Automation & Robotics -20EC53I

Week-1

Introduction to Industrial Automation and robotics

Introduction to Automation

Automation or automatic control is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching in telephone networks, steering and stabilization of ships, aircraft and other applications with minimal or reduced human intervention. Some processes have been completely automated.

Definition: Industrial automation or automation is basically the delegation (ನಿಯೋಗ) of human control function to technical equipments for

1. Increasing productivity
2. Increasing quality
3. Reducing cost
4. Increasing safety in working condition

Automation has been achieved by various means including mechanical, hydraulic ( ), pneumatic ( ), electrical, and electronic and computers, usually in combination. Complicated systems, such as modern factories, airplanes and ships typically use all these combined techniques.

Role &benefits of Automation in Industry

Role (Need) for automation:

Companies undertake projects in manufacturing automation and computer-integrated manufacturing for a variety of good reasons. Some of the reasons used to justify automation are the following:

1. **To increase labor productivity:** Automating a manufacturing operation usually increases production rate and labor productivity. This means greater output per hour of labor input.

2. **To reduce labor cost:** Ever-increasing labor cost is the major issue industrialized societies. Consequently, higher investment in automation has become economically justifiable to replace manual (labor) operations. Machines are increasingly being substituted for human labor to reduce unit product cost.

3. **To reduce the effects of labor shortages:** There is a general shortage of labor in many manufacturing industries, this leads to the development of automated operations as a replacement for labor.

4. **To reduce or eliminate routine manual and clerical tasks:** Automating the routine, boring, fatiguing ( ), and possibly tedious( ) tasks serves a purpose of improving the general level of working conditions.

5. **To improve worker safety:** By automating a given operation and transferring the worker from active participation in the process to a supervisory role, the work is made safer. The safety and physical wellbeing (ದೈಹಿಕ ಯೋಗಕ್ಷೇಮ) of the worker has become a national objective of the Occupational Safety and Health Act (OSHA) in 1970.

6. **To improve product quality:** Automation not only results in higher production rates than manual operations; it also performs the manufacturing process with greater uniformity ( ) and

conformity ( ) to quality specifications.

7. To reduce manufacturing lead time: Automation helps to reduce the elapsed time between customer order and product delivery, providing a competitive advantage to the manufacturer for future orders.

8. To accomplish processes that cannot be done manually: Certain operations cannot be accomplished without the aid of a machine. These processes have requirements for precision, miniaturization, or complexity of geometry that cannot be achieved manually. Examples include certain integrated circuit fabrication operations, rapid prototyping (ಮೂಲಮಾದರಿ) processes based on computer graphics (CAD) models, and the machining of complex, mathematically defined surfaces using computer numerical control. These processes can only be realized by computer-controlled systems.

Importance of industrial automation in the Indian manufacturing industry (Advantages of Automation):

1. High productivity: Automation enables a continuous mass production and speeds up all the processes, reduce assembly times and improve productivity.

2. Reduced costs: The introduction of technological innovations, such as robotics, smart machinery, and AI systems, helped to increasingly reduce production costs. This enhances the value of business assets and makes companies more profitable.

3. Better quality and consistency: Another valuable advantage of implementing automation solutions is the elimination of human error and much greater consistency, leading to better quality of the products.

4. Greater safety: Considerably improved work safety and employee protection is another valuable advantage of wide implementation of industrial automation solutions. The minimization of human errors leads to reduction of accidents and injuries, while deploying robots and machines to handle tasks in dangerous and hazardous conditions allows employees to avoid risks and prevent long-term health effects of working in industrial environments.

5. Improved flexibility: Automation solutions are also designed to make the industrial processes and machinery a lot more flexible. The ability to reprogram robots and devices allows organizations to adapt robustly to the fast-changing market demands.

6. Increased added value and human capacity: Designed to liberate employees from having to perform repetitive and mundane work, automation solutions are adding value by allowing humans to concentrate on more complex creative tasks. This is why combining powerful industrial automation solutions with expert human labour also leads to a great
Increase in human capacity.

7. New level of data support and production traceability: Automated data collection is another crucial component of automation, and Industry 4.0 solutions in particular. Innovative systems able to collect and analyse various kinds of data in real time provide a whole new level of possibilities. They allow companies to improve traceability, reduce waste and continuously optimize all work processes.

8. Real-time monitoring and predictive maintenance: As a final advantage that we would like to highlight, one of the key functions of industrial automation systems is to enable continuous monitoring of all the processes in real-time mode. Thanks to a variety of highly sensitive sensors in modern-day industrial machinery, issues and errors in production processes can be easily detected and addressed. This results in lower maintenance costs and longer life cycles of the equipment, as well as minimization of incidental malfunctions.

Challenges faced by the manufacturing industry in manual process:

Demand Forecasting (**ಬೇಡಿಕೆ ಮುನ್ಸೂಚನೆ**): Many factories are still having trouble anticipating (ನಿರೀಕ್ಷಿಸಲಾಗುತ್ತಿದೆ) future demand today. The biggest issue is that they lack effective monitoring systems that would allow them to forecast how many goods they should sell in the coming months or years. As a result,

their products fall short of client expectations and reduce sales.

Inventory (**ದಾಸ್ತಾನು**) **Management :** Inventory management remains one of the most critical challenges faced by the manufacturing industry, but it has become much easier with the help of automated solutions. Many manufacturers, tiny ones, continue to handle their inventories manually. The use of software can cut down time-consuming tasks such as Inventory management. Manual stock checks are inefficient and prone to errors, resulting in mistakes, shortages, excess, and unidentified losses. Organizations are under a lot of pressure to deliver consistently (ಸತತವಾಗಿ) high-quality goods that meet the needs of their customers. However, if a manufacturer has trouble keeping track of inventory, it could result in shortages and various

3. Improving Manufacturing Plant Efficiency (**ದಕ್ಷತೆ**): Many of them prefer to cut production costs by reducing product quality, but this will only decrease their profitability since dissatisfied customers will stop buying. It's all about revolutions in manufacturing. Every step in the process, every input and output, changes from raw materials to the completed product and progresses.

4. Wastage of material: Waste is an unavoidable element of any process manufacturing production cycle, frequently due to poor planning or formula changes. To avoid financial losses, prevent high overhead, and improve overall efficiency, a process manufacturer's primary value is to limit the amount of material wasted.

5. Keeping Track of Sales Lead: Another problem that companies commonly experience is managing and evaluating sales leads. Each sales lead is unique in terms of persona (□ಯ ಕ್ತಿತ್ವ), preferences (ಆದ್ಯತೆಗಳು) and requirements (ಅ□ವಯ ಕತೆಗಳು), they must be treated specifically. Manufacturers also often find it challenging

to identify potential leads (ಸಂಭಾ□ಯ ದಾರಿಗಳು), so they often focus on unpromising opportunities and forget to follow up with high potential leads.

6. Shortage of Skilled Labor: Although automation and robotics can help close the labour gap, humans will still be required to assess and solve problems and manage out. Moreover, the industry is suffering from a

7. Adapting to Technological Changes: Due to the systems and technology that currently support the business and how organizations sell their products or give services to their consumers, innovating and implementing developing technology is practically required for any company. The actual factors that blocker emerging tech adoption within companies are

- The company's culture and its workers' resistance
- The leadership team's lack of support
- A lack of clarity or a project that is incredibly complex
- A lack of governance and transparency in the reporting of results
- There is a lack of cooperation between teams.
- Forcing adoption or insufficient adoption speed
- The discrepancy (□ಯತ್ಯಾಸ) between –acquiring technology‖ and –adoption of technology.‖

8. Environmental Consciousness: Consumers today are more ecologically concerned than ever before, and they want the same degree of commitment from the brands they buy from. Process manufacturers, particularly those who work with chemicals, must be aware of the environmental impact of their materials and actively seek out ways to reduce emissions and produce green goods.

What is Industry 4.0?

- The transition from history to present brings us to the concept of the Fourth Industrial Revolution or Industry 4.0, which is actually linked to industrial automation.
- The concept of Industry 4.0 describes rapid changes in industries, technologies and processes, fueled by the integration of latest tech innovations.
- Transition to Industry 4.0 is marked by wide adoption of multiple technologies that are part of the automation field. Such as
    1. Artificial intelligence (AI)
    2. Robotics
    3. Large-scale machine-to-machine communication (M2M)
    4. Internet of Things (IoT)
    5. Smart automation and interconnection techniques, etc.

- Industry 4.0 is an emerging and complex technological system that is being mould fundamentally by Co-ordination, connectivity, integration and digitization, focusing on the opportunities of integrating all units in a value-adding system.
- This idea embraces technology for digital manufacturing, network communication, computerization and automation.
- Advancements in technologies related to Industry 4.0 are eliminating the gaps between the digital and physical world, integrating human, machine, materials, products, production systems and processes together.
- Industry 4.0 is allowing quick technological advancements in various areas, however, the rising fourth industrial revolution is being predominantly formed by the technical integration of Cyber-Physical Systems (CPS) into manufacturing processes and therefore the use of the Internet of Things and Services in industrial processes.

Challenges in implementation of Industry 4.0 in India (in Industrial automation)

Industry 4.0 is a critical area as it offers esteem expansion (ವಿಸ್ತಾ ರಣೆ) to the manufacturing yields and frameworks by integrating emerging technologies in manufacturing sector and services. The primary explanations behind the vulnerabilities (ದುರ್ಬಲತೆಗಳು) lie in the high capital investment levels and the unclear financial benefits for the industry 4.0 implementation areas. Further, there is lack of adequate knowledge and skills in the employees which is required to cope up with the upcoming emerging technologies and automation. This digital revolution will need to cross many barriers before being successfully implemented by all organizations. The list of barriers for implementation of Industry 4.0 with a brief description is presented before:

1. **Employment Disruptions (ಅಡಚಣೆಗಳು): It** is characterized as the interruptions brought in the employment because of the development of the emerging technologies and automation. Current employments in the industrial sectors are inclined (ಒಲವು) to be robotized bringing about human employment misfortunes.

2. **High Implementation Cost:** High implementation cost refers to the capital cost (ಬಂಡವಾಳ ವೆಚ್ಚ) that the organizations must incur for developing the industry 4.0 framework in their organizations. It is difficult for small and medium industries to adopt Industry 4.0, as there is a lack of capital for appropriate emerging technologies. Emerging and promising technologies such as IoT, always carry a significant threat for investments to organizations as there can be potential capital losses and no recovery of investments.

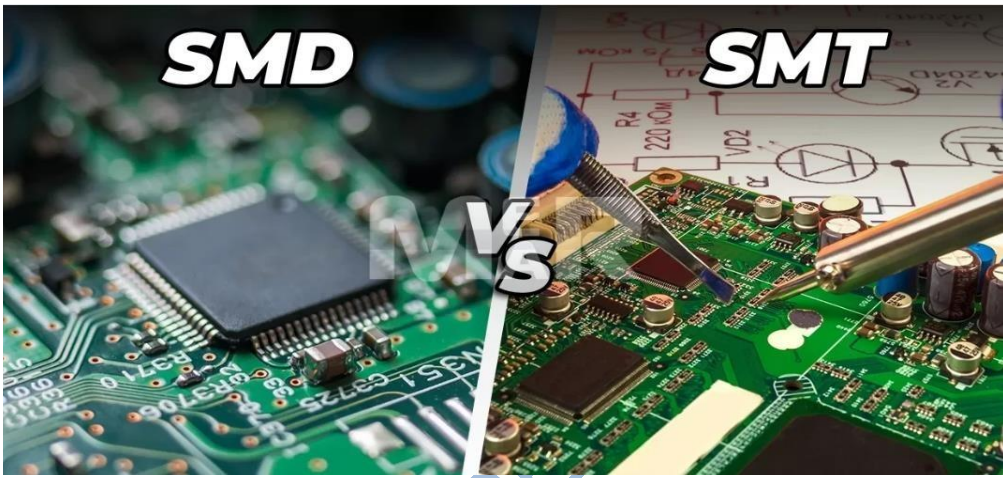
3. **Organizational and Process Changes:** There will be change in organization functions after adoption of

Industry 4.0 and this will give rise to decentralized organizational structure. Decision making can be done at the shop floor level. With the enormous IoT applications and solutions, which are being beneficial across industries also carry significant challenges which apply to the integration of both internal and external systems.

4. Need for Enhanced Skills: With the adoption of the Industry 4.0 by the organization, the knowledge, qualification and skills of the employees will be the key to success of a highly innovative organization. The organizations must be focused on the development of skilled workforce by the effective Human Resources Management. Effective design and deployment of IoT solutions require a lot of primary knowledge which lacks across various technical and non- technical programs

5. Lack of Data management system: Data management systems refer to information technology systems that store and recover information, improve coordinated effort, find information sources. The real time data may not be handled by existing systems. Extensive technical skills are required to switch from operational to more strategic and specific tasks. There will be a significant demand for data analysts who will analyze the big data and create value through optimization and forecasting.

Difference between SMT (Surface Mount Technology) and SMD (Surface mount devices):



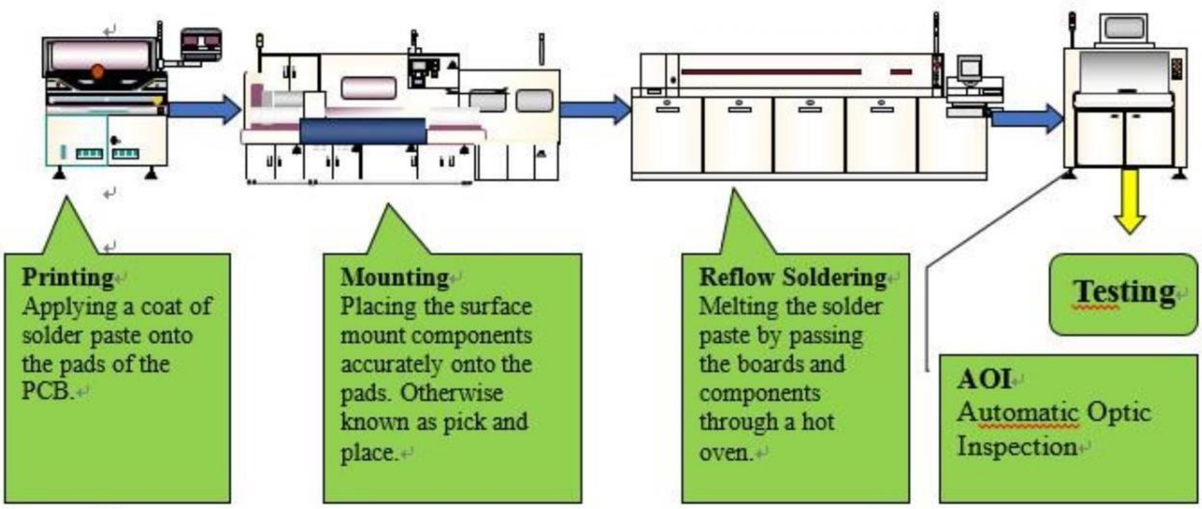
The primary difference between the two is that one refers to the mounting process while the other refers to the actual components. However, they are clearly dependent on each other. It is the proper selection and arrangement of SMDs that is the primary process behind SMT. Automated SMT machines can mount several SMDs onto the board in a short period of time. While SMDs determine the capacity of the board, SMT involves the installation of these components on the board.

What is SMT in electronics?

Surface Mount Technology is a relatively newer way of arranging components on the printed circuit board. Prior to this, components were arranged using through holes where component leads are placed into drilled holes on a bare PCB. Surface Mount Technology, on the other hand, involves soldering the components directly onto the boards. Since there is no need to pass leads through the PCB, the process is far quicker as well as cost-efficient. The big advantage of SMT PCB assembly is that it saves space. What it means is that more components can be housed on a smaller board. In times of miniaturization of devices, its advantage cannot be overstated.

Process involved in SMT (surface mount technology) includes

1. Printing: This involves applying a coat of solder paste onto the pads of the PCB.
2. Mounting: This refers to placing the surface mount components accurately onto the pads.
3. Reflow Soldering: This process involves melting the solder paste by passing the board and components through a hot oven.
4. Testing: The final process involves testing the boards through processes such as AOI which runs a number of quality checks on the boards such as component alignment and checking for solder bridges.
As is evident from the above processes, SMT is an intricate process that involves applying the right amount of solder paste to mount each component. SMT also lends itself to automation as machines can be programmed to mount components on the PCB in a short time frame. This ensures accuracy while also speeding up the production process and making go-to-market that much quicker.



Advantages of SMT

- Significant savings in weight and real estate.
- Reduced cost of the board as also a reduction in material handling costs.
- Stability and better mechanical performance.
- Components can be placed on both sides of the board and in higher density.
- PCBs created with the surface mount technology process offer higher circuit speed. Also, because SMD components have no leads or have short leads, RF interference is reduced.
- It offers more resistance to vibration and there is less noise.

The drawbacks of SMT however include the fact that it requires a high capital investment that can increase costs, particularly when you are dealing with low volume runs. SMT inspection equipment can also turn out to be very costly. Additionally, SMD components are prone to damage if dropped. Also, the power of such components is generally less.

What is SMD (surface mount device) in electronics?

Surface Mounted Devices are the components fitted onto PCBs. Evolved SMDs use pins that can be soldered directly onto the PCBs as opposed to using leads and wiring them through the circuit board. It enables many more components to be fitted on the board and improves its functionality. With no holes to be drilled, they also make the process quicker and cost-effective.

What is important is to choose the right SMDs and then mount them correctly on the board. SMDs can now be automatically mounted onto the electronic board as opposed to manually soldering them.

Types of SMD

Some of the various types of SMD include:
Chip Resistors
Network Resistors
Capacitors
Diode
LEDs
Transistors
Integrated Circuits

Medical Electronics /equipment manufacturing Industry

- ## Improving Manufacturing Plant Efficiency

1. Business in the electronic manufacturing services (EMS) segment of the medical technology industry is booming. According to MarketWatch, medical/healthcare EMS is expected to grow at a compound annual growth rate of more than 4% through 2026. This is primarily due to the growing use of automation and advanced technologies such as the Internet of Things (IoT), wireless and artificial intelligence. (AI).

2. This business rise also reflects the evolution of EMS companies from pure manufacturing capabilities to end-to-end services supporting the entire product lifecycle for medical device manufacturers (MDMs). –This includes handling all aspects of production, including assembly, manufacturing processes and testing for high-quality, complex products.

3. Medical device manufacturers are tasked with accelerating innovation and adopting new and unknown technologies. Technological innovations such as miniaturization, high-performance computing, and data analytics are driving the development of highly complex electronic components for mission-critical tasks in medical applications.

4. New product designs are primarily aimed at using electronics, automation and sensors to minimize the human error and improve usability. For example, smart baby monitor products that measure heart rate, ECG [heart electrical activity] and blood oxygen. Parents can take home from the hospital.

5. The development of wearable and non-invasive monitoring devices continues to be of great interest in the medical device industry. These products use sensors, flexible electronics, and wireless technology to help people monitor their health at all times. Sensorization will become a reality in the future of patient care.

6. Wearables will be able to monitor ever-growing health metrics every day, enabling home care and real-time communication with medical professionals. For example, non-invasive remote monitoring devices used in dental care allow patients to scan their teeth from the comfort of their own home and wirelessly transmit thedata to their dentist for review.

7. The medical device industry has adopted IoT technologies such as networking, cloud computing, signal processing and data analytics. This trend will continue at an accelerated pace as more IoT capabilities are built into new and upcoming devices. However, the industry is also well aware that development must consider security and data protection.

8. One example is the wireless transmission of firmware upgrades. Firmware must be cryptographically signed and encrypted to ensure that only legitimate updates are installed on medical devices already on the market. This capability means not only a set of new capabilities for medical devices (such as cryptographic algorithms), but also new requirements for other parts of this medical device ecosystem. Firmware images are protected when temporarily stored in the cloud or on your phone.

9. Due to the global pandemic, many MDMs are adopting his IoT technology to improve the efficiency of their manufacturing and supply chains, allowing executives to make faster, more informed operational decisions. I am forced to do it. The ability to remotely monitor operations and automate basic tasks via IoT has become essential during lockdowns to ensure safety and productivity. Combining AI and machine learning predicts quality issues and equipment failures before they occur, minimizing downtime and increasing efficiency on the factory floor.

- **Wastage of material- waste disposal for medical device manufacturers:**

Medical waste management is a concern for all medical device manufacturers. There are many medical waste disposal facilities across the globe, but because medical wastes can be grouped into just a few discrete categories, there are only a small number of disposal facilities available near specific manufacturing locations.

Many medical devices may be used for varying applications, but the waste produced during medical device manufacturing is fairly consistent from site to site. Typical waste from medical device manufacturing processes include:

– halogenated and non-halogenated solvents

– Wastewater

– unused medical devices which can include both RCRA (Resource Conservation and Recovery Act) and non-RCRA materials

Solvents

Many different solvents can be used for cleaning and production of medical devices during manufacturing. The solvents are categorized into two primary groups: halogenated and non-halogenated solvents.

Non-halogenated solvent wastes like methanol, ethanol, and acetone are primarily composed of one type of solvent that can often be recycled or blended into fuels.

Halogenated solvent waste containing halogens—fluorine, chlorine, or bromine often must be disposed of using a chemical incinerator. This process is often significantly more expensive than the disposal of than non-halogenated solvent waste. It's worth noting that if non-halogenated solvents are mixed with halogenated solvents, the entire mix must be treated as halogenated waste and disposed of accordingly.

Thus, it is important to keep different kinds of wastes separated throughout the production process when possible.

Wastewater

Wastewater from medical device manufacturing processes is usually runoff water from medical device cleaning processes and may contain both inorganic (metallic) components and organic (solvent) components. It is very important for medical device manufacturers to properly treat all of their wastewater streams. Improper treatment of wastewater streams, such as allowing wastewater containing higher-than-regulation amounts of inorganic or organic compounds to leave the processing environment can result in severe fines and penalties.

Unused devices

Because medical devices are strictly regulated and must achieve rigid accuracy and precision standards due to the nature of their use, medical device manufacturing processes are susceptible to producing unused medical device waste from medical devices that do not qualify for use based on predefined standards. Typically, unused medical device waste is incinerated or sent to landfills. Additionally, waste medical devices that are high metal content are typically sent to landfills if they cannot be recycled.

In contrast, incineration, which is the destruction of waste materials via burning, is often used to dispose of unused device waste when the device waste does not have a high metal content. Incineration can be subcategorized into RCRA and non-RCRA incineration, depending on the material incinerated.

RCRA waste materials, also called solid wastes, are classified as hazardous waste materials and thus must be disposed of in a more regulated manner. As such, RCRA waste incineration is often more expensive than non-RCRA waste incineration. Interestingly, RCRA classification is not based on the material composition as much as the product use or disuse. Solid waste includes abandoned materials, inherently waste-like materials, discarded military munitions, and materials recycled using certain processes.

Sustainable Manufacturing

In addition to disposal methods, many medical device manufacturers are implementing sustainable manufacturing practices to reduce the amount of waste they have to dispose of. Through waste reduction and closed-loop recycling techniques, medical device manufacturers can potentially reduce waste disposal costs as well as raw material costs.

However, because the medical device industry is severely regulated, lean manufacturing practices may be difficult to implement, as all changes to the manufacturing process must be thoroughly tested, documented, and approved prior to implementation.

How robots are revolutionizing medical device manufacturing: Robotics in Medical (2021) – Technology Trends

- The emergence of technologies such as cloud computing and artificial intelligence (AI) is expected to drive innovation in the medical robotics segment thereby reducing the need for the surgeon to be physically present.
- Robotics technologies are expected to help in improving the quality of life for elderly patients through non-invasive surgical procedures.

Below are the technology trends that impacting the topic of Robotics in Medicine (2021).

AI:

- AI technology, especially machine learning, is an integral part of developing intelligent industrial robots that can predict and adapt to specific situations based on the interpretation of data from various sensors.
- Taking industrial automation and robotics to the next level requires further advances in certain AI technologies such as computer vision, conversational platforms, and context-aware computing.
- Neuromorphic processors will be an important part of the next generation of robots. They are trained on a basic library of relevant data and learn how to think for themselves by processing sensory input. These processors will eventually use their acquired skills to perform assigned tasks.

Edge computing:

- Robot operations can be performed from the cloud, but security and latency issues may require the robot to process real-time data about the operating environment and react immediately. Edge computing can improve robot performance due to lower latency. Security is also better because the edge is more secure than the cloud. Edge computing, combined with self-contained "sense-decide-act" firmware loops in robotics, makes cyber-attacks more difficult.

Cyber security:

- One of the biggest challenges to the widespread implementation of robots is the threat of cyber-attacks. Robots, especially those connected to the internet, are highly vulnerable to hacking. Left unprotected, it can allow unauthorized access to critical applications and systems, resulting in the loss, theft, destruction, or improper use of sensitive information.

Industrial Internet:

- The Industrial Internet implies a higher level of connectivity between systems and assumes that monitoring and control data will flow beyond factory boundaries and be consumed and managed by cloud-based services. Existing factories, machines, and processes are prime opportunities for the Industrial Internet.
- The greatest short-term gains come from retrofitting today's industrial infrastructure with advanced communication and management capabilities. By giving industrial equipment manufacturers access to real-time performance data, they can offer new services and support new business models such as predictive maintenance and robotics as a service (RaaS).

Cloud robotics:

- Advances in AI have enabled the evolution of robots, allowing them to become highly complex products rather than stand-alone, fixed-function machines, with an increasing number of roles that robots can play. Central to this development was the cloud computing. This enables faster, more secure and more scalable management of sensing, computing, and storage.

- Using the cloud in robotics could change the way we use technology. The RaaS market includes products that integrate cloud-based management and analytics services with physical robots. Major robot manufacturers have implemented cloud connectivity to enable remote monitoring, management and maintenance of their robots.

Robotics centres of excellence (CoEs)

- The Robotics CoE is responsible for designing and implementing robotic solutions that are efficient, productive, and address industry needs. The CoE collects, evaluates, and manages information that facilitates the use of robotic solutions. A robotics CoE requires a strong governance model and the right mix of people, including sponsors, leads, project managers, business analysts, architects, developers, and controllers.

Types of automation in the industry: Following are the types of automation in the industry.

1. **Permanent/Fixed (hard) automation**
2. **Programmable automation**
3. **Flexible (soft) automation**

1. Fixed (hard) automation: Fixed automation, which is also often referred to as hard or rigid automation, describes the most permanent and application-specific types of industrial automation systems that are typically designed to carry out a single process, tasks or a set of tasks and can't be easily adapted for other applications.

Once a fixed automation solution is implemented, it would be challenging to configure it or modify the way it handles processes. This is why fixed industrial automation systems are typically used in mass production and continuous flow systems to automate repetitive non-variational processes of all kinds.

Here are some examples of fixed automation solutions:

1. Automated conveyor belts
2. Assembly lines in the automotive industry
3. Material handling conveyor systems
4. Machining transfer lines
5. Paint and coating stations
6. Welding machines

2. Programmable automation: Programmable automation describes a field of automation solutions that can perform multiple functions and are controllable via commands delivered by the means of entering computer code in the systems. Designed to be more adjustable than fixed tools, programmable automation components are widely used across the industries, but today most commonly can be found in manufacturing operations focused on producing goods in batches. Programmable automation solutions allow customization and adjustment of the manufacturing equipment in accordance with the requirements for each specific product.

Examples of programmable automation are:

1. Computer Numerical controlled (CNC) machine tools
2. Programmable logic controllers (PLC)
3. Machine vision-based quality control systems
4. Industrial robots
5. Various automobile and machinery manufacturing systems

3. Flexible (soft) automation: Flexible automation, also sometimes referred to as soft automation, includes computer-controlled systems and software solutions designed to interconnect, adjust control and measure the sequence of operations of various machines and equipment, as well as human workers.

Here are some examples of flexible automation:

1. Robots and robotic devices that can be configured to perform a number of activities
2. Movable welding, painting and coating stations
3. Configurable material-handling systems
4. Other industrial tools that are highly versatile and customizable