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Industry 4.0: Cyber-Physical Systems and Next-Generation Sensors

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What are Cyber-Physical Systems?

- *"Cyber-Physical Systems or 'smart' systems are co-engineered <u>interacting networks of physical and computational components</u>. These systems will provide the foundation of our critical infrastructure, form the basis of emerging and future <u>smart services</u>, and improve our <u>quality of life</u> in many areas."*

-- NIST, Engineering Laboratory

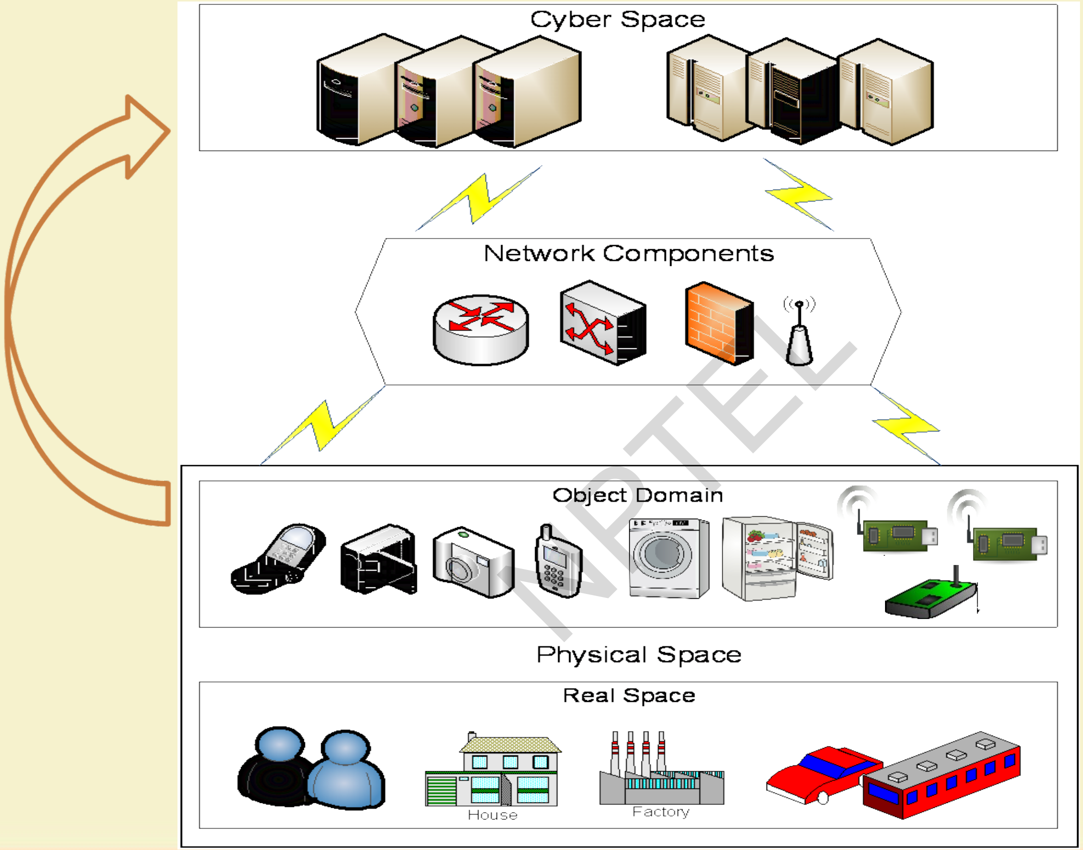
What are Cyber-Physical Systems? (Contd.)

- 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

Source: Lee, IEEE ISORC, 2008

Sensing



Actuation

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

Differences with Embedded Systems

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

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

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

Features of Cyber-Physical Systems (Contd.)

- 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

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

Next-Generation Sensors

Need for Next-Generation Sensors

- Interoperability of networks, transducers and control systems of different manufacturers
- Compatibility of sensors with multiple sensor actuator bus standards, reducing wiring cost and complexity
- Interconnection of analog transducers with digital networks
- Increasing usage of existing networks instead of proposing new standards

Source: Gervais-Ducouret, IEEE SAS, 2011

What are Next-Generation Sensors?

- "Smart Sensors" –
  - Integration of sensors and actuators with a processor and a communication module.
  - Defined in IEEE 1451 Standard as:

    "Sensors with small memory and standardized physical connection to enable the communication with processor and data network"
  - Functionalities - Self calibration, Communication, Computation, Multi-sensing, Cost improvement

Source: Spencer Jr et al., J. STC, 2004

What are Next-Generation Sensors? (Contd.)

- Limitations of Smart Sensors –
  - Pre-defined embedded functions, customization not possible
  - Narrow application spectrum
  - Sensor data aggregation not possible
  - External processor for sensor calibration
  - Basic communication protocols
- To overcome these, next generation sensors–

  "Intelligent Sensors"

Source: Gervais-Ducouret, IEEE SAS, 2011

What are Next-Generation Sensors? (Contd.)

- “Intelligent Sensors” –
  - Capable of processing sensed data and performing pre-defined functions by processing data
  - Capable of customizing embedded algorithms on the fly
  - Capable of managing and controlling external sensors/devices
  - Comprises of a sensor, a microcontroller, a memory unit comprising of flash, RAM and ROM, and a platform for running sensor applications

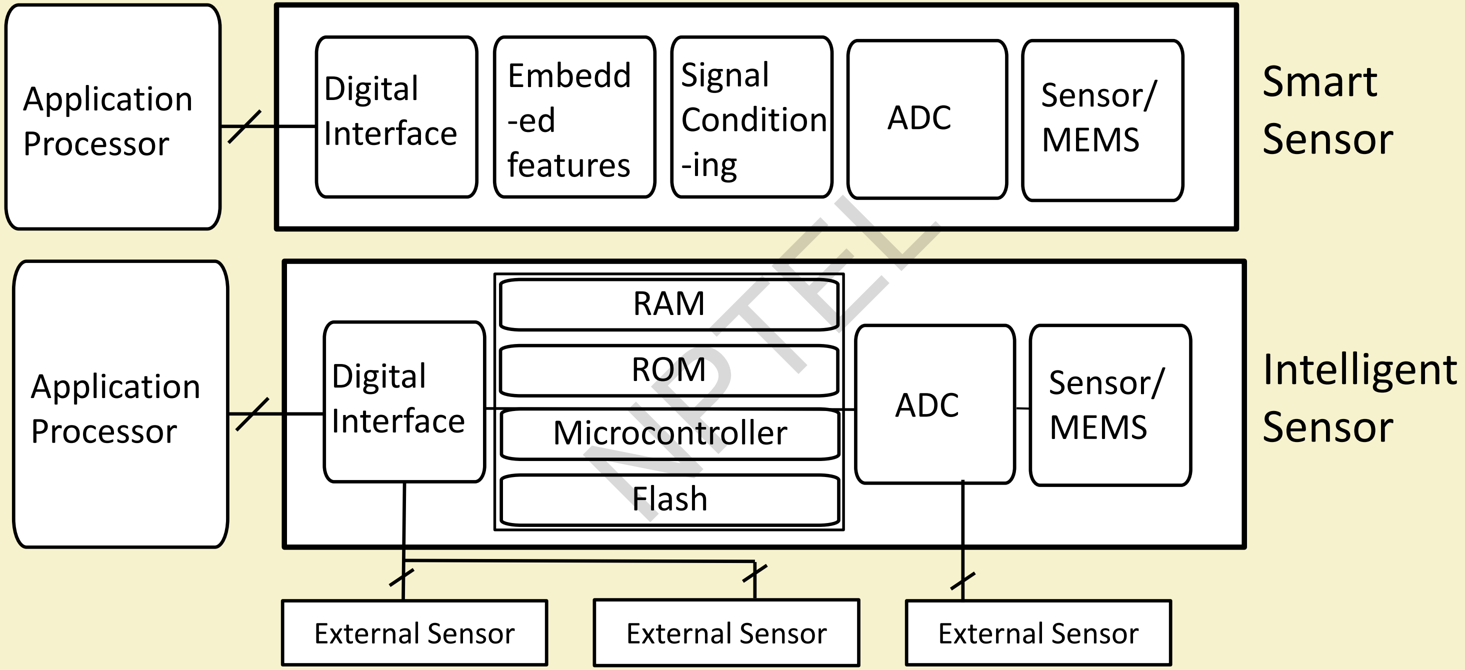
Source: Gervais-Ducouret, IEEE SAS, 2011

What are Next-Generation Sensors? (Contd.)

- Advantages of Intelligent Sensors –
  - Reduce data communication
  - Reduced power consumption
  - Application-specific customization of sensor nodes
  - Continuous calibrating and monitoring of the sensors
  - Adaptive sampling rate and sleep-wake cycles
  - Shorter software development time
  - Improved compatibility of sensors

Source: Gervais-Ducouret, IEEE SAS, 2011

What are Next-Generation Sensors? (Contd.)



Source: Gervais-Ducouret, IEEE SAS, 2011

Next-Generation Sensors: Applications

- Automatic assembly in factories
- Smart fabric and intelligent textiles
- Advanced driving assistance systems
- Fault detection and forecast using machine intelligence
- Non-invasive biomedical analysis
- Chemical composition analysis
- Resource lifecycle management

Source: Gervais-Ducouret, IEEE SAS, 2011

Next Generation Sensors: Design Challenges

- Hardware Issues –
  - Limited power
  - High response time
  - Synchronization
  - Limited bandwidth
  - Security issues
- Software Issues –
  - Software partitioning with applications processor

Source: Gervais-Ducouret, IEEE SAS, 2011

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Industry 4.0:
Collaboration Platform and Product Lifecycle Management

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What is Collaboration platform?

- Category of business software which combines organizational networking capacities to operations.
- It includes <u>knowledge management</u> into business operation to encourage renovation.
- Collaboration platform helps employees to <u>share information</u> and solve business problems.

Source: Techtarget.com: Collaboration-platform

What is Collaboration platform? (Contd.)

- There are some perspectives to build collaboration platforms.
  - A social layer is combined with provision of business utilizations.
  - New products are implanted with collaboration tools.
- There are some common attributes in business collaboration platforms.
  - Easily accessible and easy to use.
  - They require some familiar functions which help team collaboration.
- Example: **ProWork Flow**
  - Web-based project management designed for Managers
  - Collaborate to improve project delivery

Source: Techtarget.com: Collaboration-platform

Collaboration Productivity in Industry 4.0

- Collaboration Productivity
  - There are four key parts, which enable collaboration productivity:
    - IT Proliferation
    - Single Source of Truth
    - Industrialization
    - Coordination

Source: Collaboration Mechanisms to increase Productivity in the Context of Industries 4.0

Collaboration Productivity in Industry 4.0 (Contd.)

- IT Proliferation
  - It shows the huge impact of computers on economic growth and their impact on increased capital stock's shares.
  - Industries are required to consider and promote global information technology and computing power.
  - Storage capacity and high speed computing are increasing day by day.

Source: Collaboration Mechanisms to increase Productivity in the Context of Industries 4.0

Collaboration Productivity in Industry 4.0 (Contd.)

- Single Source of Truth
  - It is a kind of practice of formatting <u>information models to store every data element exactly once</u>.
  - SSoT must employ the right software for decision making.
  - SSoT is needed to be realized across the whole product lifecycle, so that even a single change in product associated information is visible.

Source: Collaboration Mechanisms to increase Productivity in the Context of Industries 4.0

Collaboration Productivity in Industry 4.0 (Contd.)

- Industrialization
  - It is the bridge between the virtual world and the physical environment.
  - Physical environment is linked with the virtual world using CPS, which fix computers and sensors into an application platform.
  - It requires intuitive and self-effective elements.
  - For dynamic objectives in technology and industrial area, it adapts the system behaviour like smart factories.

Source: Collaboration Mechanisms to increase Productivity in the Context of Industries 4.0

Collaboration Productivity in Industry 4.0 (Contd.)

- Coordination
  - Stronger coordination between multiple industry agents is required in Industry 4.0 for enabling collaboration productivity.
  - It can be initiated in two steps:
    - First, establish a network which communicates with overall target.
    - Second, provide authority to decision-makers in a decentralized system.
  - This network is maintained by encouraging the exchange of the employees or by using smart devices.

Source: Collaboration Mechanisms to increase Productivity in the Context of Industries 4.0

Product Lifecycle Management (PLM)

- It is a type of business activity to manage the lifecycle of a product.
- PLM works as a management system for a company's products.
- PLM handles a product completely, from single part of the product to entire portfolio of that product.
- **Example**: Computational Intelligence System (CIS)

Source: Product Lifecycle Management: Stark

Product Lifecycle Management (PLM) (contd.)

- The main goal of PLM is:
  - To maximise product revenues.
  - To decrease product-associated costs.
  - To increase product's value.

Source: Product Lifecycle Management: Stark

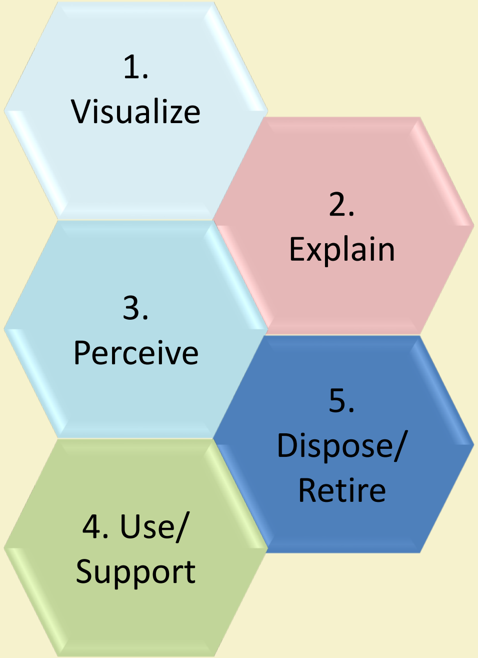
P, L and M in PLM

- The P of PLM
  - P means product in PLM.
  - The product has an essential role in industry.
  - The product is origin of company earnings.
  - There are no services without product.
  - An industry leads in industry sector because of its products.
  - Product has different type of shapes and sizes.

Source: Product Lifecycle Management: Stark

P, L and M in PLM (Contd.)

- The L of PLM
  - L stands for lifecycle.
  - Product lifecycle has five phases.



Source: Product Lifecycle Management, Stark J

The P, L and M in PLM (Contd.)

- **Visualization**: People have an idea regarding the product.
- **Explanation**: This idea is transformed into a representation.
- **Perceiveness**: By the end of the phase, the product is in its final form.
- **Use/Support**: The customer starts to use the product in use/support phase.
- **Retire**: Company retires a product when it is not useful.

Source: Product Lifecycle Management: Stark

P, L and M in PLM (Contd.)

- The M in PLM
  - M means management in PLM.
  - Product management has:
    - Coordination and institution of product-related devices.
    - Fix objectives, capability of decision taking and result control.
  - To ensure that a product works well, it is managed across its lifecycle and management guarantees that the product will earn the profit for the company.

Source: Product Lifecycle Management: Stark

PLM for Industry 4.0

- The efficiency and effectiveness of PLM has an important role in today's enterprise operation systems.
- This efficiency and effectiveness of PLM improves market share and market size with increasing revenue.
- PLM system manages product's portfolio. It also manages the services from the initial concept to the final disposal.

Source: Product Lifecycle Management: Stark

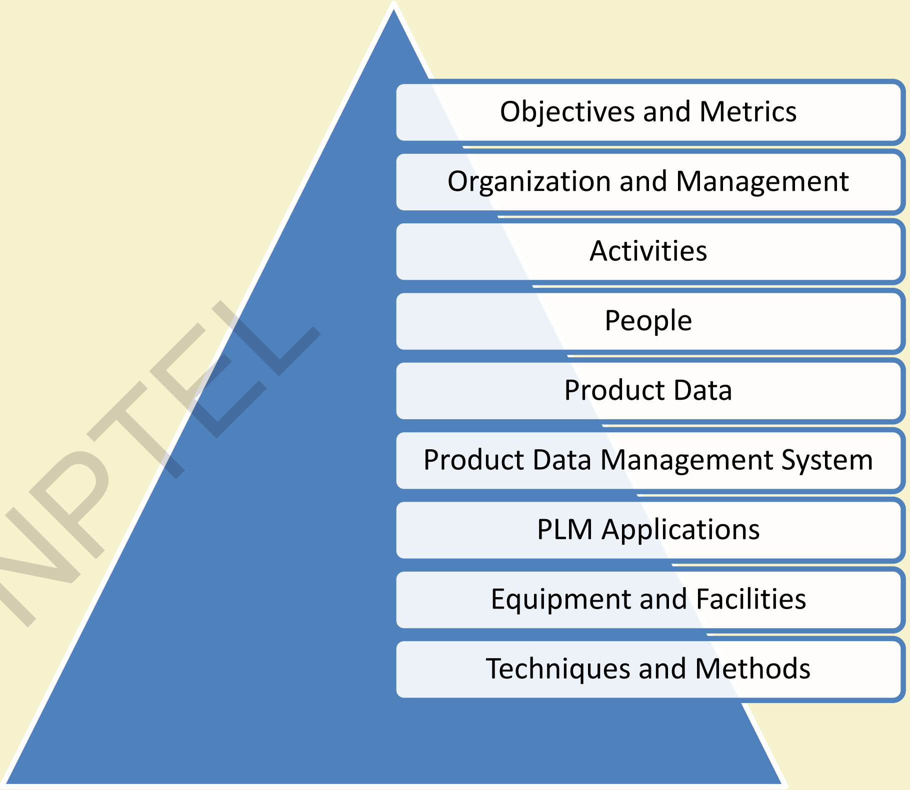
Business Objectives of PLM for Industry 4.0

- Financial Performance
  - Increase market revenue, reduce development cost, etc.
- Time Reduction
  - Reduce project time overrun, decrease profitable time(in less time more profit) , etc.
- Improve Quality
  - Decrease defect rate in manufacturing , increase customer satisfaction rate, etc.
- Business Improvement
  - Decrease the delay time in new product release, ensure 100% configuration conformity, etc.

Source: Product Lifecycle Management: Stark

Scope of PLM

- There are nine components in PLM to handle a product across its lifecycle.



Source: Product Lifecycle Management, Stark J

Scope of PLM (Contd.)

- **Objectives and Metrics**
  - The objective of the company for PLM is to improve quality and business, reduce the time, improve financial performance.
  - Key Performance Indicators (KPIs), which are known as metrics set targets for the company.
- **Organisation and Management**
  - Resource management and company's effectiveness are crucial for PLM.
  - Plans must organize in such a way such that all resources are managed to fulfil the desired objectives.

Source: Product Lifecycle Management: Stark

Scope of PLM (Contd.)

- **Activities**
  - There are many product associated activities such as idea management, program management, new product development.
- **People**
  - Many people are involved to progress and maintain a product. E.g.- Business analyst, cost accountant etc.
- **Product Data**
  - It is a major asset throughout the product lifecycle.
  - Product will face problem, if we provide false product data.

Source: Product Lifecycle Management: Stark

Scope of PLM (Contd.)

- **Product Data Management System**
  - It manages all the generated product data and it is used for product lifecycle.
  - It provides correct information at the right time.
- **PLM Applications**
  - To get desired performance levels, these applications are responsible for enabling the people to take decisions.
  - These applications support the people to build and maintain the products.

Source: Product Lifecycle Management: Stark

Scope of PLM (Contd.)

- **Equipment and Facilities**
  - Product lifecycle <u>use equipment and facilities in every phase</u>.
  - They are required to produce, maintain and service the product.
  - Cost and quality of the product are effected by them.
- **Techniques and Methods**
  - To refine production across the lifecycle by means of product progress time, product cost etc. many methods and techniques are proposed:
    - ABC (Activity Based Costing)
    - Concurrent Engineering
    - DFS (Design For Sustainability)
    - LCA (Life Cycle Assessment)

Source: Product Lifecycle Management: Stark

Challenges in PLM for Industry 4.0

- **Business Drivers**
  - There are new business challenges for PLM in Industry 4.0.
  - Challenges
    - Product lifecycle is short.
    - Outsourcing is increasing.
    - Products' structure is complex.
  - Increase in speed, increase in demand and quality of product are the other challenges to drive a business.

Source: Product Lifecycle Management: Stark

Challenges in PLM for Industry 4.0 (Contd.)

- **Industrial Requirement**
  - To design products virtually, geographically dispersed design teams and supply chain partners are required to collaborate.
  - A new perspective must be generated to hold net-centric technology. This perspective will be able to free the inherent value in today's enlarged business model.
  - Perform project management, exchange and maintain product information is a challenge in industry.

Source: Product Lifecycle Management: Stark

The Ten Step Approach: PLM solution in Industry4.0

- It is based on working experience of companies in Industry sector.
- This approach has ten steps.

Data Gathering	Education of PLM	Practice of management in PLM	PLM Concept Generation	PLM Roadmap Generation
Development Strategy	Rate of Interest Calculation	Management Report Preparation	Executive Presentation	Executive Decision Support

Source: Product Lifecycle Management: Stark

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Industry 4.0:
Augmented Reality and Virtual Reality

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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.

"Manufacturing", Reality technologies

Augmented Reality and Virtual Reality in IIoT (contd.)

- Use cases:
  - Machining and production
  - Education and collaboration
  - Assembly
  - Safety and security
  - Digital prototyping
  - Factory planning
  - Maintenance and inspection

"Virtual-reality-vr-augmented-reality-ar-trends", I-scoop

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.

“Augmented Reality”, Reality technologies
“ Augmented Reality”, Techtarget

Key Features of AR

- The key features of AR are:
  - 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.

“Augmented Reality”, Reality technologies
“ Augmented Reality”, Techtarget

Chronological order of Augmented Reality

Idea of Electronic display/ spectacles

L. Frank Baum (author, 1901)

Published heads up display for teaching real-world flight skills

Gavan Lintern

(University of Illinois, 1980)

Coined the term Augmented Reality

Thamos Caudell

(Boeing Researcher, 1990)

First functioning AR system

Louis Rosenberg (1992)

Battlefield Augmented Reality System (BARS)

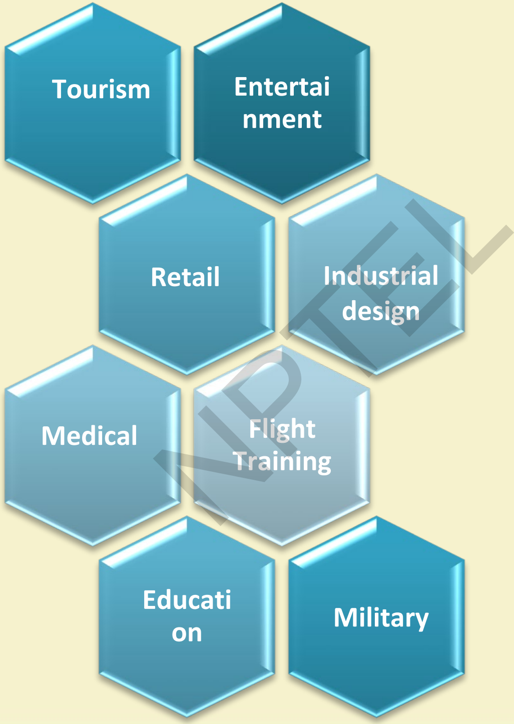
US Naval research laboratory (1999)

Google glass

Google (2013)

“Augmented Reality”, Wikipedia

Applications of Augmented Reality



“Augmented Reality”, Wikipedia

Applications of Augmented Reality (contd.)

AR Eyeglasses

Head-up display

Medical Applications

Key components of devices:

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

"Ar glasses", Uploadvr
"Medical Research", Pehub

Types of Augmented Reality

- Marker-Based Augmented Reality
- Markerless Augmented Reality
- Projection Based Augmented Reality
- Superimposition Based Augmented Reality

“Augmented Reality”, Reality technologies

Types of Augmented Reality (contd.)

- 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.

"Augmented Reality", Reality technologies

Types of Augmented Reality (contd.)

- 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.

"Augmented Reality", Reality Technologies

Types of Augmented Reality (contd.)

- 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.

"Augmented Reality", Reality technologies

How do Augmented Reality works ?

- Sensors gather real world interaction, communicate them
- Camera scan to collect data from surrounding
- Projector projects into an interactive environment
- Processing devices processes to provide users' the experience
- Mirrors assist the reflection according to user's eye

"Augmented Reality", Reality technologies

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.

“Augmented Reality”, Reality technologies

Key Features of VR

- 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.

"Augmented Reality", Reality technologies

Chronological order of Virtual Reality

Experience Theatre
Morton Heilig (film-maker, 1962)

Sword of Damocles
Ivan Sutherland (MIT Computer Scientist, 1968 God father of VR displays)

Coined the term Virtual Reality
Jaron Lanier (American Philosopher and Scientist, 1987)

Produced navigable virtual worlds
David EM (First artist, 1977 - 1984)

Large Expanse, Extra Perspective (LEEP) optical system
Eric Howlett (1979)

Google's first-ever "resident artist"
Michael Naimark (2015)

"Virtual Reality", Wikipedia

Applications of Virtual Reality

- Real estate agents
- Entertai nment
- Robotics
- Astronauts
- Health and Safety
- 3-D artists
- Educati on
- Mass surveillance

"Virtual Reality", Wikipedia

Applications of Virtual Reality (contd.)

Key components of headsets:

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

"Glasses", Uploadvr
"Sony-hmz", Polygon

Types of Virtual Reality

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

"Virtual Reality", Reality Technologies

Types of Virtual Reality (contd.)

- 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.

"Augmented Reality", Reality Technologies

Types of Virtual Reality (contd.)

- 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.

"Virtual Reality", Wikipedia

Types of Virtual Reality (contd.)

- 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.

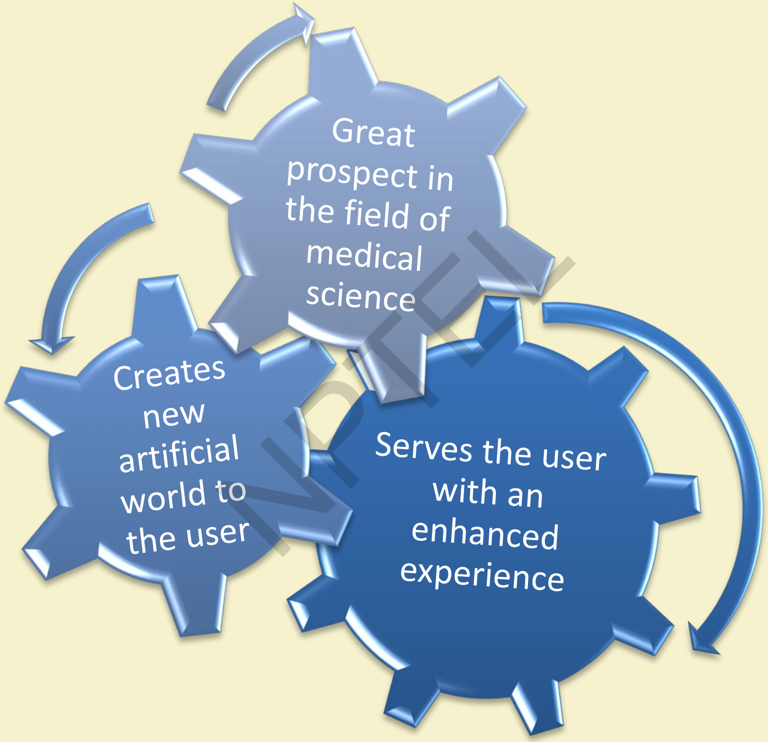
"Virtual Reality", Reality Technologies

How do Virtual Reality works ?

1. Sensors estimate the user's motion and direction in space
2. Lenses focus and reshape the image for each eye
3. Processing units takes the input information from user, process them, and creates sensations for user.
4. Display screen displays the user view through the lenses.

"Virtual Reality", Reality Technologies

Similarities of AR and VR



"Virtual Reality", Reality Technologies

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.

"Virtual Reality", Reality Technologies

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Thank You!!

Industry 4.0:
Artificial Intelligence

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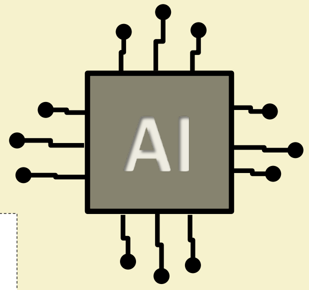
What is Artificial Intelligence (AI)?



"AI is a branch of computer science that deals with the study and the creation of computer systems that exhibit some form of intelligence."

- Patterson

"AI is the study of mental faculties through the use of computational models."

- Eugene Charniak and Drew McDermott

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

What is Artificial Intelligence (AI)? (Contd..)

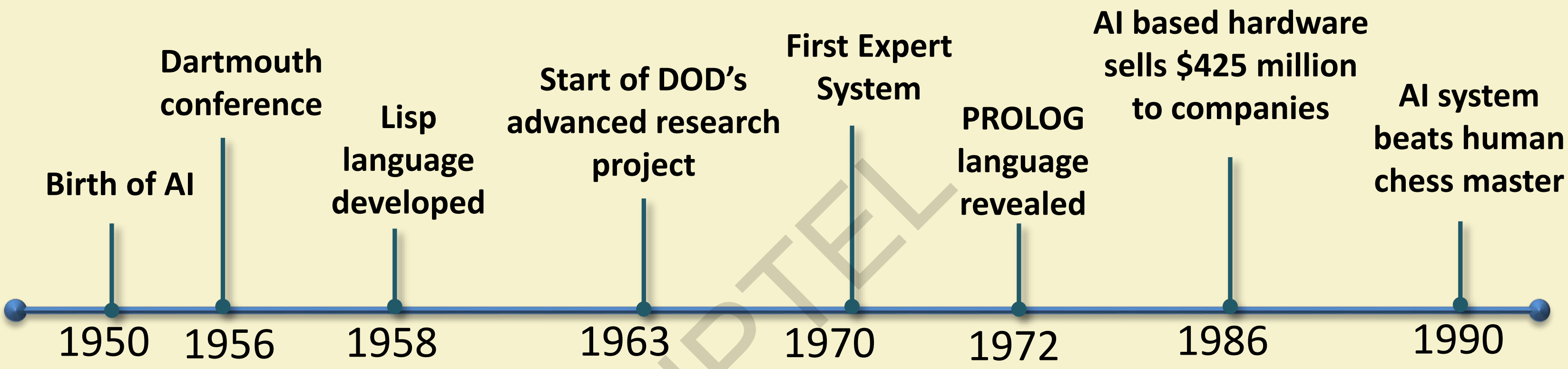
Artificial + Intelligence = Artificial Intelligence

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

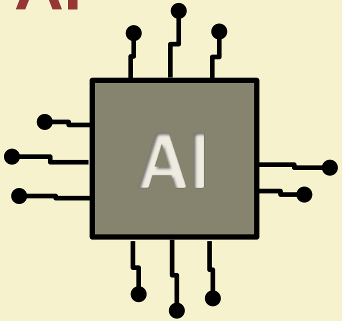
History of AI



The first use of phrase Artificial Intelligence was proposed by **John McCarthy** in 1956 in the article *A Proposal for Dartmouth Summer Research Project on Artificial Intelligence*

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

Difference between program with and without AI

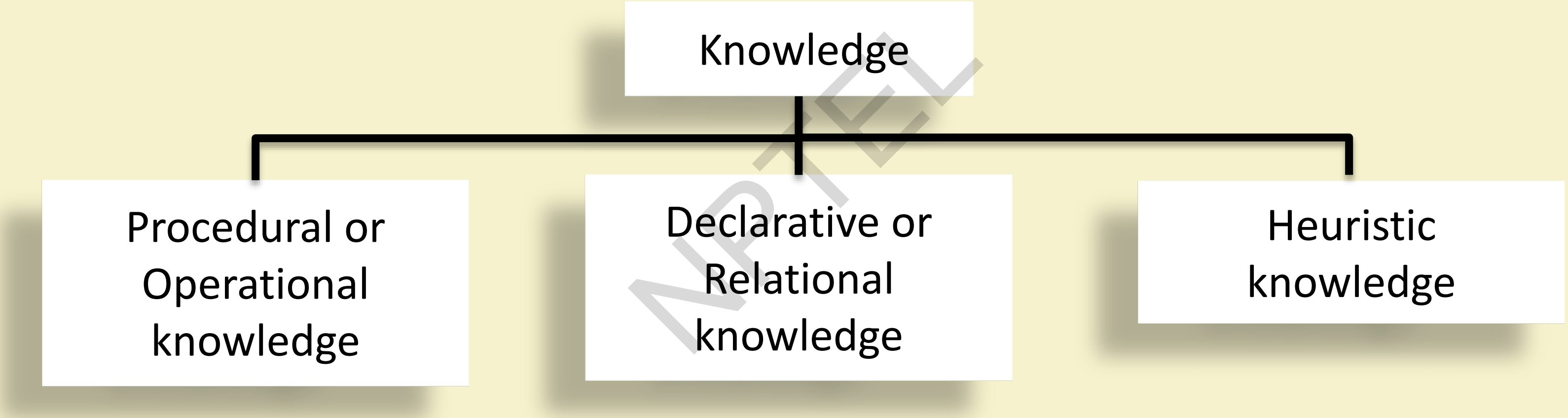


A computer program without AI uses large database and uses algorithmic search method whereas computer program with AI uses large knowledge base and heuristic search method

Source: Artificial Intelligence by Rajiv Chopra

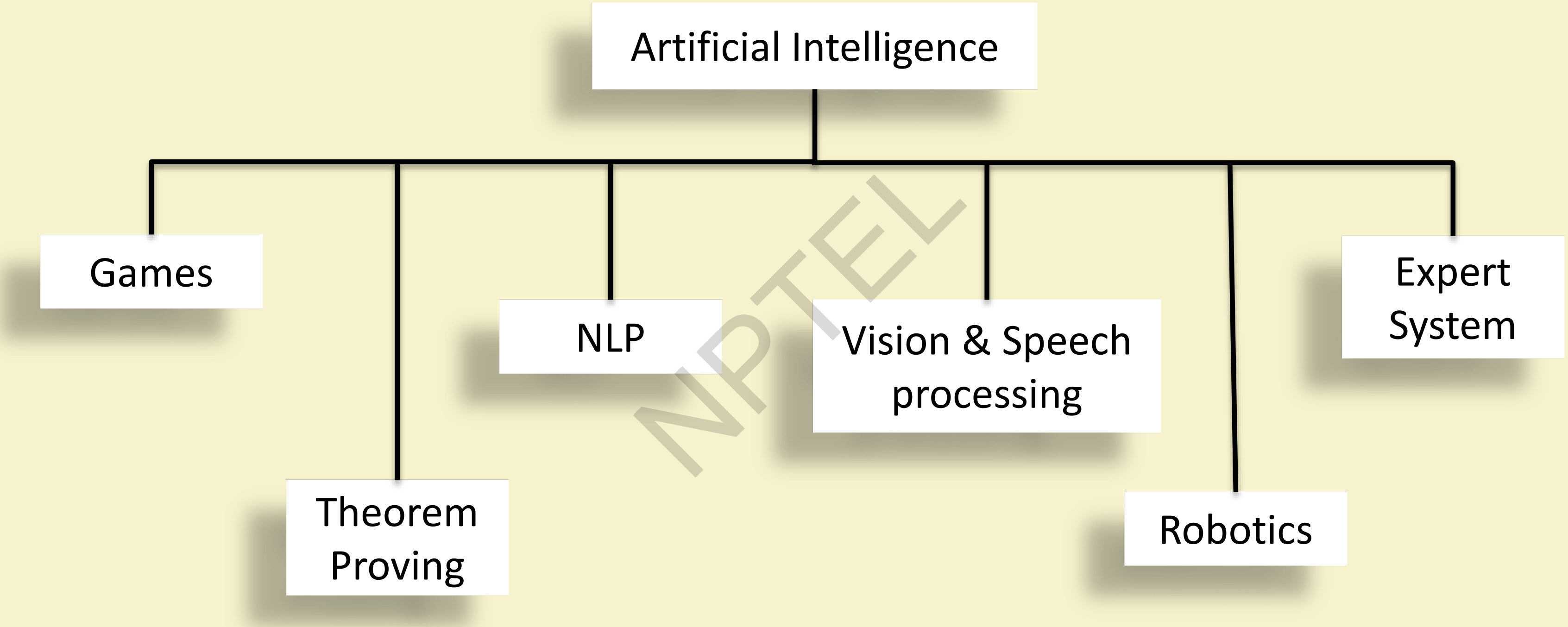
AI Techniques

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



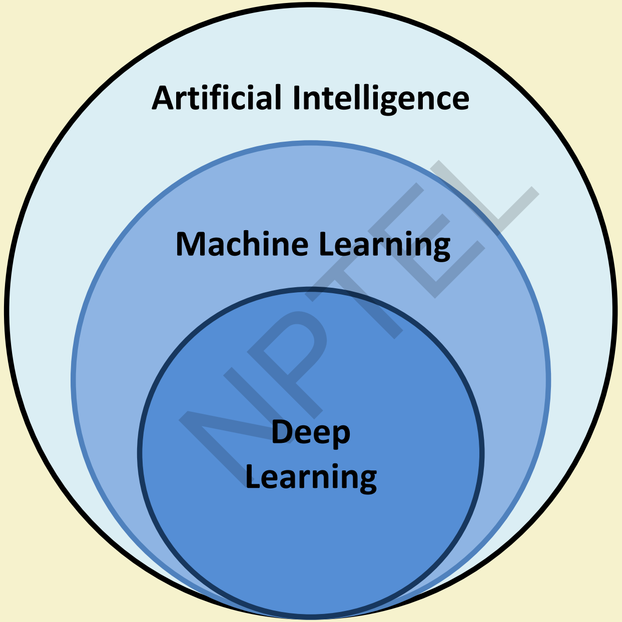
Source: Artificial Intelligence by David L. Poole, Alan K. Macworth, Artificial Intelligence by Rajiv Chopra

Scopes of AI



Source: Artificial Intelligence by Rajiv Chopra

AI vs Machine learning vs Deep learning



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

Machine learning

Machine learning is a part of Artificial Intelligence which empower machines to make decisions based on their <u>experience</u> rather than being explicitly programmed.

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

Deep learning

Deep learning is a subset of machine learning which can learn automatically by finding the features of the object by own.

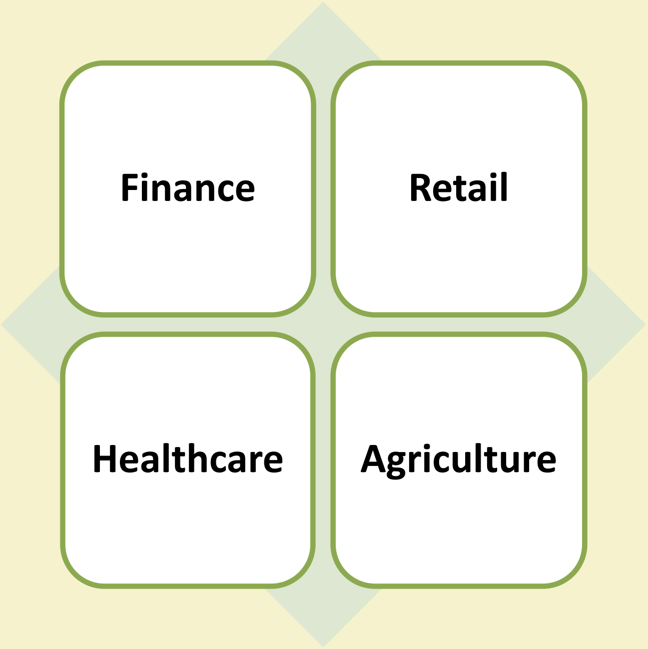
Source: Artificial Intelligence by David L. Poole, Alan K. Macworth, Artificial Intelligence by Rajiv Chopra

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.

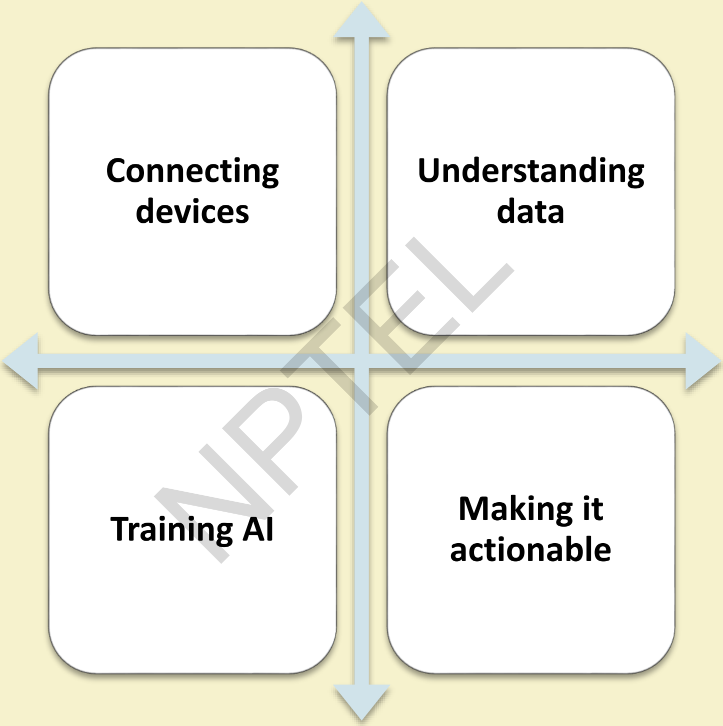
AI in IIoT

- Use of AI helps machines and equipment to communicate and relay information with one another
  - Examples: Computer Vision, Robotics, NLP, ML, DL, RL, 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

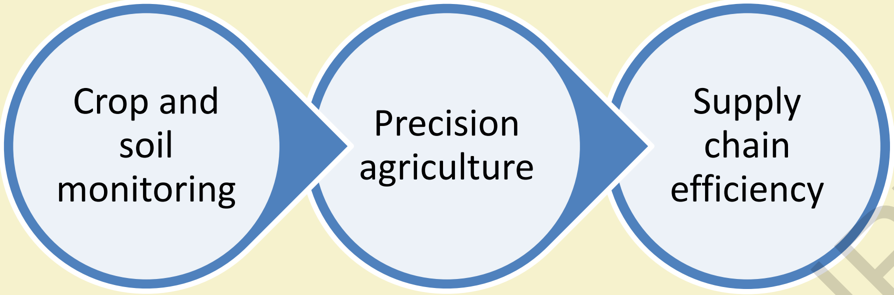
Advantages of AI in IIoT

The usefulness of AI in industrial scale are,

- Increase efficiency
- Save costs
- Improve security
- Augment performance
- Boost resources

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

Improve student retention rate → Making interesting study program → Providing immersive technology into classroom

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

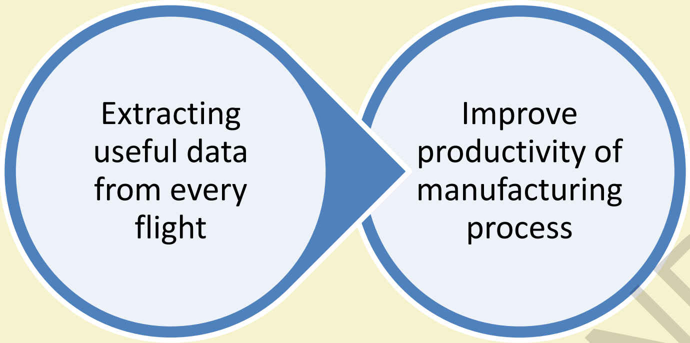
Source: AI in Education: 3 Industry Defining Trends in 2018

Significance of AI in Manufacturing factories

- Improve in machines power consumption
- Detection of machinery fault
- Maintain product supply by predicting consumer demand

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

Significance of AI in Aerospace industry

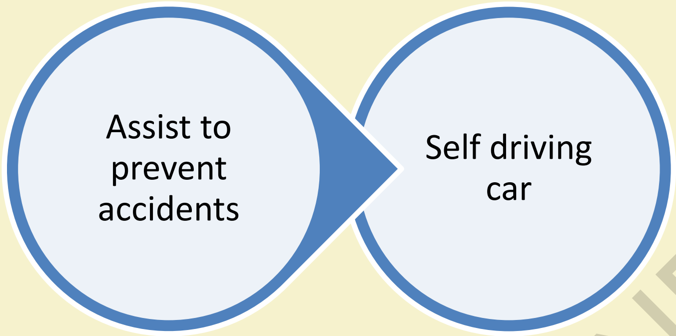


- **Boeing 787** generates large amount of data at each flight where AI is used to extract useful information

- **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

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Thank You

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Industry 4.0: Big Data and Advanced Analysis

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What is Big Data?

- Big data means
  - data which is "too big" to be handled by
    - processing tools, and
    - conventional databases.
- Big data consists of
  - structured and
  - non-structured data

such as web blogs, FB chats, images, news, tweets, comments, etc.

Source: cs.kent.edu: Big data

Big Data: Definition

- *"Big data will represent the data of which acquisition speed, data volume or data characterization restricts the capacity of using conventional associated methods to manage successful analysis or the data which can be successfully operated with important horizontal zoom technologies."*

  [NIST(National Institute of Standards and Technology)]

Source: cs.kent.edu: Big data

Data Types

- Structured data
  - Data that can be easily organized.
  - It is stored in relational databases.
  - It is managed by Structured Query Language (SQL) in databases.
  - It accounts for only 20% of the total available data today in the world.

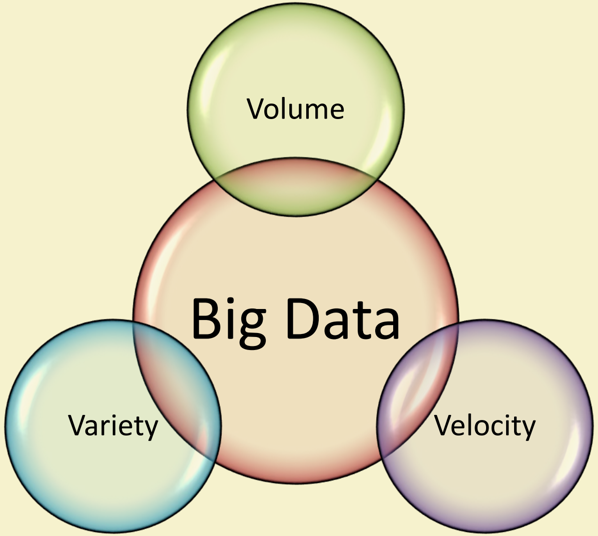
Source: Big data analytics : Srinivasa

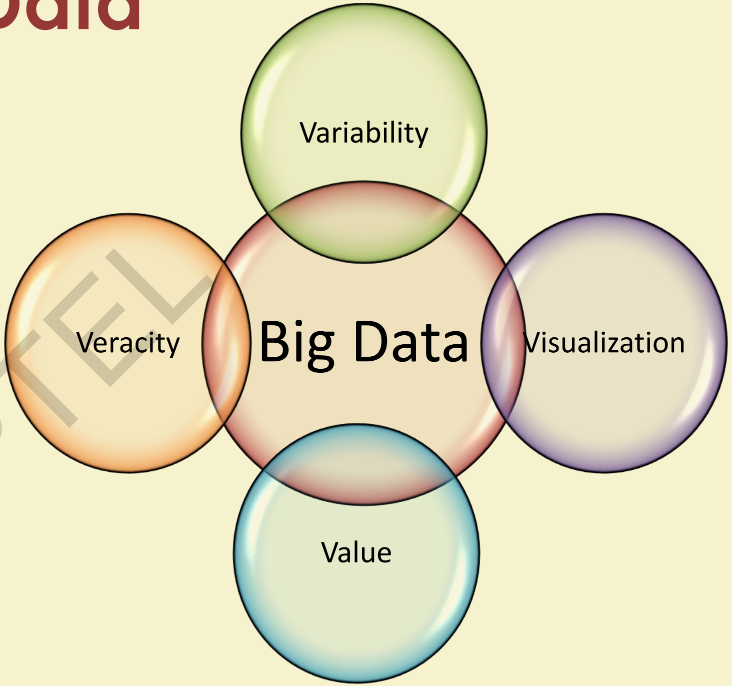
Data Types(Contd.)

- Unstructured data
  - Data that do not possess any pre-defined model.
  - Traditional RDBMSs are unable to process unstructured data.
  - Enhances the ability to provide better insight to huge datasets.
  - It accounts for 80% of the total data available today in the world.

Source: Big data analytics : Srinivasa

Characteristics of Big Data





- There are mainly 3 Vs in Big Data
- Some authors also include another 4 Vs

Source: Big data analytics : Srinivasa

Characteristics of Big Data (Contd.)

- Volume
  - Quantity of created data.
  - Sources of data are added continuously.
  - Example of *volume* -
    - More than 32TB of pictures will be created each night from the Large Synoptic Survey Telescope (LSST).
    - In every minute, 70 hours of video is uploaded to Youtube.

Source: Big data analytics : Srinivasa

Characteristics of Big Data (Contd.)

- Velocity
  - Speed of generation of data.
  - Data processing time is decreasing day by day to provide real-time services.
  - Older processing technologies can not help to handle high velocity of data.
  - Example of *velocity* –
    - 140 million tweets per day on average (according to a survey conducted in 2011)
    - NYSE(New York Stock Exchange) measures 1TB of exchange data during every exchanging session.

Source: Big data analytics : Srinivasa

Characteristics of Big Data (Contd.)

- Variety
  - Category of the data.
  - No restriction over the input data formats.
  - Mostly data are not structured.
  - Example of *variety* –
    - Pure text, images, audio, video, web, GPS data, sensor data, SMS, documents, PDFs, flash etc.

Source: Big data analytics : Srinivasa

Characteristics of Big Data (Contd.)

- Variability
  - Variability is different from variety.
  - Data whose meaning is constantly changing.
  - Such data appear as an indecipherable mass without structure.
  - Example:
    - Language processing, Hashtags, Geo-spatial data, Multimedia, Sensor events.

Source: Big data analytics : Srinivasa

Characteristics of Big Data (Contd.)

- Veracity
  - Veracity indicates biasness in the data, unusualness and noise in data.
  - It is important in programs which involve automated decision-making.
  - It is also important for feeding the data into an unsupervised machine learning algorithm.
- Veracity deals about the data understandability, not just the data quality.

Source: Big data analytics : Srinivasa

Characteristics of Big Data (Contd.)

- Visualization
  - Data can be in form of pictures or in form of a graphical format.
  - Visualization provides the power to decision makers to see visually.
  - It is helpful to identify new patterns.
- Value
  - It means extracting useful business information from scattered data.
  - Simple to access and provides quality investigation that empowers informed decisions.

Source: Big data analytics : Srinivasa

Data Sources

Enterprise data
- Online trading & data analysis
- Production and inventory data
- Sales and other financial data

IoT data
- Industrial data
- Healthcare data
- Agricultural data

Source: The Making of ENCODE: Lessons for Big-Data Projects : Birney

Data Sources

Biomedical data

- Data generated from gene sequencing
- Data from medical clinics

Others

- Computational biology
- Astronomy
- Nuclear research

Source: The Making of ENCODE: Lessons for Big-Data Projects : Birney

Data Acquisition

- Data collection
  - Data sources automatically generate log files or record files to record activities for further analysis.
  - Complex and variety of data collection through mobile devices. E.g. – geographical location, 2D barcodes, pictures, videos etc.
- Data transmission
  - Categorized as – Inter-DCN transmission and Intra-DCN transmission.
  - Collect data and transfer to storage system for further processing and analysis of the data.

Source: The Making of ENCODE: Lessons for Big-Data Projects : Birney

Data Acquisition (Contd.)

- Data pre-processing
  - Pre-processing of data is necessary as collected datasets suffer from noise, redundancy etc.
  - Pre-processing of relational data mainly follows-

1. Integration
2. Clearing
3. Redundancy Mitigation

Source: The Making of ENCODE: Lessons for Big-Data Projects : Birney

Data Acquisition (Contd.)

- Integration:
  - combine data from various sources and
  - delivers the users a constant data view.
- Clearing:
  - spot incorrect, insufficient, or uncooperative data, and
  - correct or remove such data.
- Redundancy mitigation:
  - eliminate data repetition through detection, filter and compression of data to avoid unnecessary transmission.

Source: The Making of ENCODE: Lessons for Big-Data Projects : Birney

Data Storage

- File system
  - Distributed file systems that store massive data and ensure – consistency, accessibility, and fault tolerance of data.
    - GFS is a distributed file system that supports large-scale file system.
    - HDFS(Hadoop Distributed File System) is a notable file systems, derived from the open source codes of GFS.
- Databases
  - Emergence of non-traditional relational databases (NoSQL) in order to deal with the characteristics that big data possess.

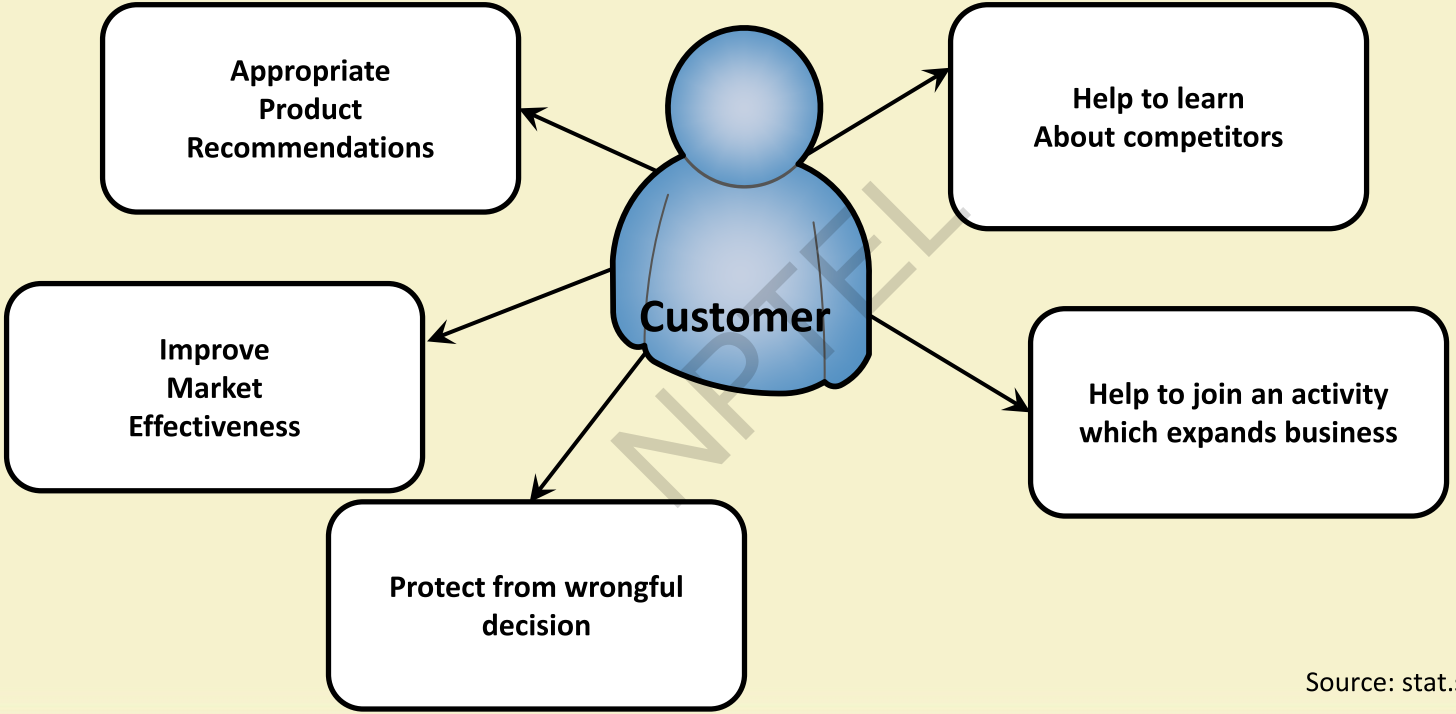
Source: The Making of ENCODE: Lessons for Big-Data Projects : Birney

Why Data Analytics?

Sensors are very small in sizes. They can be placed anywhere and transfer the data over wireless technology, because of this explosion of data moving to systems from sensors. Some data are irrelevant for systems. How can one know which data are relevant, this requires analysis of the data.

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

Why Data Analytics?(Contd.)



Source: stat.si: Big data tutorial

Big Data Analytics

- Big data is different from conventional Data Warehouse (DW) approaches.
- Big data apps cannot be fit in traditional DW architectures (e.g. Exadata, Teradata).
- Distributed nothing, mighty parallel performing, scale out frameworks are convenient for big data apps.

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

Big Data Analytics for Industry 4.0

- Industrial Internet require an approach to manage and process data coming from thousand of sensors for precious perceptions .
- To manage and handle the huge data in health services and manufacturing etc. is not new. For example-
  - An event is detected by a sensor and sent to the operational recorder. An operational recorder is a database which stores data. After that this data is optimized by querying such as, what about this hour's production from the norm.

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

Big Data Analytics for Industry 4.0 (Contd.)

- IIoT can be recognized as a big benefactor of Big Data.
- It needs new technologies to manage vast data.
- Cloud services are accessible to handle Big Data with no-limit of storage on demand.
- In IIoT, Hadoop (open source cloud based distributed data storage) is also available for managing the data.

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

Cloud-Based Method for Analytics

- Essential features (according to NIST)
  - On-demand self service
  - Wide network access
  - Method grouping
  - Fast flexibility
  - Measured service

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

Types of Analytics

Prescriptive Analytics

-> Best action?

-> Should we try this?

Predictive Analytics

->What next?

->Pattern?

Descriptive Analytics

->When, where?

->What happened?

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

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Thank You!!