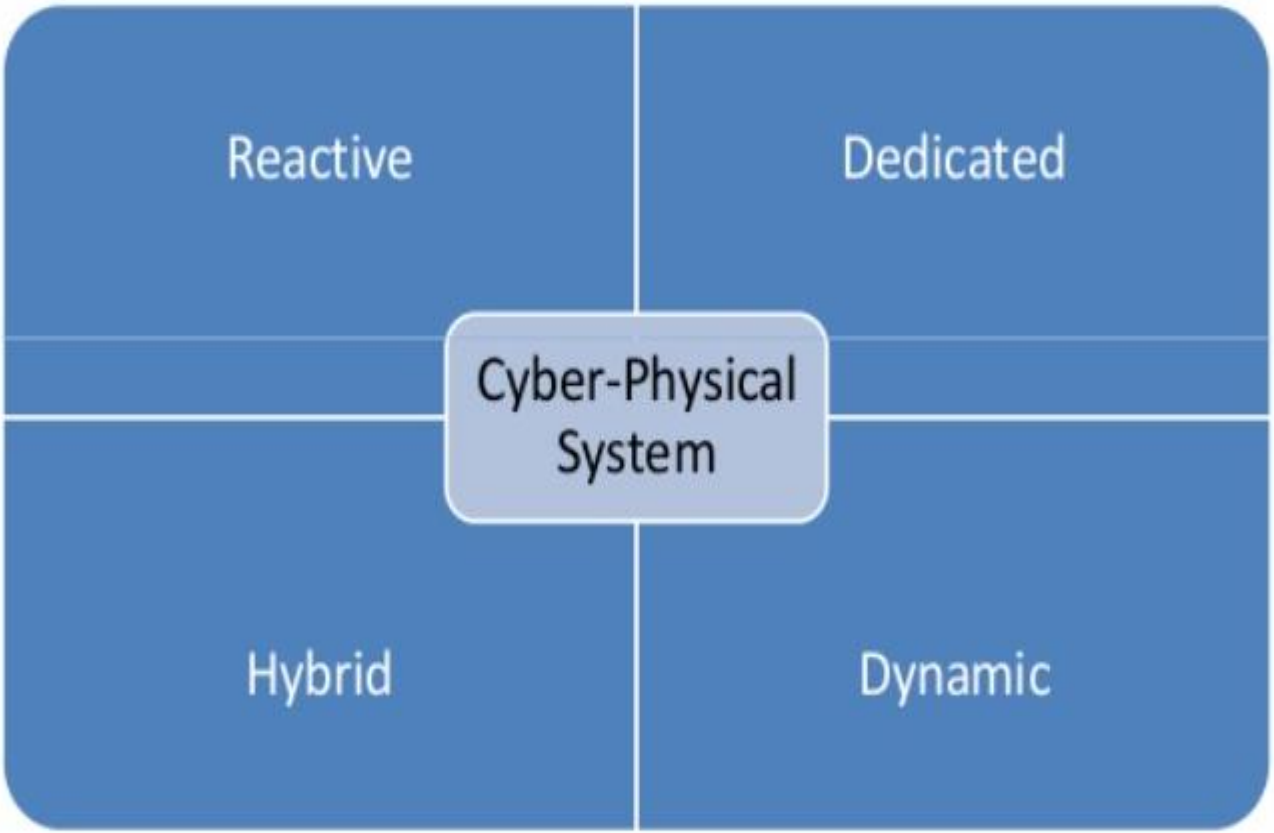

Embedded systems
Physical Environment
Cyber-physical systems

Features of Cyber -Physical Systems

- Reactive Computation:
  - Interact with environment in an ongoing manner
  - Sequence of observed inputs and outputs
- Concurrency:
  - Multiple processes running concurrently
  - Processes exchange information to achieve desired result
  - Synchronous or asynchronous modes of operation
- Feedback Control of the Physical World:
  - Equipped with *control systems* with feedback loop
  - Sensors sense environment and Actuators influence it
  - Hybrid control systems for complex tasks
- Real-Time Computation:
  - Time sensitive operations such as coordination, resource-allocation
- Safety-Critical Applications:
  - Precise modelling and validation prior to development

Source: R. Alur, Principles of Cyber-Physical Systems, The MIT Press

Characteristics of cyber-physical systems



- Reactive Typically, CPS are reactive systems:

"A reactive system is one which is in continual interaction with its environment and executes at a pace determined by that environment"

- Hybrid Cyber-Physical System Hybrid systems (analog + digital parts)
- Dedicated towards a certain application Knowledge about behavior at design time can be used to minimize resources and to maximize robustness
- Dedicated user interface
- Dynamic Cyber-Physical System
- Frequent changes of environment
- High volume of (sensored) data traffic; fluctuation •Delay, delay fluctuation

Applications of CPS: Healthcare

- Highly accurate medical devices and systems
  - Image-guided surgery and therapy
  - Control of fluid flow for medicinal purposes and biological analysis
  - Intelligent operating theatres and hospitals
- Engineered systems based on cognition and neuroscience (e.g., brain-machine interfaces, therapeutic and entertainment robotics, orthotics and exoskeletons, and prosthetics)

- Source: Baheti and Gill, Cyber Physical Systems, Tech. Rep., IOCT, 2011

Applications of CPS: Transportation

- Infrastructure-based transportation CPS
  - Real-time monitoring of traffic infrastructure (traffic signals, cameras, etc.) and traffic control
- Vehicle-Infrastructure-coordinated transportation CPS
  - Transit signal priority, queue warning (for e.g., ambulances)
- Vehicle-based transportation CPS
  - Proximity detection for safety
  - Vehicle health monitoring

- Source: Baheti and Gill, Cyber Physical Systems, Tech. Rep., IOCT, 2011

Applications of CPS: Smart Grid

- Smart meters
  - Demand management with distributed generation
  - Automated distribution with intelligent substations
  - Wide-area control of Smart grids
- Phasor measurement units (PMUs)
- Data aggregation units (DAUs)

Source: Rajkumar et al., DAC, 2010

Applications of CPS: Industry

- Manufacturing systems and logistics integrated with communication abilities, sensors and actuators
  - Smart control
  - Optimal resource utilization
  - Smart diagnostics and maintenance
- Flexibility of development of systems
- End products customized specific to needs of customers

Source: Rajkumar et al., DAC, 2010

CPS Architecture for Industry 4.0

- Designing CPS-based manufacturing systems for Industry 4.0
- “5C architecture” comprising of 5-levels
  - Connection
  - Conversion
  - Cyber
  - Cognition
  - Configuration

Source: Lee et al., Manufacturing Letters, 2015

CPS Architecture for IIoT: Connection

- Smart connections to ensure accurate data is obtained from the IIoT devices
- Two factors to be considered:
  - Obtaining seamless and tether-free data
  - Selection of sensors with proper specifications

Source: Lee et al., Manufacturing Letters, 2015

CPS Architecture for IIoT: Conversion

- Conversion of machine data to meaningful information
- Data analysis tools and methodologies to be developed for
  - Prognostics and health monitoring of machine components
  - Multi-dimensional data-correlation
- Machines become self-aware

Source: Lee et al., Manufacturing Letters, 2015

CPS Architecture for IIoT: Cyber

- Central information hub
  - Gathers system information from fleet of machines
    - Obtaining precise status information of individual machines
    - Rating of performance of individual machines among fleet
    - Predicting future behavior of machines based on historical data
  - Utilize clustering for data mining
- Machines achieve self-comparison ability

Source: Lee et al., Manufacturing Letters, 2015

CPS Architecture for IIoT: Cognition

- Proper presentation of information to users for generating thorough knowledge of the system
- Collaborative diagnostics
- Decision making for:
  - Prioritization
  - Optimization processes

Source: Lee et al., Manufacturing Letters, 2015

CPS Architecture for IIoT: Configuration

- Supervisory control to determine actions to be taken by the machines:
  - Self-configuration for resilience
  - Self-adjustment for variations
  - Self-optimization for disturbances
- Machines become self-adaptive

Source: Lee et al., Manufacturing Letters, 2015

Challenges for CPS Development

- Safety, security and robustness
- Hybrid control systems
- Computational and real-time embedded system abstractions
- Sensor and mobile networks
- Architecture and modelling
- Verification, validation and certification
- Education and training

Source: Sha et al., IEEE SUTC, 2008

What is robotic process automation?

- Robotic process automation (RPA) is a software technology that makes it easy to build, deploy, and manage software robots that emulate humans actions interacting with digital systems and software.
- Just like people, software robots can do things like understand what's on a screen, complete the right keystrokes, navigate systems, identify and extract data, and perform a wide range of defined actions. But software robots can do it faster and more consistently than people, without the need to get up and stretch or take a coffee break.
- *https://www.uipath.com/rpa/robotic-process-automation#:~:text=Robotic%20process%20automation%20(RPA)%20is,with%20digital%20systems%20and%20software.*
- *https://www.guru99.com/robotic-process-automation-tutorial.html*

Collaborative Robots

- The collaborative application of robotics enables humans and robots to safely and effectively work together in an uncaged environment, with no risk of injuries/damages. Collaborative robots (cobots) were designed with multiple advanced sensors, software, and EOATs that help them swiftly and easily detect and adapt to any sort of intrusion into its work envelope.
- Cobots typically have a rounder shape without any pinch points and internalized wires and motors. They also have the ability to detect any abnormal force applied to their joints while in motion. These robots can be programmed to respond immediately by stopping or reversing positions when they come into any sort of human contact.
- In addition, programming and integration is made simpler as they can be hand guided. This means a worker can show the positions/paths that are desired of the robot and they will immediately repeat them.
- Overall, the collaborative robotics movement is able to improve application functionality, while also decreasing the amount of space necessary for a robotic unit. This collaborative technology is offering huge advantages to businesses, production lines, and workers.
- RobotWorx is an integrator of collaborative robots and we are ready to help make your production line bring in the best ROI

robot :

- A robot is a machine especially on eprogrammable by a computer capable of carrying out a complex series of actions automatically.
- Robltics deals with the design, construction, operation, and use of robots as well as computer systems for their control,sensory, feedback, and information process.

Cobots:

- A Cobot is defined as a robot that has be designed and built to collaborate with humans.
- It is a workstation including a robot and a human collaboration.

Why do we need a Cobot?

- COBOTS is a robot system used for manufacturing.
- Typically applications of Cobts including welding, painting, assembly, pick and place for prints circuit boards, packaging and labeling, palletizing, product inspection, and testing. All accomplished with high endurance, speed and precision.

Applications:

- Hippotherapy
- Particle therapy
- Radiation surgery
- Aniography

Advantages:

- Cobots more user friendly, intelligent, and most importantly affordable.
- Cobots increase production and profit margin because they can complete tasks faster than humans.
- Cobots have the ability to work around the clock.
- Cobots eliminate dangerous jobs for humans as they work in hazardous environments.
- They can hadle lifting heavy loads, toxic substances, and repetitive tasks.

Dis Advantages

- High standard of maintenance is required.
- Precise programmer needed (time, training, specialist knowledge)
- When computer fails causes breakdown.
- New products require reprogramming.
- Complex and costly to be installed.
- People lose jobs.
- Supply of Power issues.

Collaborative robotics

- https://www.robots.com/applications/collaborative
- https://www.slideshare.net/Robotiq_Inc/collaborative-robots
- https://swamc.org/wp-content/uploads/2018/03/4.3-Craig-Tomita.pdf
- https://blog.generationrobots.com/wp-content/uploads/2014/01/Lightweight-robots-and-Collaborative-Robotics.pdf

Introduction of Mobile Computing

- Mobile Computing is an umbrella term used to describe technologies that enable people to access network services anyplace, anytime, and anywhere.
- Mobile computing can be defined as a computing environment over physical mobility
- Mobile Computing is a technology that provides an environment that enables users to transmit data from one device to another device without the use of any physical link or cables.
- In other words, you can say that mobile computing allows transmission of data, voice and video via a computer or any other wireless-enabled device without being connected to a fixed physical link. In this technology, data transmission is done wirelessly with the help of wireless devices such as mobiles, laptops etc.
- This is only because of Mobile Computing technology that you can access and transmit data from any remote locations without being present there physically. Mobile computing technology provides a vast coverage diameter for communication. It is one of the fastest and most reliable sectors of the computing technology field.

The concept of Mobile Computing can be divided into three parts:

- Mobile Communication
- Mobile Hardware
- Mobile Software

The term mobility can be classified into two parts:

1. User mobility and

- User mobility refers to as users who have access to similar communication services at different places.

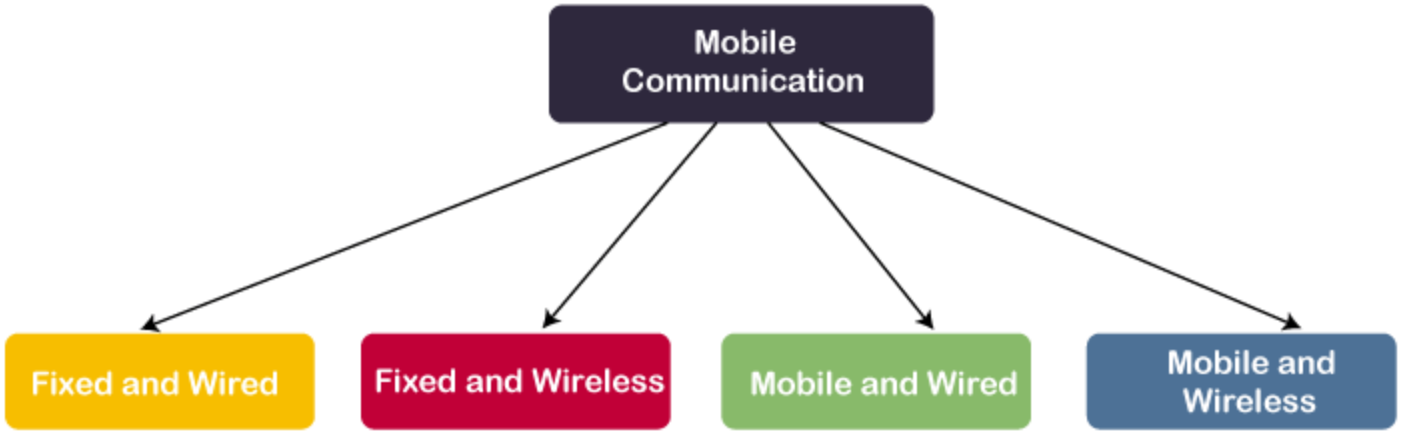
2. Device mobility

- Device portability refers to the movement of a communication device with or without a user.

- There are 2 aspects of mobile computing • – User mobility: users communicate “anytime, anywhere, with anyone” (example: read/write email on web browser) • – Device portability: devices can be connected anytime, anywhere to the network
- There are two different kinds of mobility: • user mobility and device portability. • User mobility refers to a user who has • access to the same or similar telecommunication services at different places, i.e.,the user can be mobile, and the services will follow him or her. • With device portability, the communication device moves • Many mechanisms in the network and inside the device have to make sure • that communication is still possible while the device is moving.

Mobile Communication

- **Mobile communication can be divided in the following four types:**
- Fixed and Wired
- Fixed and Wireless
- Mobile and Wired
- Mobile and Wireless
-



- **Fixed and Wired:** In Fixed and Wired configuration, the devices are fixed at a position, and they are connected through a physical link to communicate with other devices.

Example, Desktop Computer.

- **Fixed and Wireless:** In Fixed and Wireless configuration, the devices are fixed at a position, and they are connected through a wireless link to make communication with other devices.

Example, Communication Towers, WiFi router

- **Mobile and Wired:** In Mobile and Wired configuration, some devices are wired, and some are mobile. They altogether make communication with other devices.

Example, Laptops.

- **Mobile and Wireless:** In Mobile and Wireless configuration, the devices can communicate with each other irrespective of their position. They can also connect to any network without the use of any wired device.

Example, WiFi Dongle.

Mobile Hardware

- Mobile hardware consists of mobile devices or device components that can be used to receive or access the service of mobility. Examples of mobile hardware can be smartphones, laptops, portable PCs, tablet PCs, Personal Digital Assistants, etc.

These devices are inbuilt with a receptor medium that can send and receive signals. These devices are capable of operating in full-duplex. It means they can send and receive signals at the same time. They don't have to wait until one device has finished communicating for the other device to initiate communications.

Mobile Software

- Mobile software is a program that runs on mobile hardware. This is designed to deal capably with the characteristics and requirements of mobile applications. This is the operating system for the appliance of mobile devices. In other words, you can say it the heart of the mobile systems. This is an essential component that operates the mobile device.
-

This provides portability to mobile devices, which ensures wireless communication.

Mobile Computing Functions

- We can define a computing environment as mobile if it supports one or more of the following characteristics:

- **User Mobility**
- **Network Mobility**
- **Device Mobility**
- **Service Mobility**
- **Session Mobility**
- **Host Mobility (client –server, ip)**

User mobility: User should be able to move from one physical location to another location and use same service

Network mobility: User should be able to move from one network to another network and use same service

Device Mobility:User should be able to move from onedevice to another and use the sameservice.

Example could be salesrepresentatives using their desktopcomputer in home office. During theday while they are on the street theywould like to use their Palmtop toaccess the application.

Session Mobility:A user session should be able to move fromone user-agent environment to another.

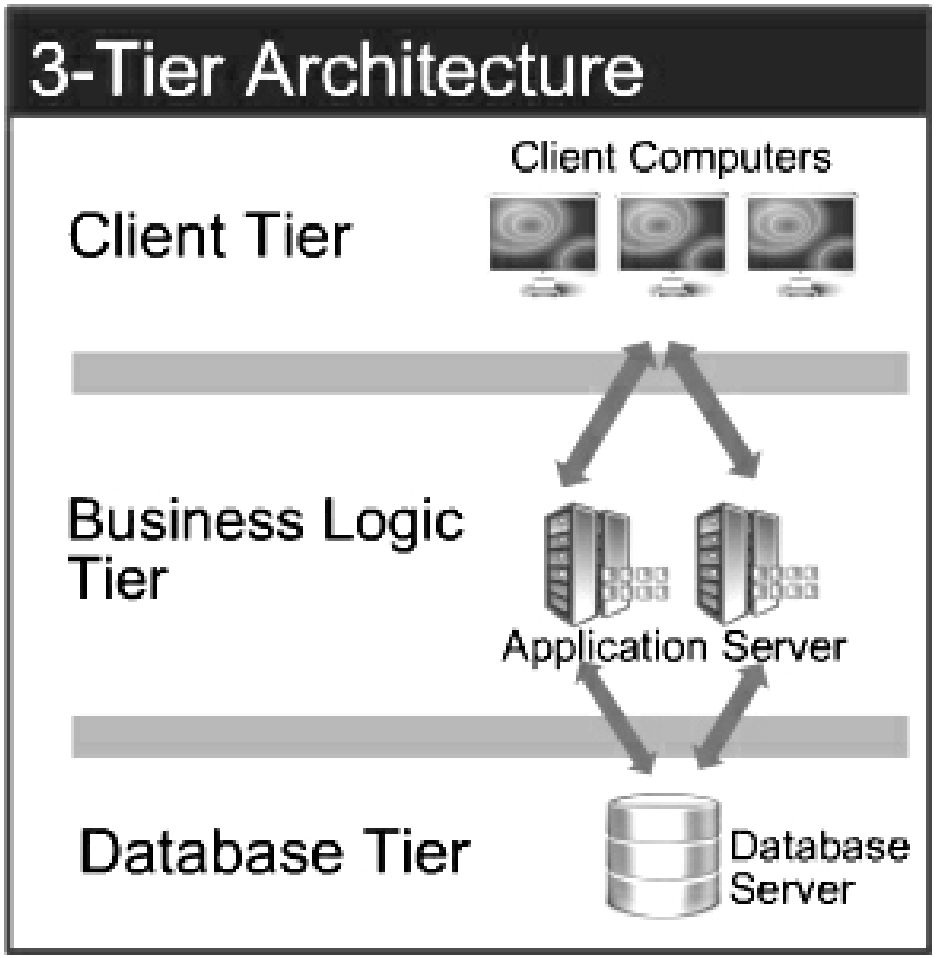
Example could be a user was using his servicethrough a CDMA (Code Division MultipleAccess) IX network. The user entered into the basement to pa rk the car and gotdisconnected from his CDMA network. Usergoes to home office and starts using the desktop. The unfinished session in the CDMAdevice moves from the mobile device to the desktop computer.

Service Mobility:□User should be able to move from oneservice to another

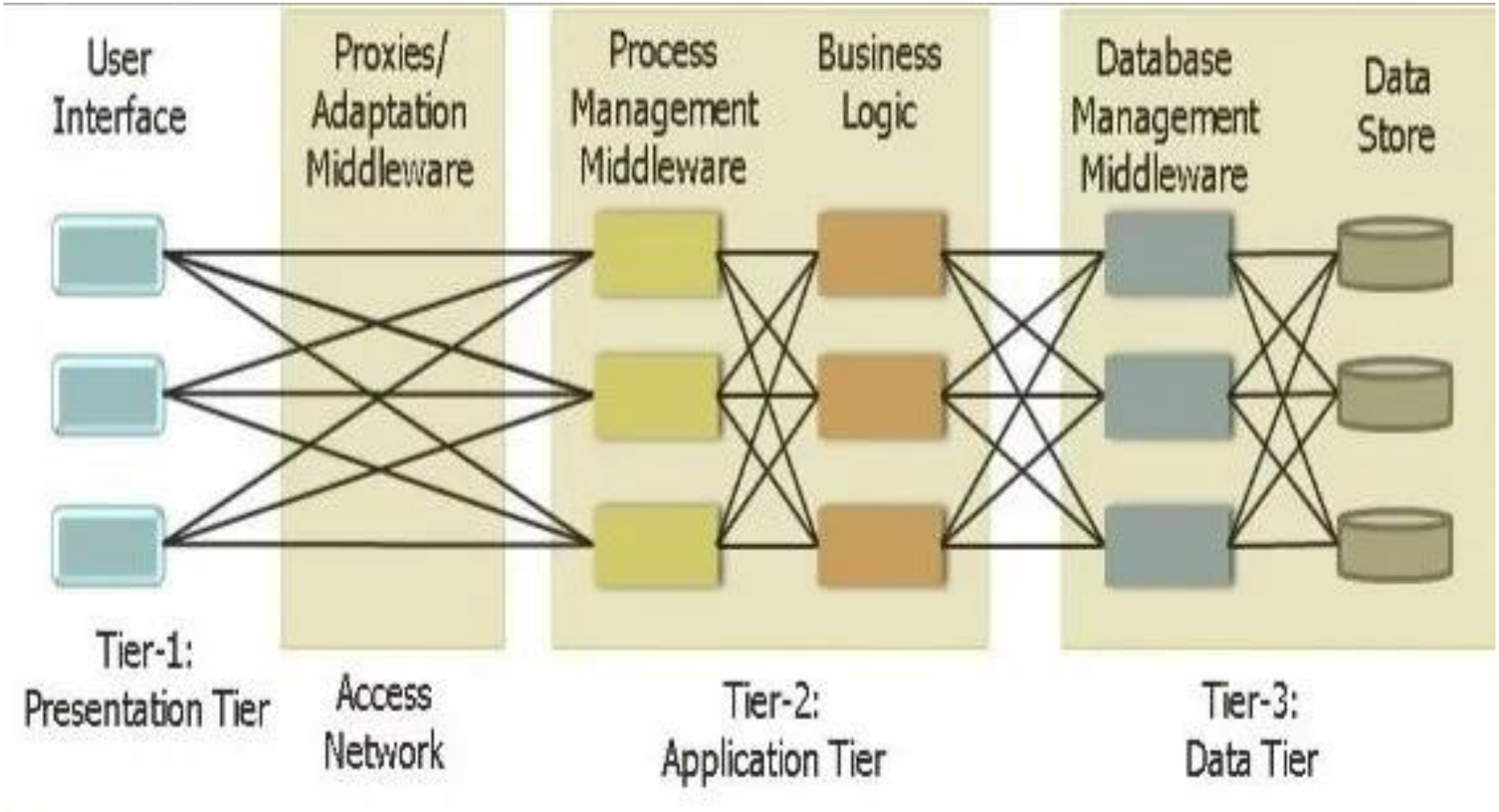
Example could be a user is writing a mail.To complete the mail user needs to referto some other information. In a desktopPC, user simply opens another service(browser) and moves between themusing the task bar. User should be able toswitch amongst services in smallfootprint wireless devices like in thedesktop.

Host Mobility:The user device can be either a clientor server.□When it is a server or host, some of the complexities change.□In case of host mobility the mobility ofIPneeds to be taken care of.

MC Architecture

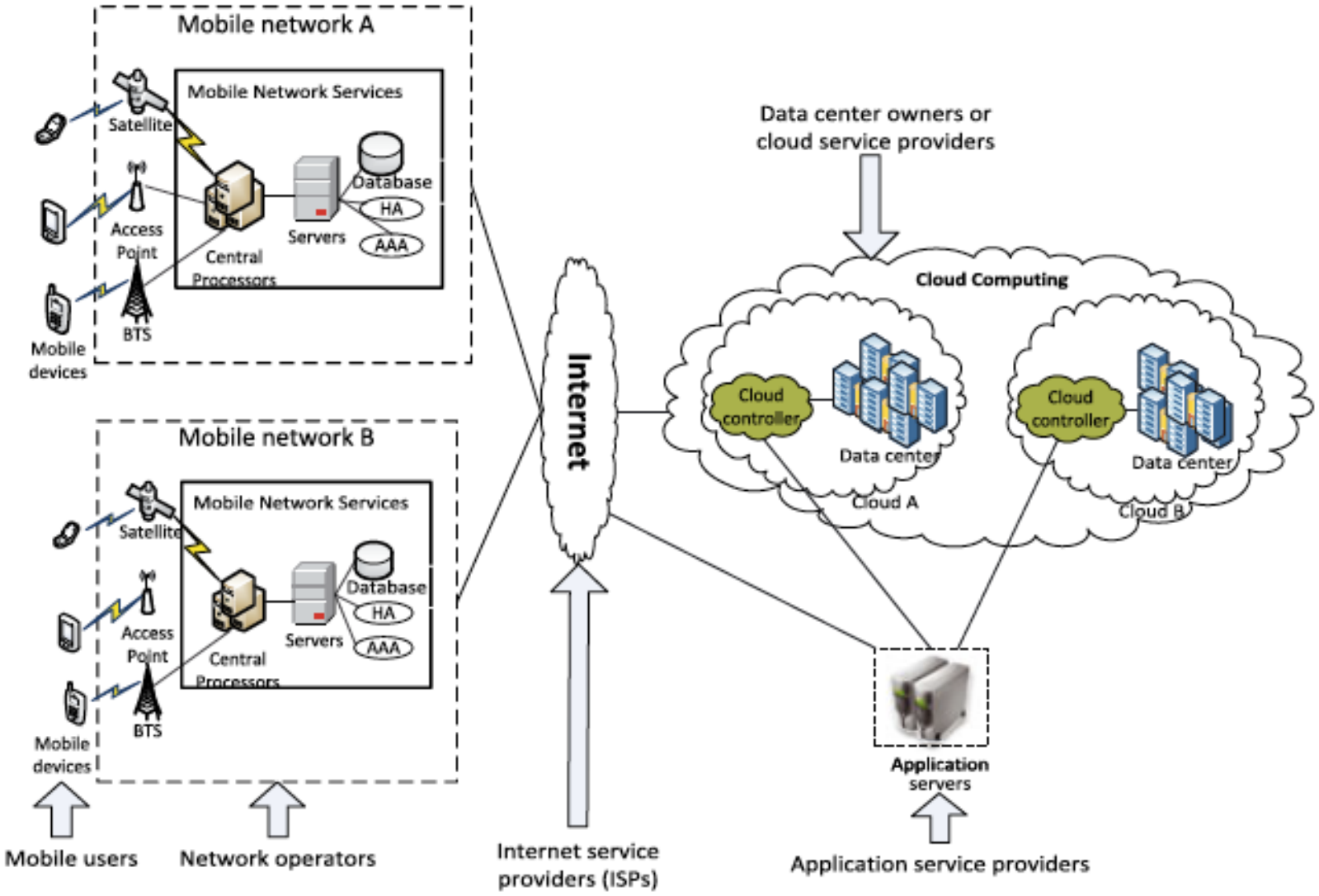


MC Architecture



- **Each tier is distributed to a different place or places in a network.** These tiers do not necessarily correspond to physical locations on various computers on a network, but rather to logical layers of the application.
- **Presentation Layer (UI):**
  - This layer presents data to the user and optionally permits data manipulation and data entry, also this layer requests the data form Business layer.
  - This layer accomplished through use of Dynamic HTML and client-side data sources and data cursors.
- **Application Layer (AL)**:
  - The business logic acts as the server for client requests from workstations. It acts according Business rules fetch or insert data through the Data Layer.
  - In turn, it determines what data is needed (and where it is located) and acts as a client in relation to a third tier of programming that might be located on a local or mainframe computer.
  - Because these middle-tier components are not tied to a specific client, they can be used by all applications and can be moved to different locations, as response time and other rules require.
- **Data Access Layer (DA):**
  - The third tier of the 3-tier system is made up of the DBMS that provides all the data for the above two layers.
  - This is the actual DBMS access layer.
  - Avoiding dependencies on the storage mechanisms allows for updates or changes without the application tier clients being affected by or even aware of the change.

MCC Architecture



MCC Architecture

- Mobile devices are connected to the mobile networks via base stations that establish and control the connections and functional interfaces between the networks and mobile devices.
- Mobile users' requests and information are transmitted to the central processors that are connected to servers providing mobile network services.
- The subscribers' requests are delivered to a cloud through the Internet.
- In the cloud, cloud controllers process the requests to provide mobile users with the corresponding cloud services.

- Architecture of mobile cloud computing consist of mobile devices, mobile networks, network operator, central processor, servers, databases, internet service provider, data centers.
- Mobile devices like mobiles, laptops communicate with the mobile network with the help of base stations, access points, satellite. The information that is transmitted is operated on central processing unit, servers, databases which contain information related to the computation on mobile network provider side. Mobile network provider provides the essential services like AAA means authentication, authorization, accounting based on the information stored in databases. Authentication, authorization, and accounting (AAA) is a term for a framework for intelligently controlling access to computer resources, enforcing policies, auditing usage, and providing the information necessary to bill for services. After that network operator request to the cloud through the internet. Cloud service provider process the request to provide the services to subscriber. MCC provide effectiveness and clearness by using advantages of cloud computing

Advantages

- Availability
- Location flexibility
- Increased productivity
- Cost effective

Disadvantages

- Connectivity issues
- Power consumption
- Security concern

Issues in categories

- Software Issues - Apps
- Technical Issues - Battery, h/w
- Network Issues – connection
- User Interface Issues - understanding
- Security Issues - attack

Applications of Mobile Computing

Following is a list of some significant fields in which mobile computing is generally applied:

- Web or Internet access.
- Global Position System (GPS).
- Emergency services.
- Entertainment services.
- Educational services.

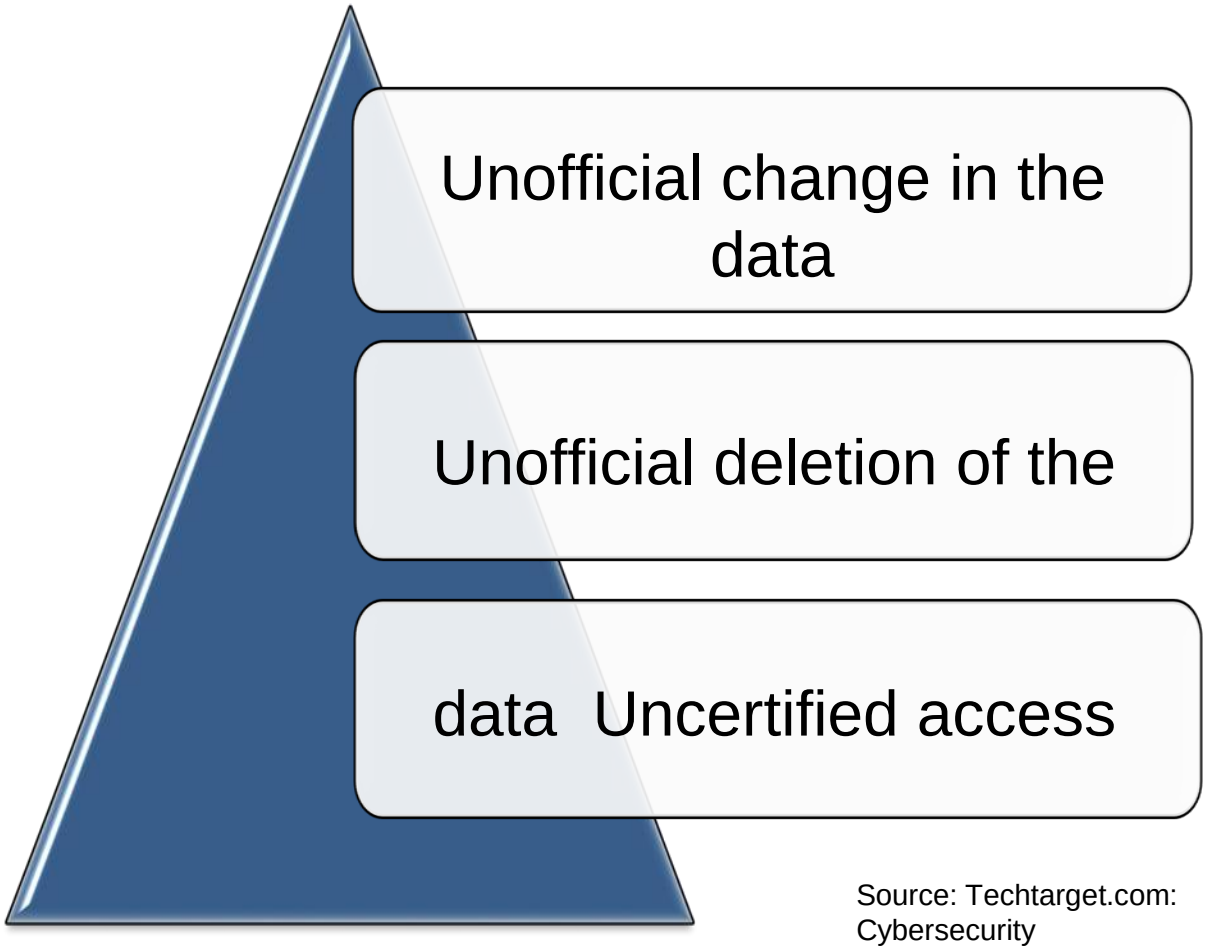
What is Cybersecurity?

- In computing, security consists of
  - Cybersecurity
  - Physical security

- Protection of internet-connected systems from cyber-attacks is known as cybersecurity.
- This protection involves protection of
  - hardware
  - software
  - data
- Enterprises use cybersecurity and physical security simultaneously against unofficial access to data centres.

Source: Techtarget.com: Cybersecurity

Protect against what?



Source: Techtarget.com: Cybersecurity

Components of Cybersecurity

- Application security
- Information Security
- Network Security
- Operational Security
- End-User education

Source: Techtarget.com: Cybersecurity

- Application security
  - It ensures the protection of applications from outer threats.
  - Some software, hardware and procedural methods are used for protection.
  - Some actions are needed to certify application security; these actions are known as countermeasures.

    There are two types of countermeasures.
    - Software countermeasure: application firewall
    - Hardware countermeasure: router/proxy
- Information Security
  - Information security is recognized as a subset of cybersecurity.
  - A set of strategies is known as information security, which handles some tools and policies. These policies filter the threats.
  - These strategies help maintain the availability, integrity and confidentiality of business data.
- Network Security
  - Network security is a process by which we take physical and software actions for protecting the network architecture.
  - It provides protection from unofficial access, improper use, fault, deletion, demolition.
  - Create a protective platform for users and computers.
  - It combines multiple layers of defences at the edge and in the network.
- Operational Security
  - Operational security (OPSEC) is an analytical action which categorizes information benefits.
  - For protection of these information benefits, it regulates the control.
  - Protection is an important factor in business perspectives; because of this OPSEC operations are commonly used in business actions.
- End-User education
  - End-users are thebiggest security risk for an industry. They are the first to compromise the security.
  - Employees do not have all information about all the attacker, hence they can easily open the doors for the attackers.
  - As cybercrimes are increasing, it will be more important for industry to educate their employees about cyber-attacks.

Types of Cybersecurity threats

- Ransom-ware
- It provides a facility to the attacker in which the attacker locks the user's computer files by using an encryption and demand some money to unlock them.
  - Example: Locky
- Malware
  - A computer program which is used to disturb the computer user, such as computer viruses, spyware etc.
  - Example: Trojan Horse
- Social Engineering
  - This attack involves human interaction to mislead users.
  - It breaks security policy to get critical information, which is typically secured.
  - Example : Watering hole and Pretexting.
- Phishing
  - Phishing is in the form of false information. These information are basically false emails which have been sent through recognizable sources.
  - The aim is to get critical data, such as login information or credit card information.
  - Example: Google docs Phishing and Dropbox Phishing.

Source: Techtarget.com: Cybersecurity

Why IIoT Security Standards is required?

- Industries will need to use diverse systems and equipment but everything will be integrated on smart factory floor.
- Legacy systems must be brought under implementation.
- Every weak line in the chain puts whole factory at risk.
- Leaving security at the hands of individual IIoT implementers is dangerous.

Cyber security Requirements

CIA Triad

- C-Confidentiality:

Confidentiality stops unauthorized disclosure of Information.

- I-Integrity:

Integrity ensures that data cannot be changed in any unauthroized manner.

- A-Availability:

Availability guarantees that information must be available only to the authorized user.

Source: Techtarget.com: Cybersecurity

Cybersecurity: Challenge in IIoT

- Cybersecurity has a major role in digital economy and it certainly is a big challenge in IIoT as well.
- In current digital transformation, capabilities such as manufacturing, logistics, shipping, healthcare and industries, which comes under the industrial internet, data breaches can occur, which increases different kinds of cybercrimes and cyber threats.

Cyber security for Industry 4.0

- Traditional cybersecurity mechanisms have the characteristics- confidentiality, authenticity, integrity, non-repudiation and access-control.
- These methods provide safety in network and computer attacks.
- The **new internet security** deals with **other attacks** which are capacious and very fast.
- Some methods are required for Industry 4.0 systems which enables automatic detection to cyber-attacks.

Source: Cybersecurity for industry 4.0: Thames

Artificial Intelligence

- PM Narendra modi says
- ”India is soon become a global hub for Artificial Intelligence”
- “ Artificial Intelligence plays a crucial role in developing solutions in agriculture, creating next generation urban infrastructure and making disaster management in the country stronger”

Introduction to Artificial Intelligence

AI is a technique to make machines to think like humans. It is a study of how human brain think, learn, decide and work to solve a problem.

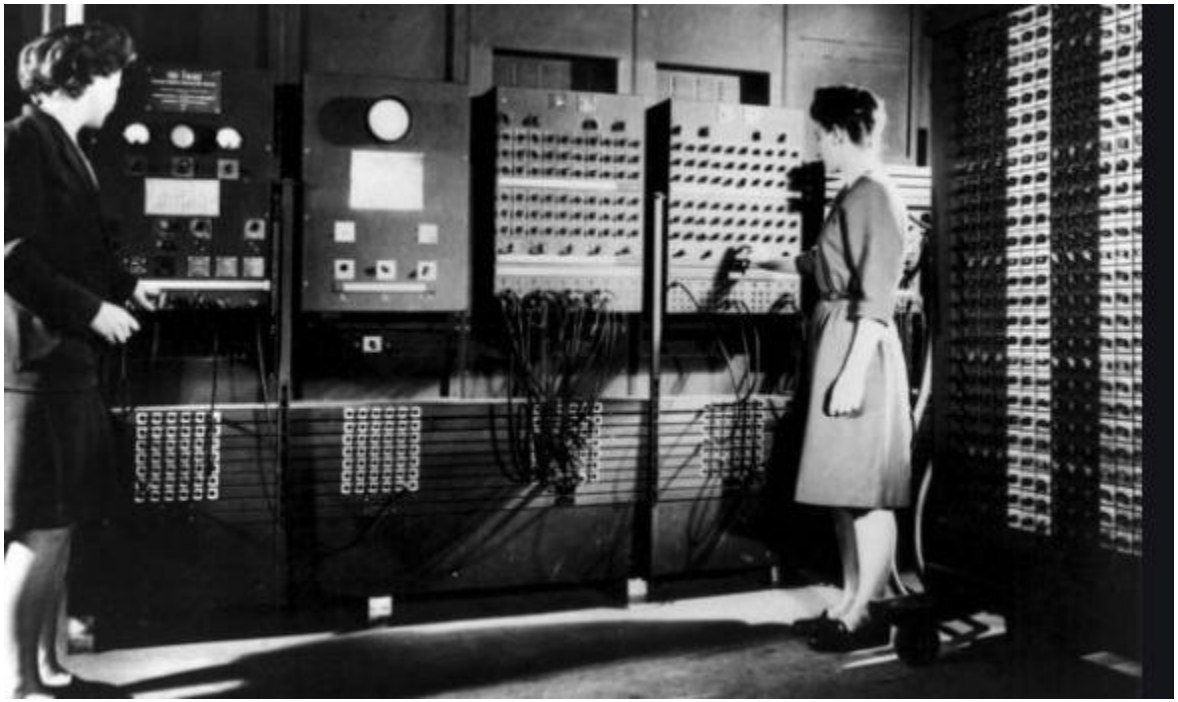
- AI is to improve computer functions which are related to human knowledge, example reasoning, learning and problem solving.

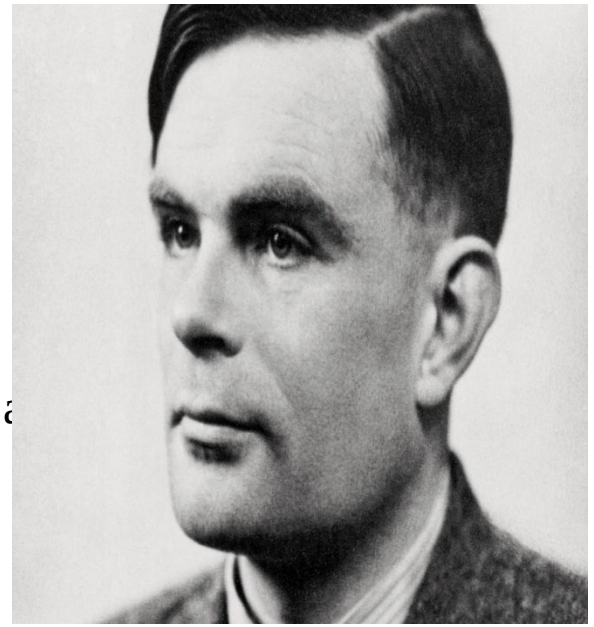
Intelligence is composed of

1. Reasoning
2. Learning
3. Problem solving
4. Perception
5. Linguistic intelligence

History of AI

1946: ENIAC(Electronic Numerical Integrator and computers) was developed which was first electronic general purpose computer . ENIAC is capable of being reprogrammed to solve a large class of numerical problems at a time.





- In 1950, Alan turing who proposed a question
" can machines think?"
- Turing test is devised by Alan turing which is used to figure out whether machine can think or not.

1956's: A new field is born, 4 people come together to do a two months work shop at the Dartmouth college in Hanover, New Hampshire.

1. John McCarthy
2. Alan Newell
3. Herbert Simon
4. Marvin Minsky

Above four are founding fathers of Artificial Intelligence

.

The Word AI first time given by John McCarthy. Hew worked on chess and created language called LISP is one of the high level programming language is one of the favourite programming language for Artificial Intelligence.

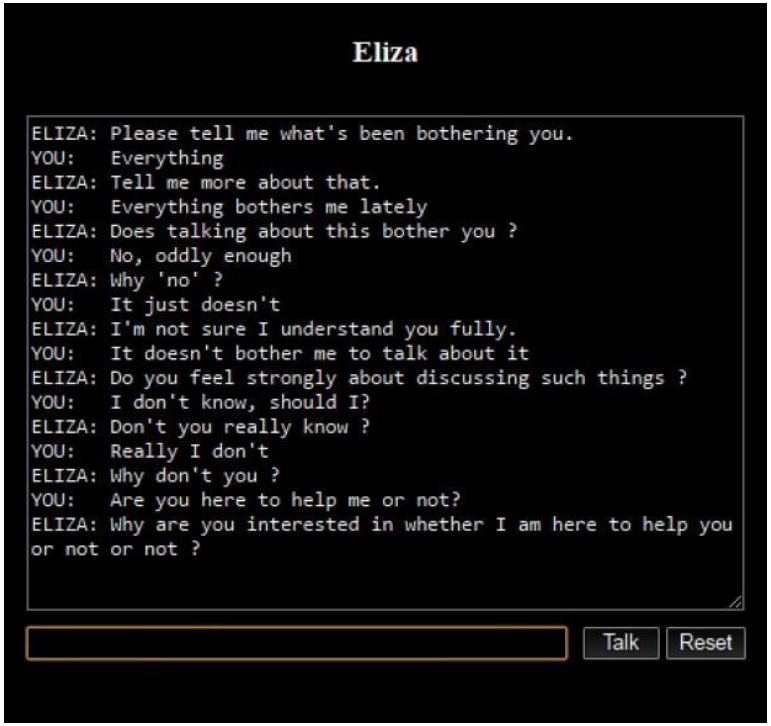
- Alan Newell and Herbert Simon worked on logic theorists they were trying to figure out theory to prove the theorems.
- We can create AI system which will be able to prove theorems automatically.
- Marvin Minsky who is from MIT who built neural networks learning machines. He started MIT AI laboratory.

1950: Turing test born to test machine intelligence

1956: AI born at Dartmouth College Workshop

1964: Eliza : one of the first chat bot , was able to converse about any subject, because it stored subject information in data banks.

- Eliza was ability to pick up speech patterns from users questions and provide responses using those patterns.



1966: Shakey: general purpose mobile robot which has many sensors, cameras , control unit , wheels and so on is able to reason about its own its own actions.

1970: Expert systems were designed and developed to predict the probability of a solution under set conditions. Expert system is a program that uses logical rules tat are derived from the knowledge of experts to answer the questions or solve problems about a specific domain of knowledge.

- Expert systems such as forecasting the stock market diagnose diseases.

1986: simulating human brain started 1986 onwards. Neural networks were used to simulate human brain functioning.

AI is combination of computer science, physiology and philosophy.

AI defined by several authors

1. AI the art of creating machines that perform functions which require intelligence when performed by people(Kurzweil, 1990)
2. AI is the study of the computations that make it possible to perceive, reason and act(Winston 1992)
3. AI is branch of computer science that is concerned with the automation of intelligent behaviour (Uger and Stubble field, 1993)/

AI is study of making computers do things intelligently. AI must have capability and characteristics of intelligent.

AI Definitions

``The exciting new effort to make computers think ... *machines with minds*, in the full and literal sense" (Haugeland, 1985)  ``The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning ..." (Bellman, 1978)	``The study of mental faculties through the use of computational models" (Charniak and McDermott, 1985)  ``The study of the computations that make it possible to perceive, reason, and act" (Winston, 1992)
``The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990)  ``The study of how to make computers do things at which, at the moment, people are better" (Rich and Knight, 1991)	``A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes" (Schalkoff, 1990)  ``The branch of computer science that is concerned with the automation of intelligent behavior" (Luger and Stubblefield, 1993)

What is Artificial Intelligence (AI)?

Artificial + Intelligence = Artificial Intelligence

Manmade

Thinking power

Creation of manmade thinking power

In simple way, *Artificial Intelligence* is a creation of software having intuitive decision making ability.

Source: Artificial Intelligence by David L. Poole, Alan K. Macworth, Artificial Intelligence by Rajiv Chopra

Goals of AI

- Replicate human Intelligence
- Solve knowledge
- An intelligent connection of perception and action
- Building a Machine which can perform tasks that requires human intelligence such as

✓ providing a theorem

✓ Playing a chess

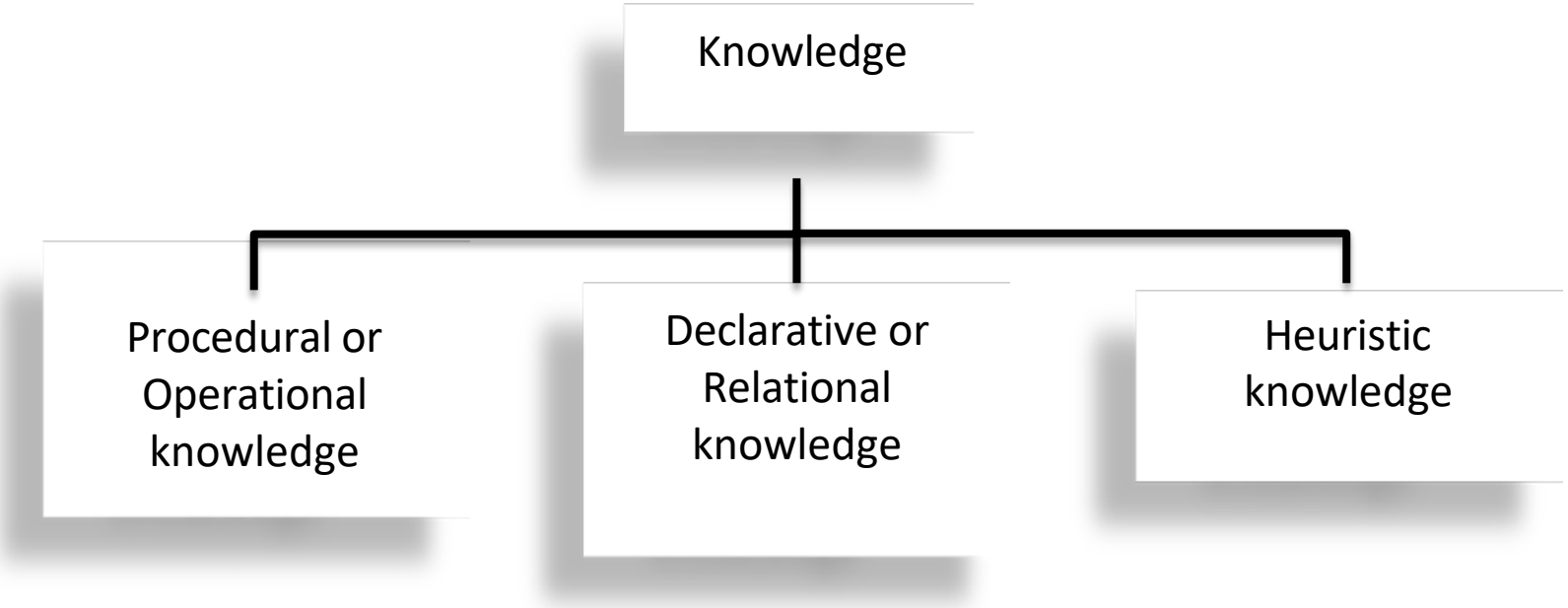
✓ plan some surgical opeartions

✓ Driving a car in traffic

- Creating some system which can exhibit intelligent behaviour, learn new things by itself, demonstrate, explain and can advise to its user.

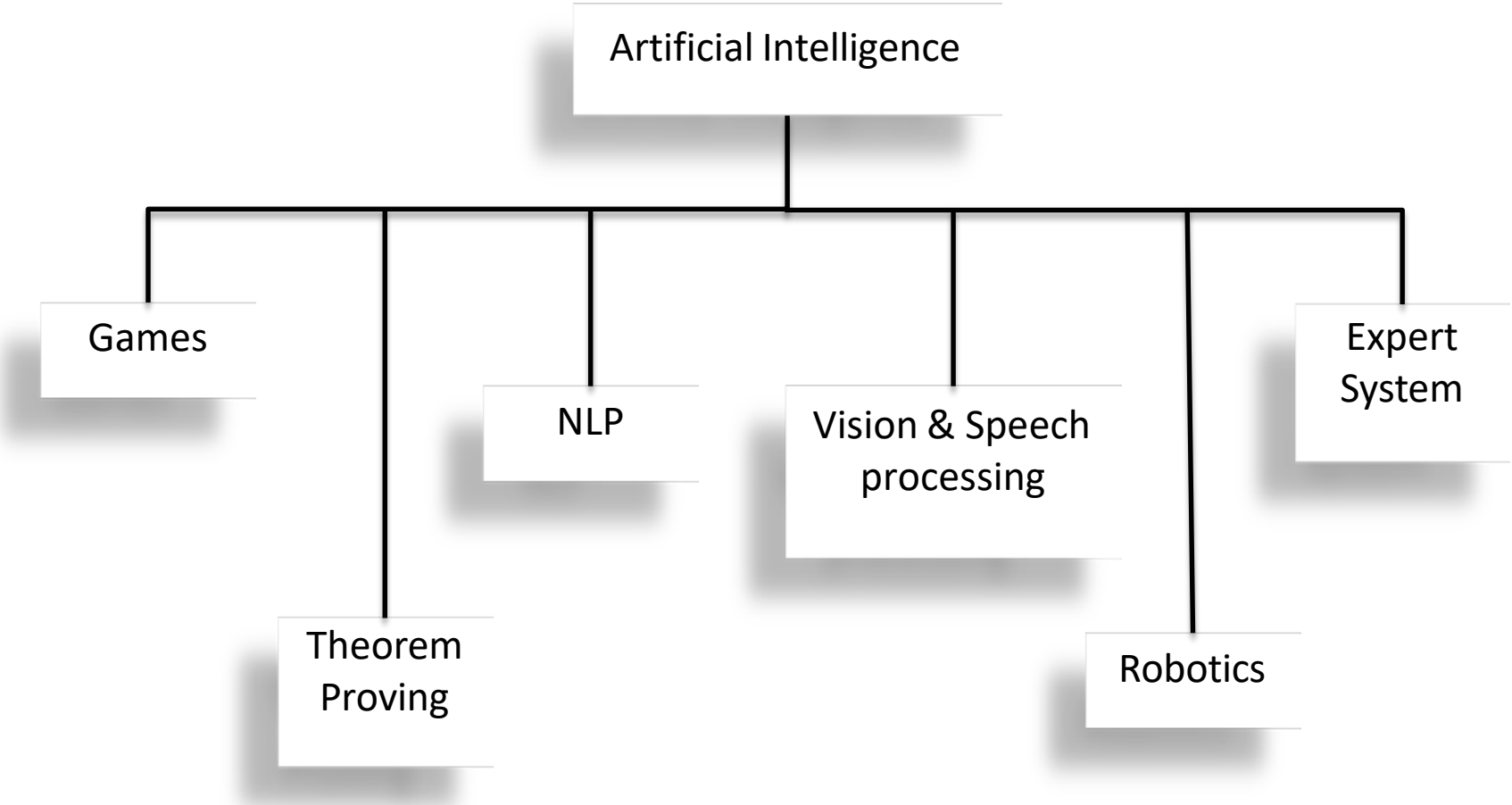
AI Techniques

Knowledge is the information that can be used to perform a particular task



Source: Artificial Intelligence by David L. Poole, Alan K. Macworth, Artificial Intelligence by Rajiv Chopra

Scopes of AI



Source: Artificial Intelligence by Rajiv Chopra

Applications of AI

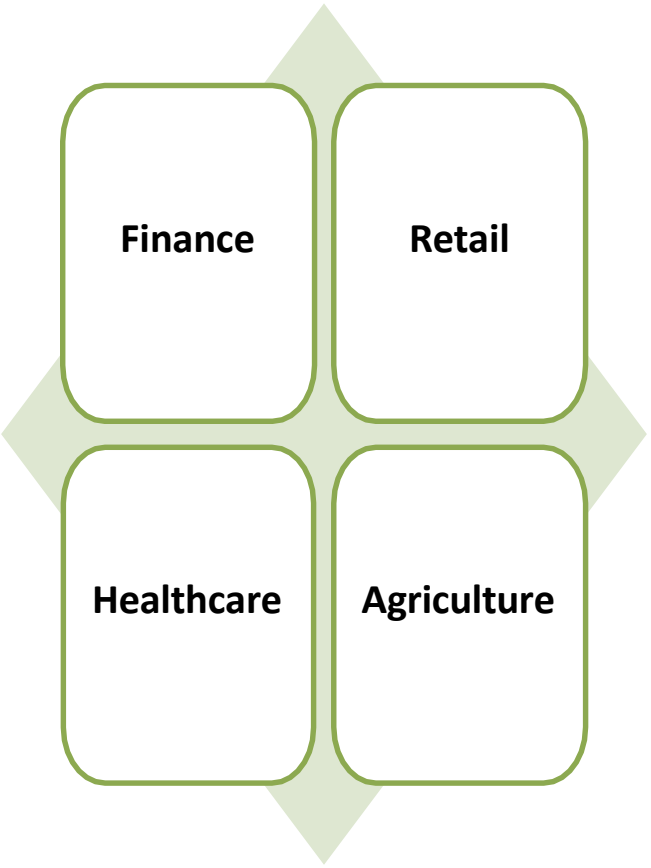
1. Gaming : chess, river crossing etc.
2. Natural language processing: computer understand different languages.
3. Expert systems: machine provides explanation and advice.
4. Compute vision : computer could identify the images or pictures
5. Speech recognition: siri and google apps
6. Hand writing recognition: reads text written on the paper.
7. Fraud detection
8. Manufacturing: assembly, inspection and maintenance
9. Business
10. Information retrieval

Role of AI in Industry 4.0

- ✓ **Industry 4.0:** Human-machine interaction, CPS, cloud computing, cognitive computing, IoT/IIoT, etc – in Manufacturing
- ✓ **Smart Factory:** Virtualized instances of physical objects in a factory interacting with one another.
- ✓ **Role of AI:** Machine safety, efficient product lifecycle, efficient manufacturing processes, etc.

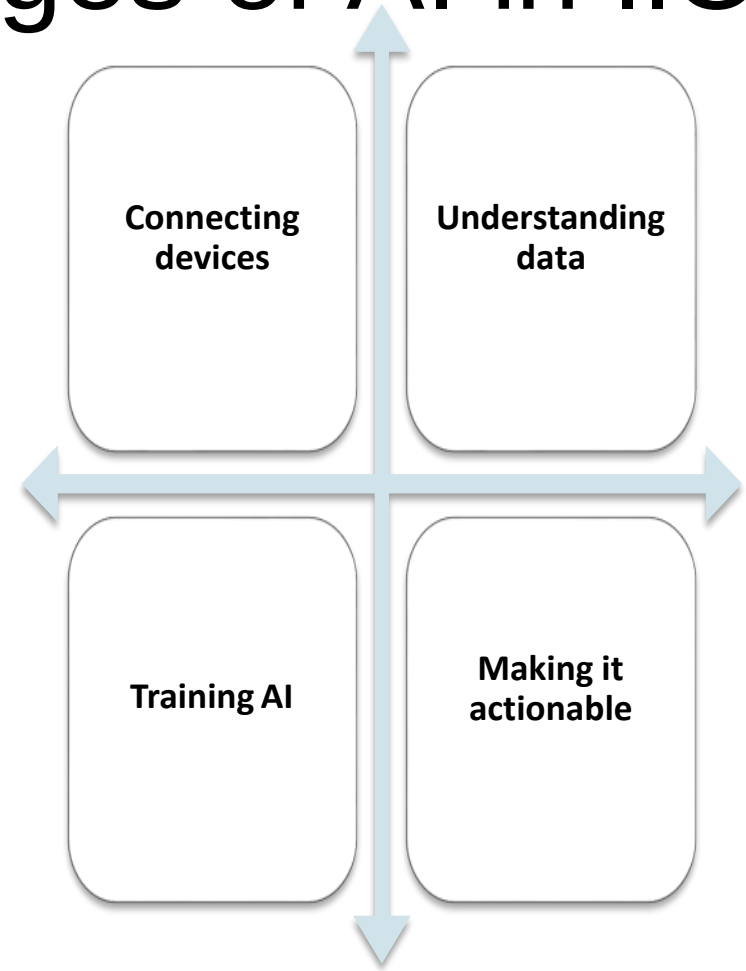
AI in IIoT

- Use of AI helps machines and equipment to communicate and relay information with one another
  - Examples: Computer Vision, Robotics, NLP, ML, DL, etc.
- With the help of AI industries are capable of taking the advantage of large amount generated data by machines
  - Example: Prediction of yield, quality of yield etc in Manufacturing



Source: The Significance of AI and Machine Learning in IIoT, Inc42

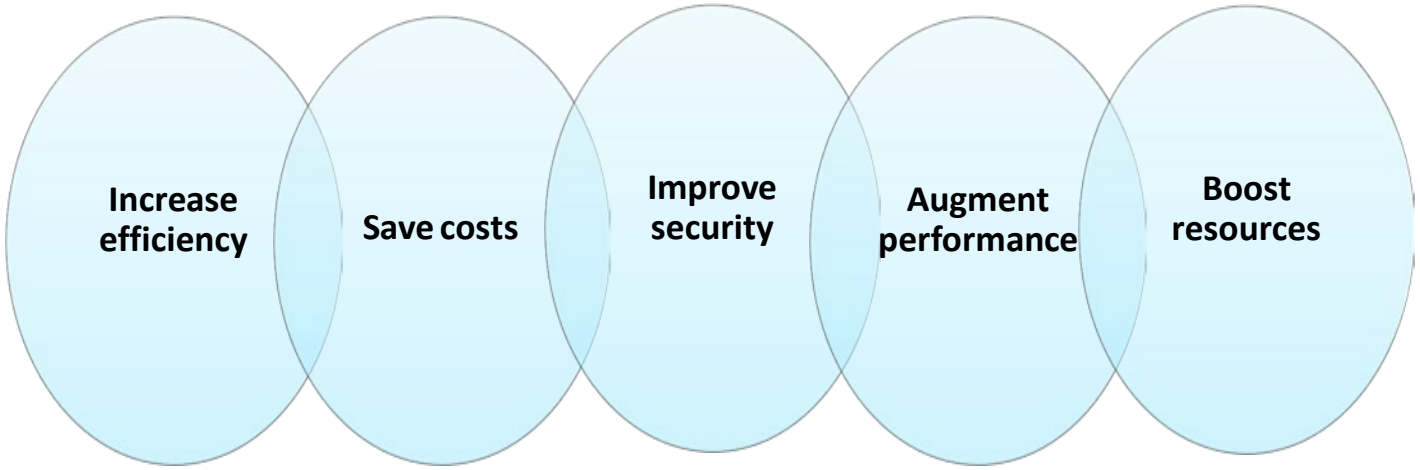
Challenges of AI in IIOT



Source: Four Artificial Intelligence challenges in facing the Industrial IoT, Clearblade

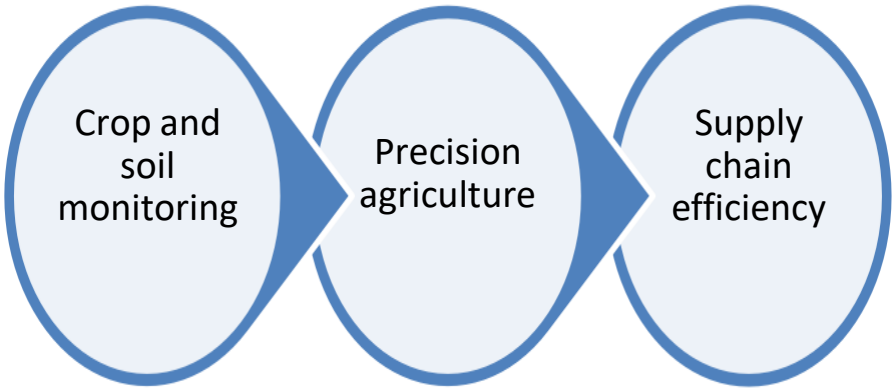
Advantages of AI in IIoT

The usefulness of AI in industrial scale are,



Source: The Significance of AI and Machine Learning in IIoT, Inc42

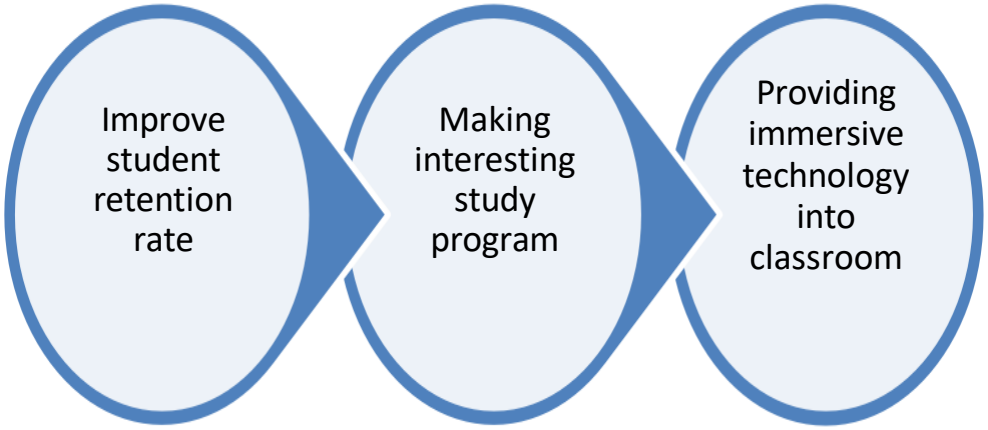
Significance of AI in Agriculture industry



- **CropIn's** smart farm solution
- **Intello lab** using AI based solution for crop health monitoring
- **Microsoft India AI** based sowing app
- **Gobasco AI** based Agri supply chain

Source: Artificial Intelligence in Indian Agriculture – An Industry and Startup Overview

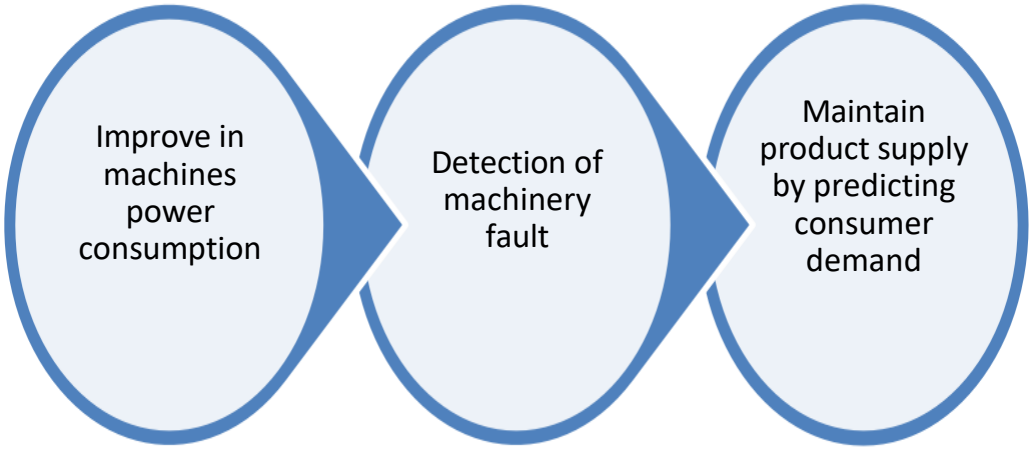
Significance of AI in Education industry



- Smart learning systems by **Carnegie Learning**
- **Querium Corporation** AI based education system

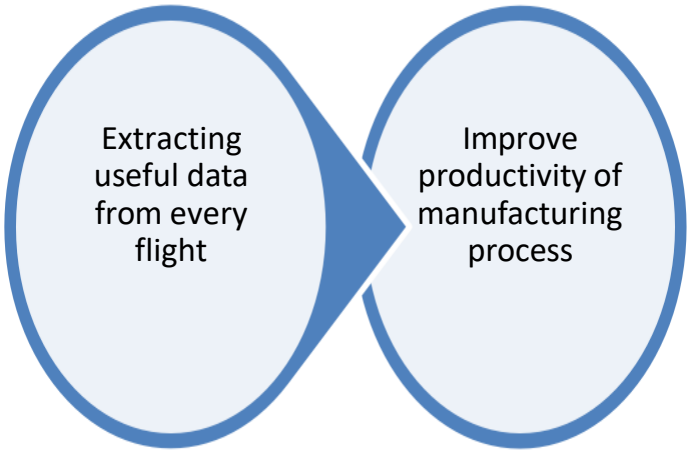
Source: AI in Education: 3 Industry Defining Trends in 2018

Significance of AI in Manufacturing factories



Source: The Significance of AI and Machine Learning in IIoT, Inc42

Significance of AI in Aerospace industry

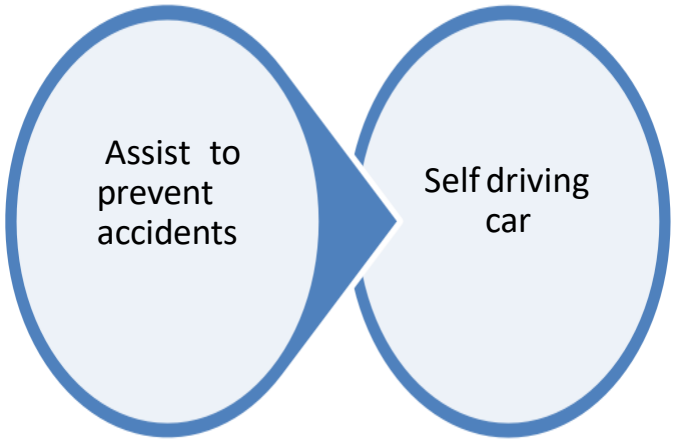


- **Boeing 787** generates large amount of data at each flight where AI is used to extract useful information

- **Airbus** is moving on with "Factory of Future", to improve the productivity of manufacturing process.

Source: The Significance of AI and Machine Learning in IIoT, Inc42
https://inc42.com/resources/the-significance-of-ai-and-machine-learning-in-iiot/

Significance of AI in Transportation industry



- **Indian railways** utilizes AI to secure safety of trains
- **Tesla** first automotive brand to launch self driving car

Source: The Significance of AI and Machine Learning in IIoT, Inc42

AI Techniques

AI Techniques: to make the machines think like machines AI techniques are to be used.

- AI technique is method used to exploits knowledge that should be represented in such a way that

1. knowledge captures the generalization
2. understandable by people
3. Easily modifiable to correct errors
4. Can be used in many situations

Parts of AI Techniques

1. Knowledge representation : to capture knowledge about the real world.
2. Search algorithms: finding/ searching solution of the problem.

AI Techniques:

1. Rule based
2. Fuzzy logic
3. Neural networks
4. Genetic algorithms

AI Problems

To solve what problems AI will be used?

1. Game playing - chess
2. Theorem proving – solves Geometry, calculus etc.
3. Commonsense reasoning – verbal and non verbal reasoning problems
4. Perception- vision and speech
5. Natural language understanding
6. Data mining
7. Medical diagnosis
8. Fraud detection

AI problem solving

To build a system to solve AI problem we need to do four things.

1. Define a problem precisely(initial state and goal state)
2. Analyze problem(identify techniques to solve)
3. Isolate and represent the knowledge necessary to solve the problem
4. Apply best technique to solve it.

- There are two types of solving methods

1. General purpose method - applicable for wide variety of problems
2. Special purpose method- applicable for specific problem

Augmented Reality and Virtual Reality in IIoT

- From the technological perspective, Augmented Reality (AR) and Virtual Reality (VR) are used in several contexts and sectors in Industry 4.0.
  - AR and VR plays important role in the primary stages where optimization and productivity are important in manufacturing industry.
  - The efficiency of warehouses are improved using various AR applications.
  - AR and VR also plays an important role in safety training, thereby the potential safety hazards can be easily located.
- Use cases:
  - Machining and production
  - Education and collaboration
  - Assembly
  - Safety and security
  - Digital prototyping
  - Factory planning
  - Maintenance and inspection

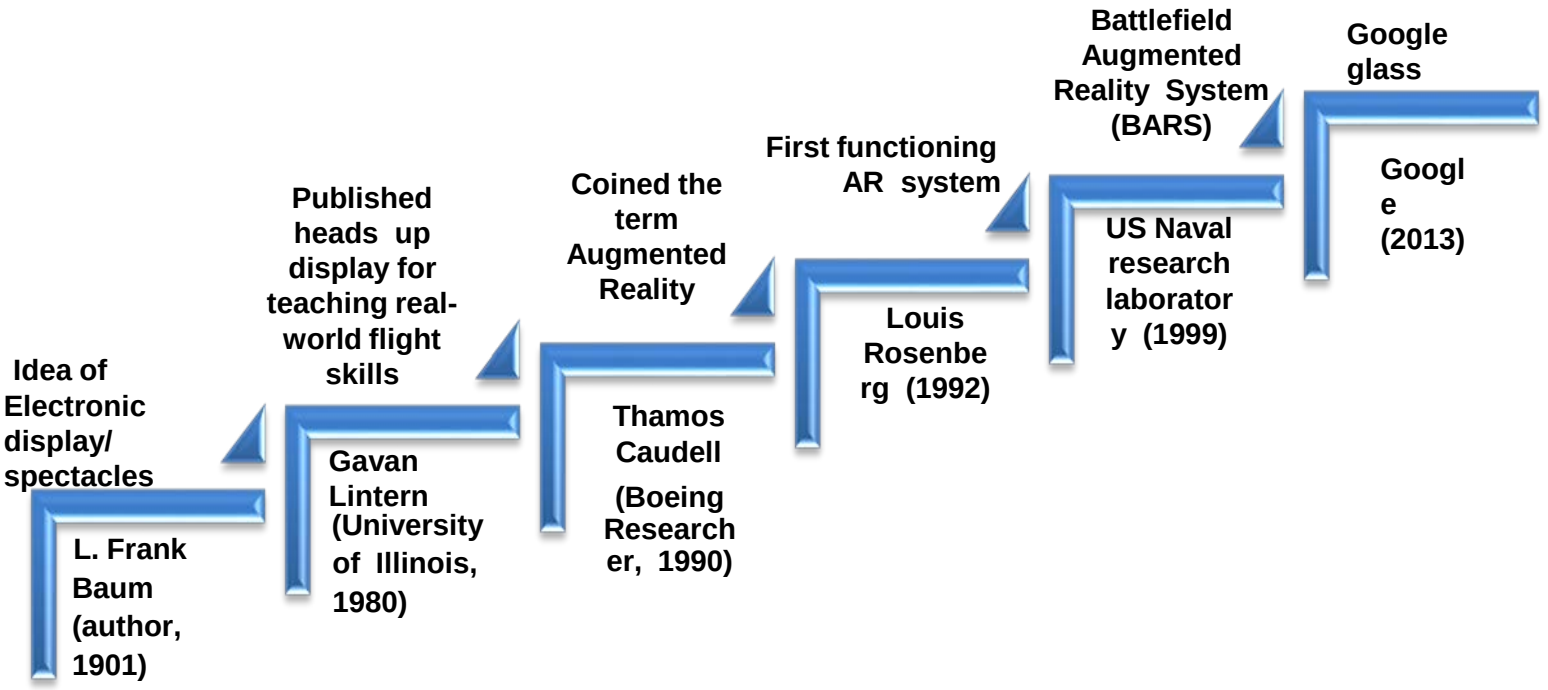
Augmented Reality (AR)

- Augmented Reality is
  - an enhanced version of reality
  - direct/indirect views of physical world environments are “augmented” with computer-generated superimposed images
  - adds digital elements into their actual environment
  - amplifies the present perception of reality.

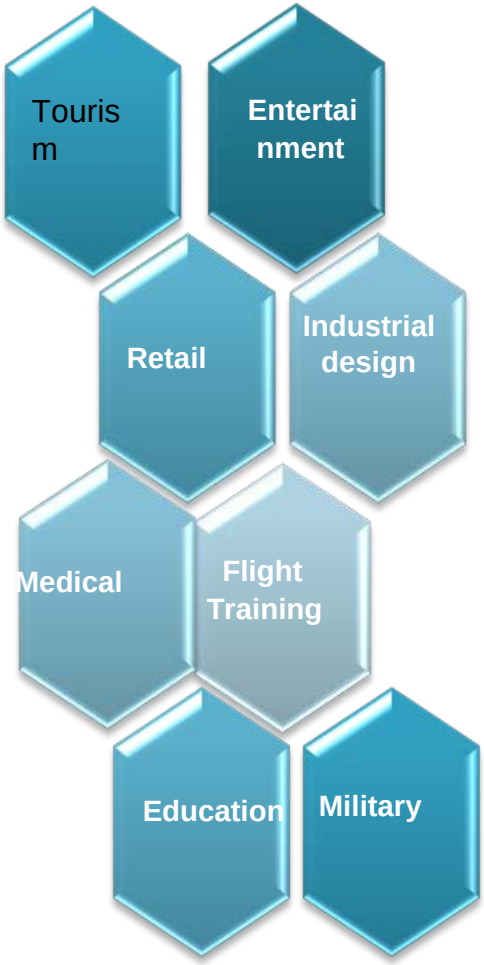
Key Features of AR

- It lies in the middle of the mixed reality spectrum.
- It provides multiple sensor modalities – visual, auditory, and haptic.
- It utilizes the existing environment and overlays new information on top of it

Chronological order of Augmented Reality



Applications of Augmented Reality



"Augmented Reality", Wikipedia

Applications of Augmented Reality (contd.)

Key components of devices:

- Sensors and Cameras
- Projection Screen
- Processing unit
- Reflection

Types of Augmented Reality

Marker-based augmented reality

Markerless augmented reality

Projection-based augmented reality

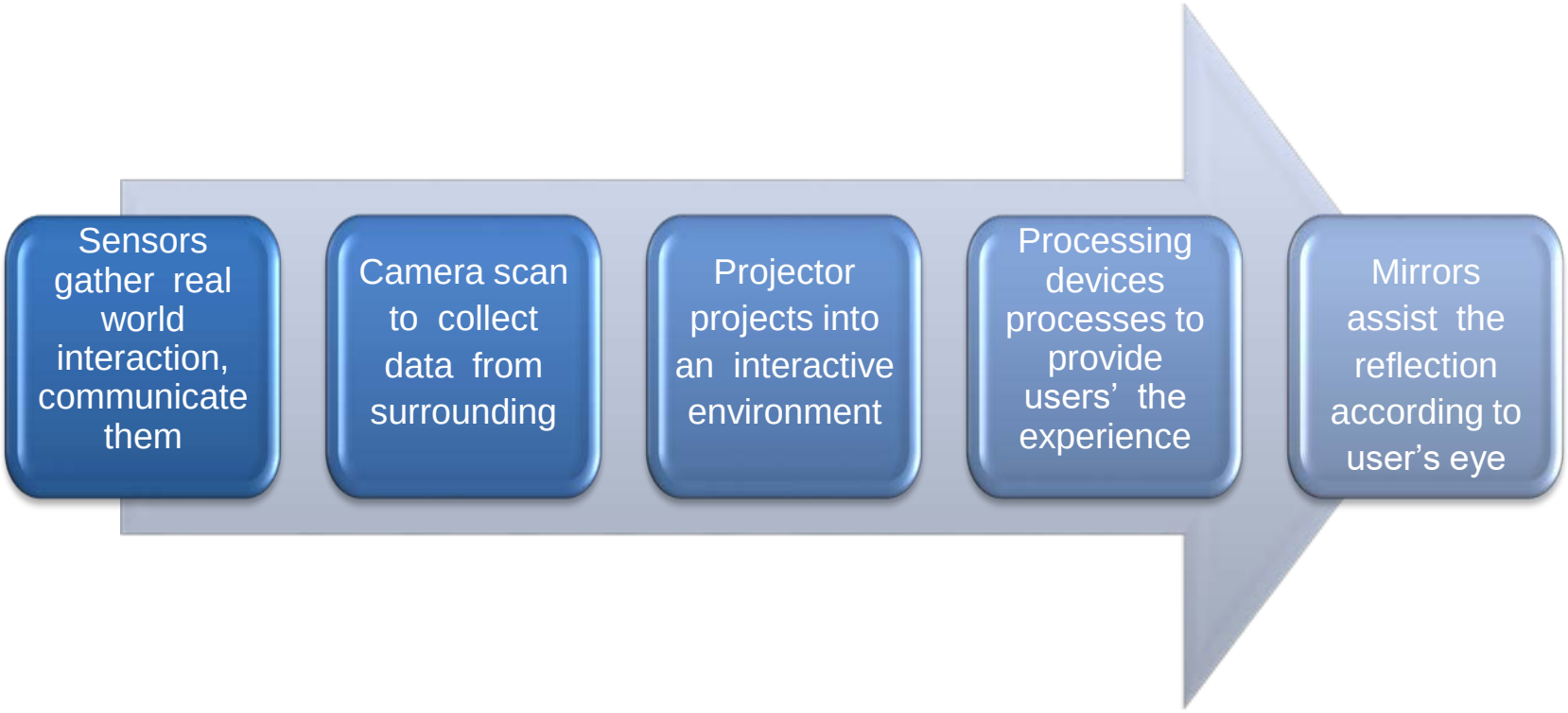
Superimposition-based augmented reality

Types of Augmented Reality

- Marker-based augmented reality gives an outcome when the reader is sensed by the camera and visual marker.
  - camera: differentiates between a marker and a real object.
  - marker: recognizes simple, distinct patterns and can be easily processed.

- Markerless augmented reality is commonly utilized for mapping directions. The location is provided based on the GPS, digital compass, or accelerometer, which is attached to the device.
- Projection-based augmented reality gives an outcome by projecting light onto real world surfaces.
  - It allows human interaction by sending light.
  - It differentiates between the expected projection and altered projection.
- Superimposition-based augmented reality partially or fully substitutes the original view of the object with the augmented view.
  - Object recognition plays an important role
  - Application cannot replace the original view with the augmented one

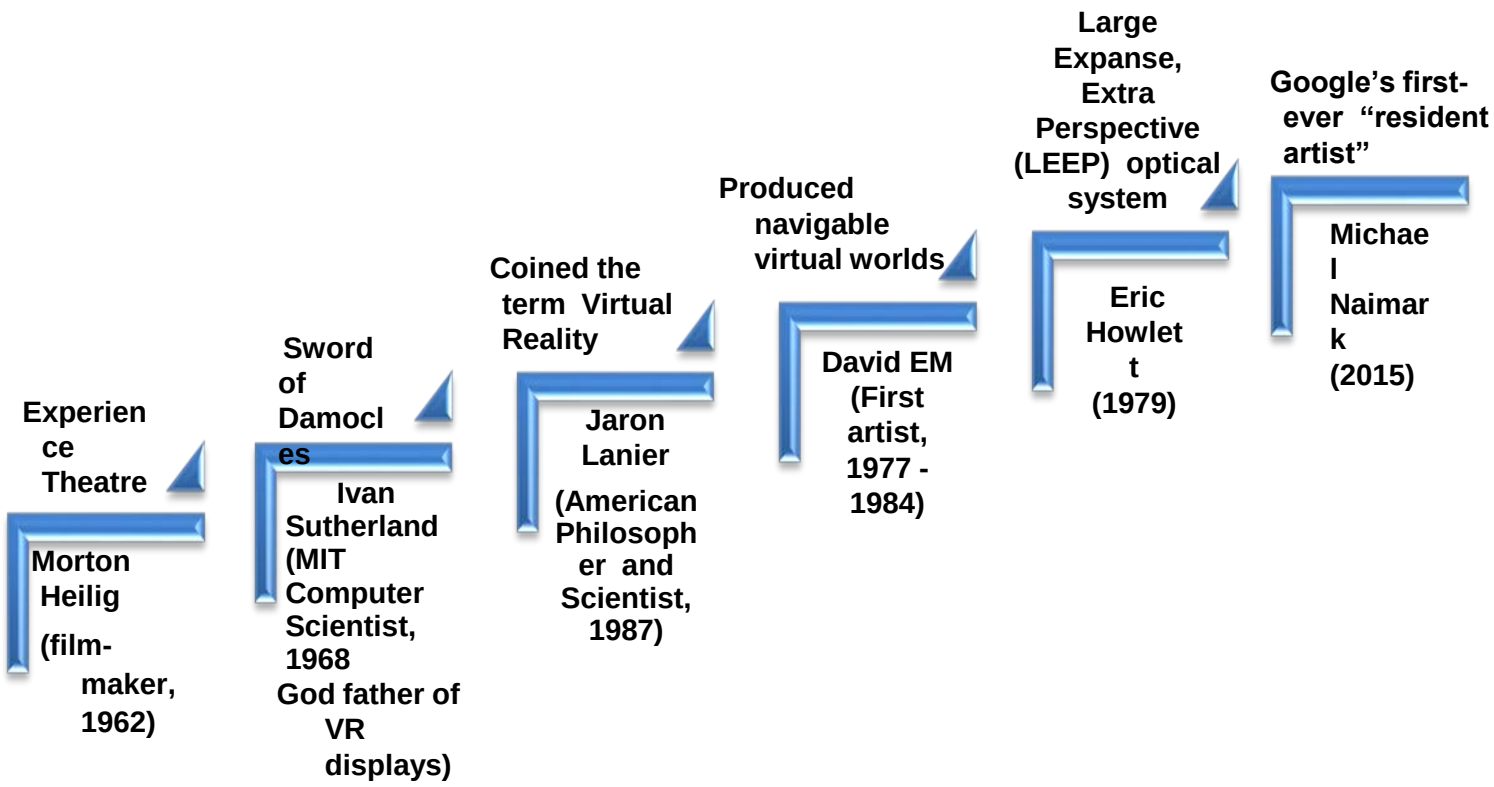
How do Augmented Reality works ?



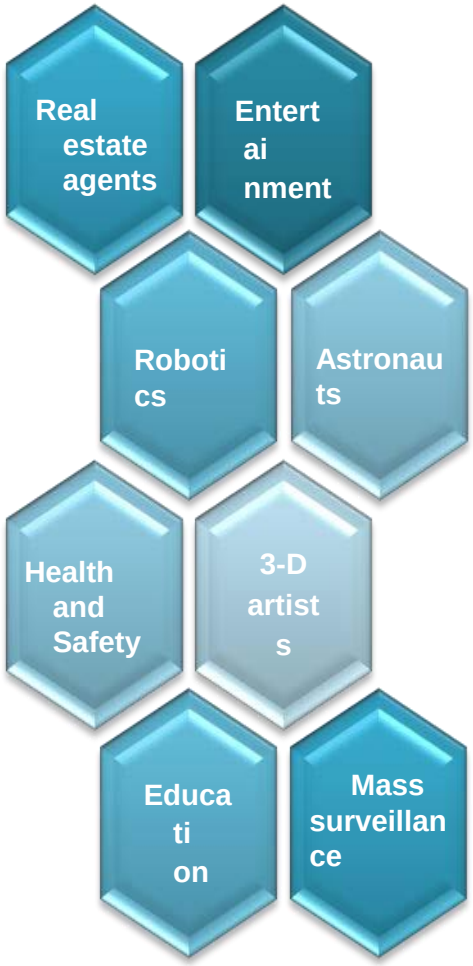
Virtual Reality (VR)

- Virtual Reality is
  - a mixture of interactive hardware and software based artificial environment
  - a realistic three-dimensional image is created
  - presented to the user, in such a way so that they interacts with the real or physical world.
- The key features of VR are:
  - It creates and enhances an imaginary reality.
  - It gives the perception of being physically present in a non-physical world.
  - It incorporates auditory and visual sensory feedback.
  - It allows users to get naturally absorbed into the virtual environment

Chronological order of Virtual Reality



Applications of Virtual Reality



Applications of Virtual Reality (contd.)

Key components of headsets:

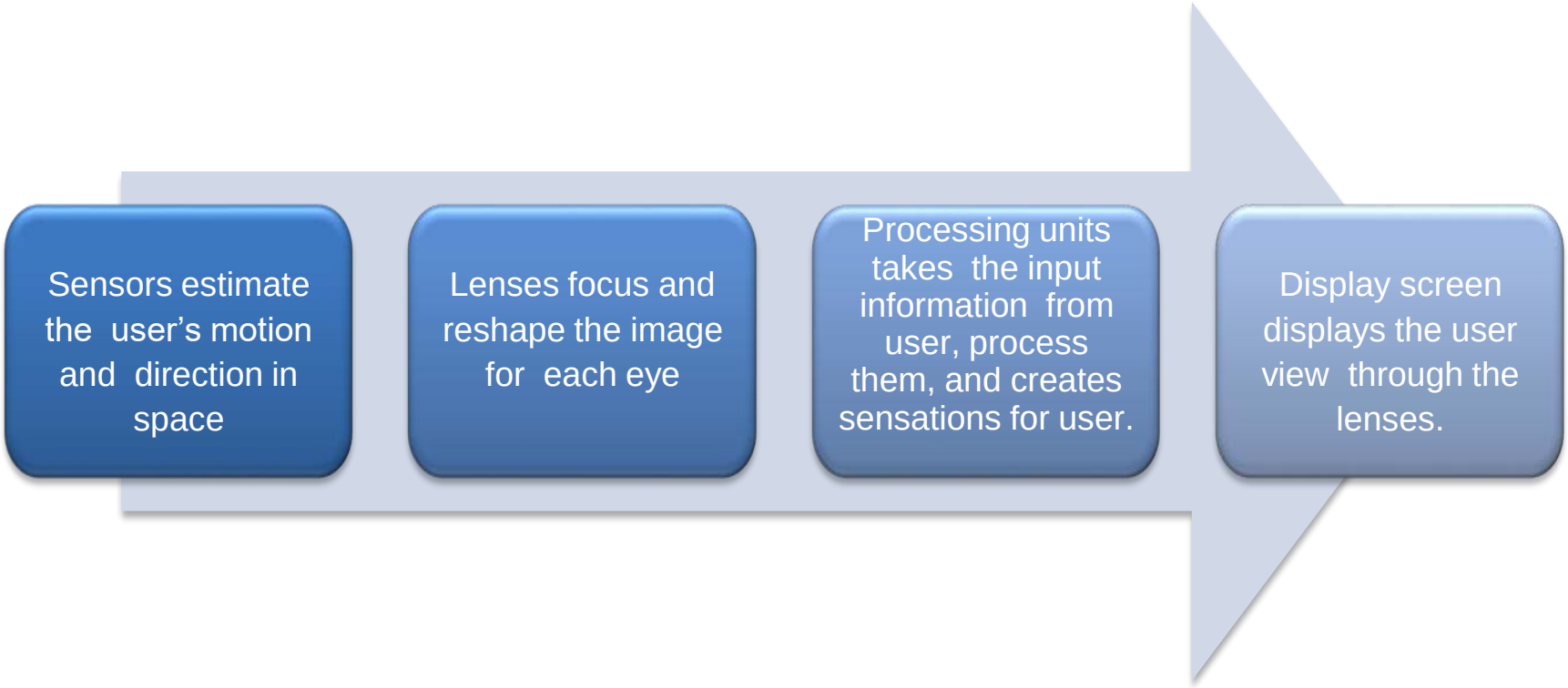
- Sensors – Magnetometer, Accelerometer, and Gyroscope
- Lenses
- Display screens
- Processing unit

Types of Virtual Reality

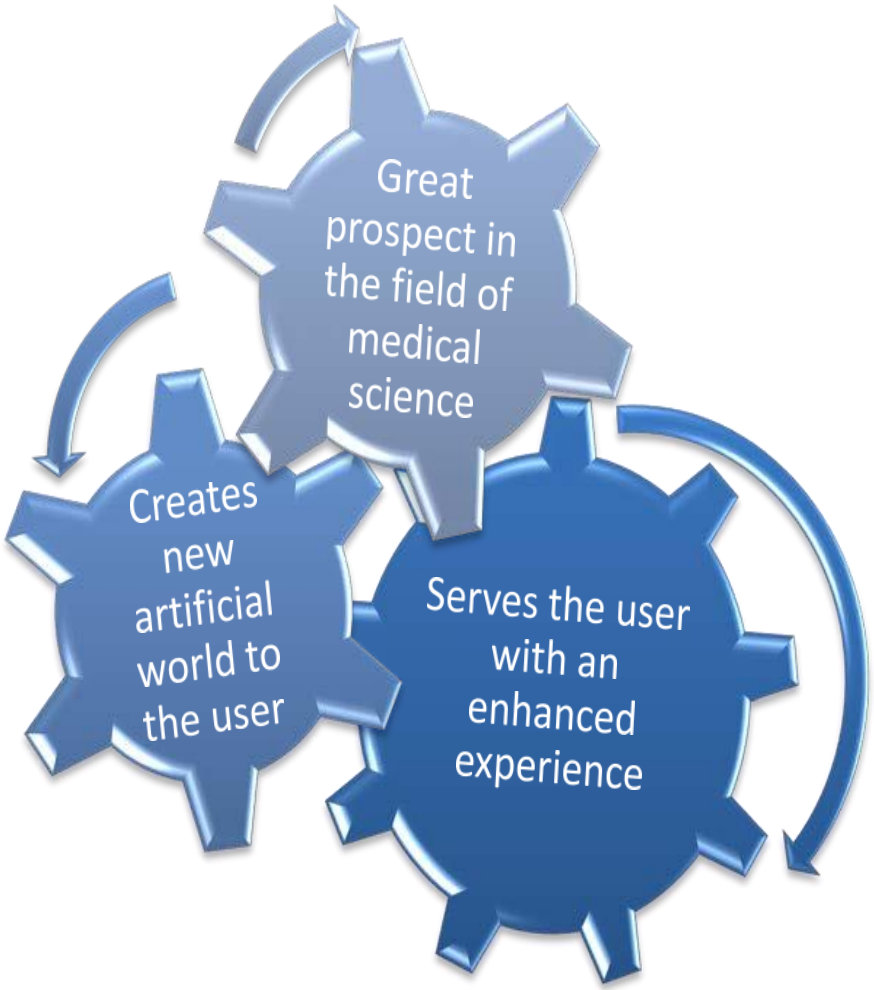
- Non-immersive Simulations
- Semi-immersive Simulations
- Fully-immersive Simulations

- Non-immersive simulations utilizes only a subset of the user's senses.
  - User enters into the virtual environment through a portal or window
  - Users allows a peripheral awareness of the reality outside the virtual reality simulations.
- Semi-immersive simulations provides a partial or fully immersive experience of the user's senses. The simulations are :
  - powered by high performance graphical computing system, and
  - coupled with a large screen projector.
- Fully-immersive simulations provides realistic experience to the users. The simulations
  - delivers a wide field of view, and
  - uses head-mounted displays and motion detecting devices to simulate user's experiences.

How do Virtual Reality works ?



Similarities of AR and VR



Comparison of AR and VR

Augmented Reality	Virtual Reality
• It adds digital elements to the actual environment. • It delivers virtual elements as an encrust of the real world.	• Immersive application, which affects the experience of user. • It offers a digital recreation of a real life setting.

Support System for Industry 4.0