Review

Smart Factory and Industry 4.0

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Chapter 1: Introduction to IISc Smart Factory

1. Introduction

In the modern era of today's world, everything is turning into its smart nature likewise industry is also growing day by day and implementing smart manufacturing and smart factory concept. Now, several types of initiatives are taken throughout every part of the world to perform the system of smart manufacturing in the real industry field by using different techniques and other processes like the Internet of Things, Embedded system, AI and others. With the introduction of the smart factory concept, there is a flow of data from the lower level which is used in future to run any machine or any such device, mainly the data is stored in the cloud and the data is then used my sensors and microcontrollers to run the device. Though the concept of smart factory and smart manufacturing came into the function from 2011 onwards, the industries did not adopt the concept of this digital factory system where automated things can be done, however, integration has been identified as one of the key requirements to realize the vision of Industry 4.0.

Examples of recent paradigms include smart manufacturing, cyber-physical production systems, Industry 4.0, and cloud manufacturing, among others. The challenge for the installation of this in a real industry scenario is not a matter of joke, the engineers had to make the solution and for which they came across a system of interoperability across these innumerable systems. But global interoperability is still a big challenge for us.

The smart factory mainly runs on integrating people, things and data and after that implementing that data into a digitally connected ecosystem. Now the data can be captured by using tools and method like Artificial Intelligence, cloud computing, IoT and other. By way of sensors and gateways, the Industrial Internet of Things (IIoT) allows connected machines to gather data into the system. Through myriad other data portals, AI-powered systems can compile data sets related to performance, market trends, logistics, or any other potentially relevant source.

With the coming of Covid -19, it is very much essential for the manufacturing industry to grab this formula of smart manufacturing, else it will to very much tough for that particular sector or a company to run in the long term. Industries are taking forward with this process. Today, more than ever, digital transformation and supply chain modernization has changed from long-term goals to urgent and immediate priorities for companies determined to innovate and compete. The typical type of system is represented in a diagram :

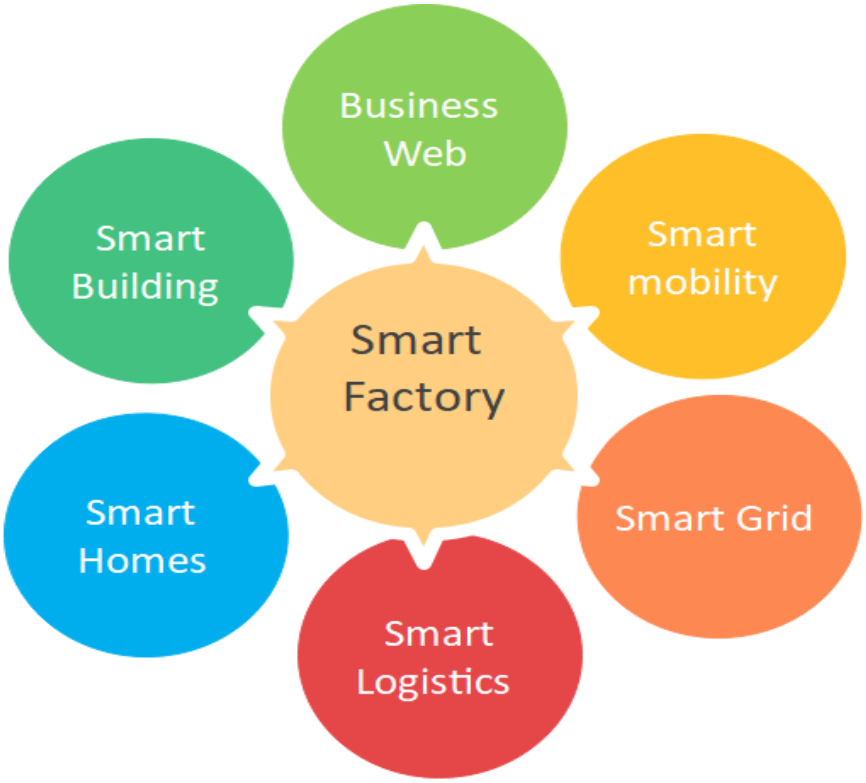


Fig: Smart Factory systematic diagram

Smart manufacturing involved the integration of devices to run them. There are mainly two types of integration used mainly vertical and horizontal systems. Finally, it can be concluded that this article conducts a review of the notion of interoperability in the context of smart manufacturing. First, an overview of the emerging concepts and paradigms in manufacturing is provided, along with their detailed characteristics and elements, comparative analysis, and common vernacular. Next, different definitions and dimensions of interoperability are introduced, and the interoperability problems associated with vertical and horizontal integration are differentiated and formalized concerning the interoperability stack model. Lastly, several reference architectures for smart manufacturing and their approaches to interoperability are evaluated and compared, followed by a summary of challenges and recommendations for future development.

Chapter 2: Webinar 1, Medtech Startup Journey

The major knowledge that we have gathered from this webinar are as follows :

- Firstly, from this webinar, we have come to know about the details of the digital factory system and how it works. The major parts in a digital factory system are Smart AGV, Electrical cable tray, Assembly fixture, conveyor, pick to the light, Drill M/c, Milling M/c, Lathe and Electrical Control Panel.

- Secondly, we have gathered knowledge on the architecture of Industrial IoT which comes under the part of Industry 4.0. In that, we came to know about the layers. Mainly there are three layers namely the cloud, the network, the edge. In the cloud, the computational and the storage part of the system is done. The network means internet connectivity for the system. The edge part involves real-time control and consists of sensors, actuators and controllers.

- Thirdly, the most important section is the Medtech journey means bringing Industry 4.0 in the medical field. By using this technology, the operations become very much efficient and accurate. The devices can keep the track record of health data such as blood pressure, oxygen level and others. Vaccines are also promoted using this system after the pandemic situation arises in our country. Industry 4.0 and the Medtech also contributes to exploring rural India opportunities and mainly deals with process optimization, recognizing rural innovations, new product development and service network. Nowadays, diploma and ITI students are also trained to get involved with modern technology such as IoT, sensors and actuators, cloud computing and other new technologies.

- Fourthly, the concept of grassroots innovation is mainly about finding out the solution of a particular task by thinking and creating solutions with an uncommon perspective, that tend to positively impact the environment, both socially and economically. Grassroots innovation is a bottom-up innovation starting from the grassroots where grassroots refers to disadvantaged class as opposed to mainstream elite. Grassroots innovation is the practical low–cost innovation based on technology.

Chapter 3: CNC machine video tour

The knowledge that we had gained from this video tour is based on the functionality and concepts of CNC machine :

Definition:

The full form of CNC machine is Computerised Numerically Controlled machines. Mainly these machines are used for a particular design of any part of a machine. These machines are the combination of electrical as well as mechanical components, in which computer programing is installed about varied no. of the axis, generally 5 or 3.5. CNC machines are first developed in 1940 -50.

Key points that can be taken from the CNC machine :

1. Standard CNC machine maintains a tolerance of less than or greater than 0.005 inches.

2. Fine Machining can maintain a tolerance greater than or lesser than 0.0001 inch and customized technique tolerance capacity of greater than or lesser than 0.00005 inches.

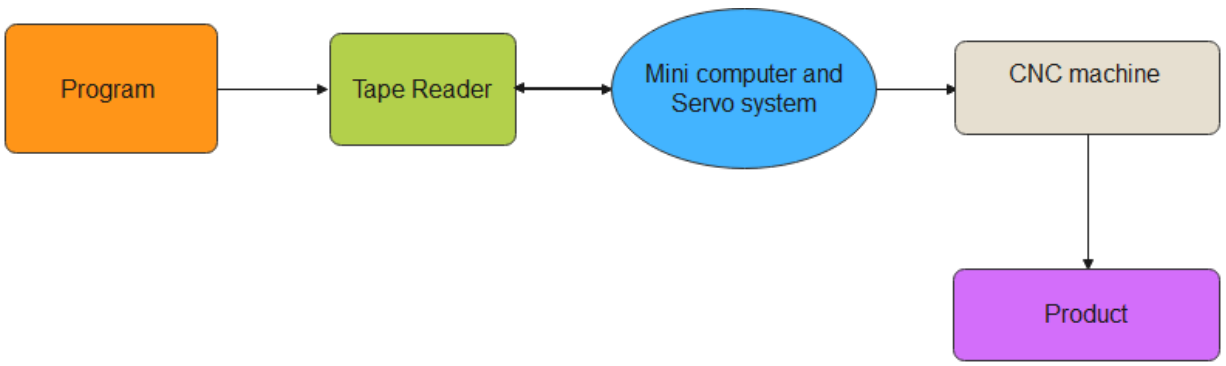
3. There is a specialized pattern of the orientation of the axis of CNC machine, mainly the axis is in the three directions i.e X-axis, Y-axis and Z-axis with patterns like 2.5 axes, 3 axes and 5 axes respectively.

4. Mainly programming is installed in the CNC machine to control them. The specified codes are namely G-code and M-code. The full form of G – code is General Code and the full form of M-code is Miscellaneous code or auxiliary code which is used to control switch on /off of lights, the opening of doors etc. . The types of G- code that is used namely G-01 and G-02.

Working principle of CNC machine :

The CNC machine is mainly based on the CAD and CAM programming software which is a designing software tool and CAM runs on the concept of G –code and M-code. Firstly, the program has to be given to the machine control unit and that program contains the G-code and M-code. Now after that data processing takes place and it prepares commands and sends it to the driving system. Then the drive system controls the motion and velocity of the machine tool. The feedback system records the position and velocity measurement of the machine tool and sends a feedback signal to the MCU. In MCU, the feedback signals are compared with the reference signals and if there are errors, it corrects them and sends new signals to the machine tool for the right operation to happen.

Systemic diagram :



Chapter 4: Introductory briefing on individual topics

The major topics that are discussed are as follows :

- Internet of Things in Smart Factory :

In the era of new trends, IoT plays an important role in the market. A wide variety of modern technologies such as communication systems (e.g., 5G), intelligent robots, and the Internet of Things (IoT) are expected to empower the fourth industrial revolution. IoT interconnects several devices, people, data, and processes, by allowing them to communicate with each other seamlessly. Hence, IoT can help to improve different processes to be more quantifiable and measurable by collecting and processing a large amount of data. IoT can potentially enhance the quality of life in different areas including medical services, smart cities, the construction industry, agriculture, water management, and the energy sector.

Elements of IoT :

IoT can be divided into major layers, including the device layer, network layer, cloud management layer, and application layer and others.

1. **Connected devices:** Devices are the primary physical objects connected to the system. For Asset Control Systems, sensors are the components of the device connectivity layer. These smart sensors are continuously collecting data from the environment and transmit the information to the next layer.
2. The latest techniques in semiconductor technology are capable of producing micro smart sensors for various applications.
3. **Cloud Man**: The Internet of things creates massive data from devices, applications and users which has to be managed efficiently. IoT cloud offers tools to collect, process, manage and store a huge amount of data in real-time. Industries and services can easily access these data remotely and make critical decisions when necessary. The cloud services layer is where all the data storage and information retrieval will take place. The management layer is where authentication, user management, and data management are done.
4. **Application Layer:** This layer gives a service to the user end and it hosts demand response management, dynamic pricing for smart grid systems and energy response management system.

5. **User Interface:** User interfaces are the visible, tangible part of the IoT system which can be accessed by users. Designers will have to make sure a well-designed user interface for minimum effort for users and encourage more interactions.

Applications of IoT in modern industry :

The major applications of the Internet of Things are as follows :

1. **Smart grid** :

Smart Grid works are becoming more widespread worldwide. Smart grids are a system that enables the communication between the supplier and the consumer. The most important component of the **IoT based smart grid** is the smart meters. **IoT for smart grid** is an issue that needs to be worked on for increasing the energy need, reducing the lost energies, increasing the production provided by the energy and many other reasons. Before explaining this topic, it is useful to explain what the Internet of Things technology is and where it is used. In traditional grids, batteries were recharged by adapters through electricity cables and AC/DC inverter.

These batteries can be charged wirelessly in a smart grid, using inductive charging technology. In addition, in a smart grid, the energy demand pattern of end users can be analyzed by collecting data through an IoT platform, for example, the time of charging mobile phones or electric cars. Then, the nearest wireless battery charge station can allocate the right time slot and that device/vehicle can be charged. Another advantage is that the use of IoT will lead to better control and monitoring of the battery-equipped devices, and therefore, first, the energy distribution can be adjusted, and second, the delivery of electricity to these vehicles can be guaranteed. This will reduce unnecessary energy consumption considerably.

Major uses of Smart Grid :

- It mainly helps to reduce the cost of the industry.
- Quick recovery after any sudden breakage/disturbance in lines and feeders.

2. **Smart Cities** :

Nowadays smart cities are new trends that are only possible because of IoT Based energy systems. The recent developments in digital technologies have provided a driving force to apply smart, IoT based solutions for the existing problems in a smart city context.

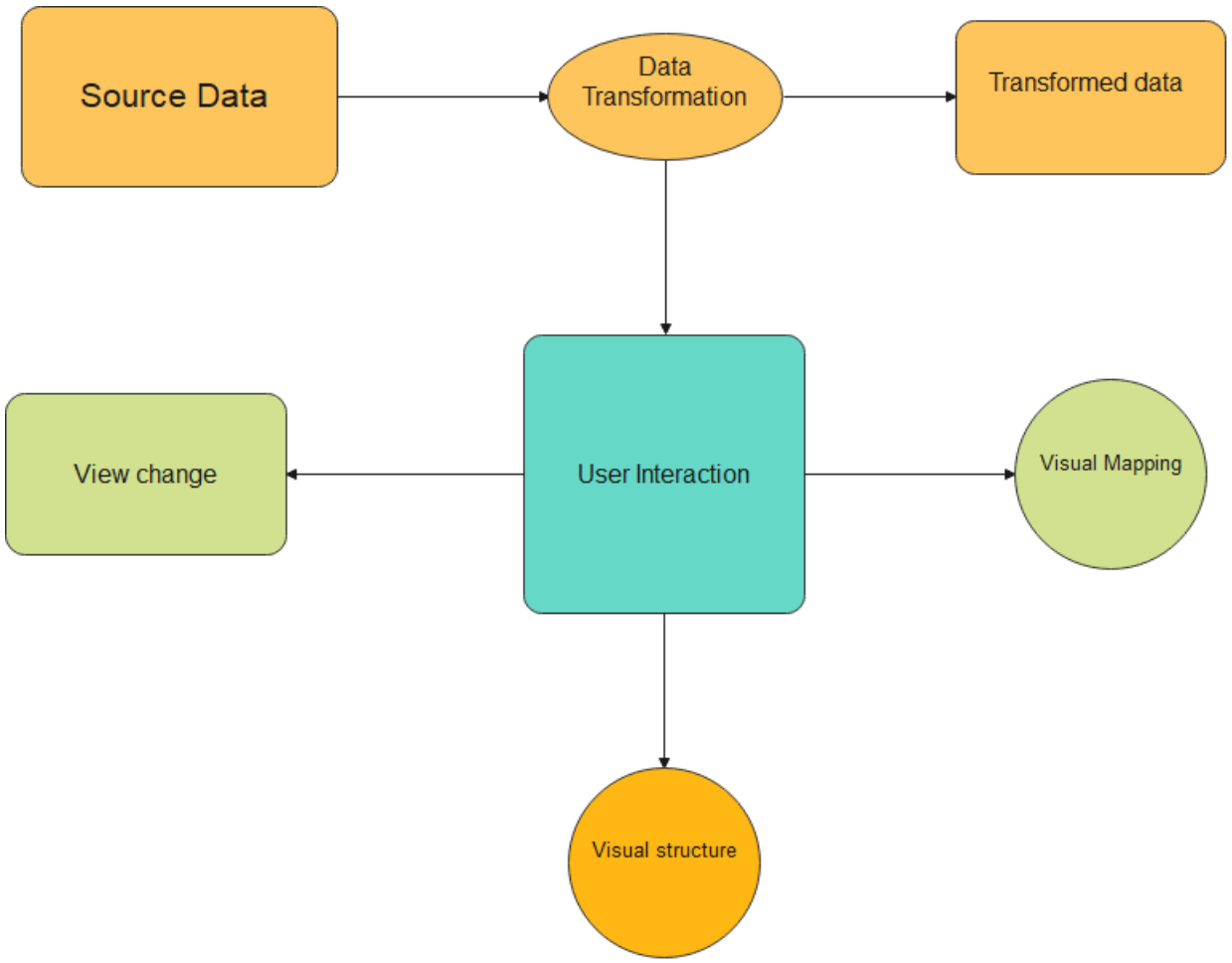
A **smart home system** can be something that makes our life quite easy. Starting from energy management where the power controls system in the AC appliances where we use the thermostat, all this is managed to cut down the power consumption that's taking place. A door management system, security management system, water management system are part of this as well. Still, these are vital things that stand out in the smart home system. The limitation of IoT in smart home applications stops where our imagination stops. Anything that we wish to automate or want to make our life easier can be a part of a smart home, a smartphone system as well. In a smart city, different processes, i.e., information transmission and communication, intelligent identification, location determination, tracing, monitoring, pollution control, and identity management can be managed perfectly with the aid of IoT technology. IoT technologies can help to monitor every object in a city. Buildings, urban infrastructure, transport, energy networks, and utilities could be connected to sensors. These connections can ensure an energy-efficient smart city by constant monitoring of data gathered from sensors. For example, by monitoring vehicles with IoT, street lights can be controlled for optimal use of energy. In addition, the authorities can have access to the gathered information and can make more informed decisions on transportation choices and their energy demand.

- Data Visualization and analysis :

Data Visualization is a concept in which people have to think about a graphical representation of their given data for any specific task or something. The data can be shown in different formats such as graphs, pie charts etc. In the world of Big Data, data visualization tools and technologies are required to analyze vast amounts of information. Even in our day today, we are implementing data visualization in the forms of graphs and all, though in the modern era it goes beyond graphs and piechart. Nowadays, the data are the collected in form of an excel sheet, a spreadsheet that displays the data in more sophisticated ways such as dials and gauges, geographic maps, heat maps, pie charts, and fever charts. To make the data visualization more effective and innovative, we have to be very much accurate in choosing the data and for this, some part of data Science can also be involved. It is commonly used in learning settings, such as tutorials, certification courses, centres of excellence, but it can also be used to represent organization structures or processes, facilitating communication between the right individuals for specific tasks. Project managers frequently use Gantt charts and waterfall charts to illustrate workflows and which proves that industries are taking this in a very serious manner and day by day the craze of technique will keep on increasing. From ancient times, this concept was there and one of the examples regarding this is the Napolean March Map. He went to conquer the city of Moscow with a group of 47000 but there was a disaster happened and he returned with a team of 10000. This all can be calculated from the graph and analysis of that data.

Another example of data visualization and analysis is the cholera Outbreak map. It uses small bar graphs on city blocks to mark the number of cholera deaths at each household in a London neighbourhood.

Data Visualization pipeline :



Importance of Data Visualization :

Data Visualization is important to this modern world to process certain data into human beings in a very efficient way. The major importance of data visualization for which, data visualization came into the field are as follows:

- To make things easier so that they can be understood in a very efficient way. Due to the technique of data visualization, data scientists did not have to go through the old school method to find the required data which would take a couple of months, where they use tools to do their data analysis.
- To discover unknown facts. It helps to find out many different concepts that were not found before.
- To summarize the result most efficiently. When you talk about a data science project, there are multiple teams involved, and not all of them are skilled in data science. Hence, for the personnel who belong to external pillars of the business, such as project management or human resources, the data science team needs to present them with results in a simplistic manner. This way, they can view the progress without missing any important pieces of information.

Types of Data Visualization :

Data Visualization can be classified into 4 categories. The types of data visualization are as follows :

- **Temporal** :
  This type of data visualization is mainly used in a one-dimensional data set and the data in the set should be linear. These types of data visualization have a common starting point and ending point. There are mainly classified into 6 types:

  1. **Scatter plots**: Mainly deals with the system of dots in a data set.
  2. **Pie charts**: Circular graphs are used for this type of representation
  3. **Polar area diagram**: Polar area diagram is a circular plot, except the sector angles are equal in length
  4. **Line graphs:** Like the system of scatter plots, where the dots are joined by using linear straight lines.
  5. **Timelines:** Helps to display a list of data in chronological order .\
  6. **Time Series Sequences:** Represent magnitude of 2 –D data set chronologically.

- **Hierarchical** :
  Mainly to display a particular set of data in a methodical way or a flow chart. There are different types of hierarchical visualization are as follows :

  1. **Tree diagram**: Mainly the flow is organized in a form of a tree structure
  2. **Ring charts**: These charts are mainly used for a radial visualization of a tree structure flow chart.
  3. **Tree**map: The treemap is represented in the form of closely packed rectangles.
  4. **Circle packing**: Uses circular structure instead of a rectangle.

- **Network** :
  These representation helps to determine how the data sets are connected within a network. The types are as follows :

  1. **Matrix Charts:** This chart is used to find the connection between the variables of different data available.
  2. **Alluvial Diagrams:** Data are represented in a flow.
  3. **Word Cloud:** Represented through text data and the words are closely packed, and the size of the text signifies the frequency of the word.
  4. **Node–link diagrams:** Here the nodes are represented as dots, and the connection between nodes is presented.

- **Multidimensional**: It is used to portray ordered groups within a larger group. Mainly deals with 2-D and 3-D visualization. The types are :

  1. **Scatter plots:** In this system, we select any 2 features and then plot them in a 2-D scatter plot and the same case is implemented for 3-D scatter plot.
  2. **Stacked bar graphs:** Mainly the values are plotted in a bar graph diagram to represent
  3. **Parallel co-ordinate plot:** In this representation, a backdrop is drawn, and n parallel lines are drawn (for n-dimensional data).

- Digital Twin :

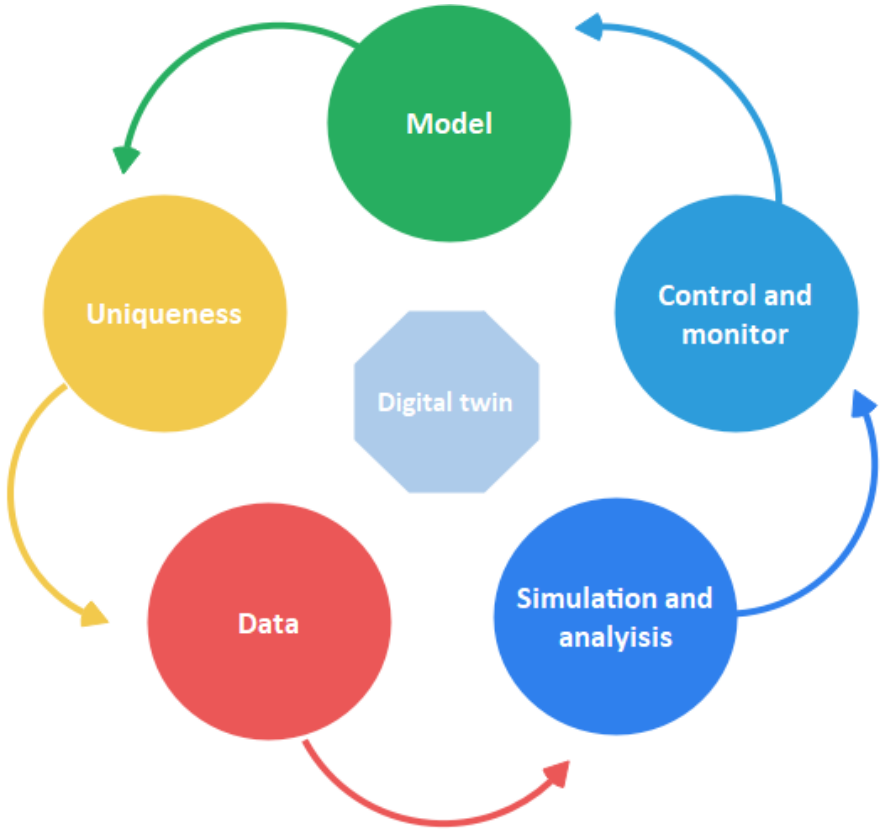
The digital twin is a very topic throughout the industry culture which brings a great impact on Industry 4.0. A virtual system or a model can be formed by using this digital twin technology synchronizing with AR and VR, which can automatically perform the real task of a human being with perfection. Constant research is going on in this field and in other words, the digital twin can be considered as a replica of the modern world.

Components of a Digital Twin technology:

There is mainly four major components of a digital twin technology:

1. **The Physical Object**: A virtual model of a physical object is created in a way that, it can perform the human task very easily
2. **Data Capturing**: Data is being stored by virtual objects and the link for the flow of data from the virtual object to the physical body and vice versa.
3. **Unique identifiers**: A unique id such as IP or any password should be connected to the digital twin to its physical counterpart.
4. **Monitoring Capability**: With the help of a sensor or a microcontroller, the system can be monitored.

Systemic diagram of a digital twin technology :



Advantages of Digital twin technology :

The major advantages of digital twin technology are as follows :

1. Productivity and performance will be far better using this technology.
2. Better collaboration with the team management
3. Industries support new products as a service business model.
4. By the use of this technology, clinical treatments in the medical field become very much accurate and efficient.
5. The maintenance cost for this technology is low.
6. Reduced risk in various areas, including product availability, marketplace reputation, and more.

- Haptics :

Haptics is the science of creating touch sensation in the human body. Haptic interfaces attempt to replicate or enhance the touch experience of manipulating or perceiving a real environment through mechatronic devices and computer control. Due to this technology, the process of doing any particular task can be very smooth as well as accurate. They are mainly made up of haptic devices such as sensors and actuators with a computer in which software is installed for the controlling purpose. Human operational inputs are given to the haptic devices and then the response output is relayed to the human operator is computed through models, haptic rendering, sensing, and/or estimation. Finally, actuators on the haptic device display corresponding touch sensations to the human operator. The ideal result is that the human operator feels that he or she is interacting directly with a real environment.

Application of Haptics in a real-world scenario:

1. **Medical Simulations**: One of the major applications of haptic devices is to provide simulation and training for the betterment of the process of medical operations. It helps in the diagnosis of any critical disease very easily and it also reduces the risk of failure of operation which saves many human lives.

2. **Computer-aided design**: My design based company using this CAD software which is mainly by haptic devices for the proper study of the design sheet of any model such as aircraft, bus etc. In the past, mechanics could verify the procedures (such as change-out of parts) on a physical prototype. However, this analysis is difficult or impossible to perform visually on an advanced CAD system. Some of the reputed company uses this technology, for example, the Boeing company has studied the use of haptic interfaces for solving advanced problems in computer-aided design (CAD). One such problem is verification of the ability to efficiently maintain a complex system such as an aircraft.

3. **Commercially available haptic devices and systems**: There is a wide range of haptic devices available in the market at different rates mainly used by scientists and researchers for their respective purpose.

Example of a Haptic device :

- AR and VR :

Augmented reality is a perfect blend of a digital system and the physical world to make a feel of artificial environment culture. Mainly this technology is one of the most emerging technology in the modern era and it is used to forecast sports on television, 3d photos, chatting with someone, emails etc. Augmented reality works on the system of computer vision. The system is designed in such a manner that it collects the data and process it to get the proper content. In Augmented reality, the user's physical environment is enhanced with contextually relevant digital content in real-time. You can experience (AR) augmented reality with a Smartphone or with special hardware.

Virtual reality is the computer-generated simulation of a real-world scenario. It is mainly used in video games or a for great animated video content. It gives a vibe that the player is in a real gaming field. It helps to create simulations similar to the real world and "immerse" the viewer using computers and sensory devices like headsets and gloves. Apart from games and entertainment, virtual reality is also used for training, education, and science.

the key difference between Virtual reality and augmented reality :

1. Augmented reality is overall addition to the real environment but in the case of virtual reality, it creates a virtual environment that is computer generated and driven.
2. Augmented reality is controlled via Smartphones, laptops, and tablets whereas virtual reality can only be used in the case of mounted panels
3. AR augments the real world scenario but the VR creates an artificial scenario.
4. AR is 25% virtual and 75 % real whereas VR is 75% virtual and 25% real.

- Sustainability and Industry 4.0 :

This is one of the most important topics to discuss in this era. Under the concept of Sustainability, sustainable manufacturing is the fact in which high efficient devices can be manufactured by using less valuable resources which is safe for a human being to use. This process of sustainable manufacturing not only create an ecosystem but also helps to reduce the cost of any device and less labour turnover by creating attractive workplaces, and a long-term business approach by creating opportunities to access financing and capital.

Bodies for the standards in Smart Manufacturing :

- IEC SMB SEG 7 Smart Manufacturing
- IEC TC 65 Industrial-process measurement, control and automation
- ISO SMCC (Smart Manufacturing Coordinating Committee)
- ISO TC 184 Automation Systems and Integration
- ISO TC 299 Robotics • IEC/ISO JTC 1 (e.g. Joint Advisory Group, Working Group 10 – IOT and System Committee 27 – Security Information Technique)
- LITD34 Sub-Committee on Smart Manufacturing – BIS, Govt of India

Industry 4.0 is the concept which mainly deals with cyber-physical systems integrated with many recent technologies such as the Industrial Internet of Things, Artificial intelligence, cloud computing and other modern technology. Nowadays the use of robots in production is evolving in their utility, increasing autonomy, flexibility, and interaction with humans and other robots.

- Digital Supply chain :

The Digital Supply Chain is the result of the application of electronic technologies to every aspect of the end to end Supply Chain. As an end-to-end supply chain strategy, digital supply chain management started to plan in the early stage and begins through relationship management after order fulfilment. At every stage of the cycle, organizations need to utilize digital tools and automated tools that support the process to find out the information and facilitate open communication.

Critical Integration requirements:

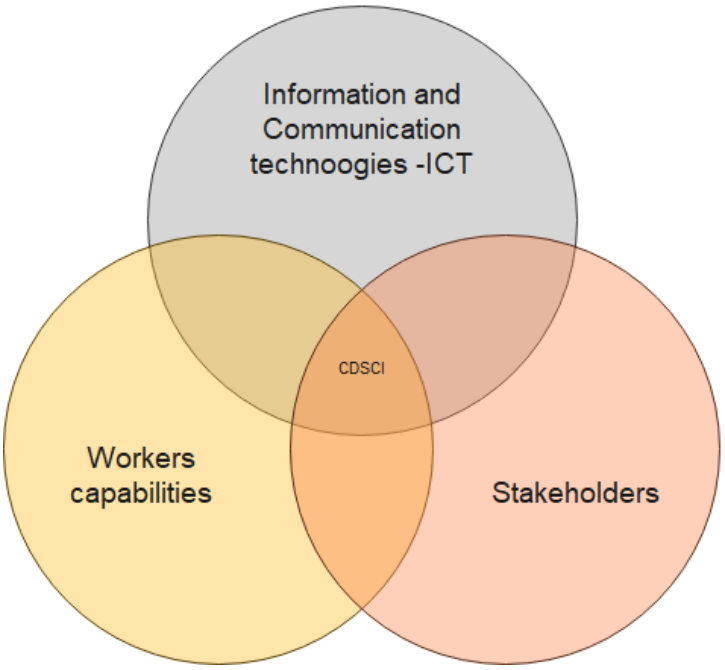


Fig : Critical digital supply chain integration(CDSCI)

Elements of Supply Chain Management Process:

- **Planning**: This planning stage is to be done to make sure of the inventory before proceeding with order management. The planning also involves forecasting demand, designing the SC, and determining KPIs and quality control, delivering value.
- **Sourcing:** The sourcing involves selecting suppliers., creating the contracts, managing and monitoring existing relationships.
- **Production:** At this stage in the cycle, your team and digital tools will be focused to perform the necessary steps and operations to manufacture the product from raw materials. It involves Coordinate all the steps involved in the production, from design to raw materials, manufacturing the product, quality testing and packaging.
- **Delivering:** It involves logistics, coordinating the orders, scheduling delivery, dispatching, invoicing, and receiving payments. Fleet management- monitoring and tracking
- **Returning:** The return stage is part of the digital supply chain management process that involves relationship management. It mainly involves returning, scrapping, recycling, and re-use.

Chapter 5: Video tour on Metal AM

The key points that we get from this video tour on Metal AM are as follows:

1. There are different types of metal repairing parts, namely:

    - ❖ Casting structure surface defects.
    - ❖ Aero-engine blades and parts
    - ❖ Worn out a thread and small feature
    - ❖ MRA services to industry

2. The additive manufacturing process is used to create an object in which the layer is coated with a metal surface. Mainly the CAD software is used to design the body of the object.
3. Some of the machine capabilities are building 3-D complex structures and in the field of research and development.
4. Due to this technology of Metal AM, the object that could not be formed a few years ago, but now they can be designed and created.
5. Hybrid manufacturing – the combination of traditional and additive manufacturing.
6. Key parameter indicators are: Laser power, power feed rate, oxygen and moisture parameters
7. DED(Directed Energy Deposition) is a process of additive manufacturing in which metal wire and power of metal are integrated with an energy source to deposit the metal parts.

Chapter 6: Webinar on Construction of a digital twin framework

Requirements for construction of Digital twin framework model:

- **Experimental setup**: Physical model, simulation model, Automation framework
- **Software Used:** Open PLC, Eclipse Ditto, Free CAD, SimFlow, OpenFOAM, Paraview

Digital twin – what is it? Why?

A digital twin is a replica of a real physical entity.

The digital twin is required due to the following reason :

1. Ensures that it captures the context under which the physical entity is functioning
2. Can be viewed to replay past and simulate input/time–based behaviour, enabling visualization.

Applications :

- The major application in smart manufacturing is that the virtual workshop goes beyond imagination, logistics simulation, factory layout simulation.
- In this webinar, sir showed his digital twin model, i.e the solenoid valve which involves the Water feed valve, liquid dispenser valve, Irrigation solenoid valve.
- When we prepare the model we use the PLC software, Robotic process automation and that all the important software are included.
- By using RPA, operations such as Data entry, Call centre, service centre duties can be performed very easily without human presence. This is one of the major applications of the digital twin.

Chapter 7: Video tour on Plastic AM

The key points that we get from this video tour on Plastic AM are as follows:

1. The process of additive manufacturing for making different parts using the layer of plastic. Mainly the Plastic additive manufacturing is used for 3-D printing.
2. The steps for the production of Plastic AM are :

   - Draw the 3-D structure
   - Picking of material
   - Definition of the parts of orientation
   - Machine starting
   - Removal of the extra parts and processing

3. Another important point behind the Plastic AM is that they mainly focused on two technology: one is the SLA (Stereolithography) and SLS (Selective Laser Sintering)

   SLS operation:

   - Layer by layer sintering of plastics powder
   - 3 machines of max dimensions 350 x 350 x 600 or 550 x 550 x 460 mm
   - Materials are selected according to need
   - Durability, high-performance mechanical or thermal properties

   SLA operation:

   - Layer by layer photo-polymerization of liquid resin
   - 9 machines of max dimensions 750 x 650 x 550 mm
   - Materials: PP-types, ABS-types and transparent resin

Chapter 8: Video tour on Metal Laser Cutting Machine (SIL 3015)

The key points that we get from this video tour on Plastic AM are as follows:

1. These machines use a fibre laser cutting generator as their light source.
2. In the video tour, we have observed that the machines are used for cutting sheets using the laser technology
3. The device which is used here is SIL 3015
4. The machine can be automated and fully and has a power of laser source of 1000 watt
5. The machine is designed by the company Suresh Indu Laser private Ltd.
6. It can cut mild steel, Stainless Steel, Coated Stainless Steel, and High-Strength steel, Aluminum, Brass, and Nickel easily.
7. Fibre Laser energy saves up to 70 per cent as compared with traditional CO2 laser cutters.
8. It can provide a cutting speed of 20 m / min and a rapid speed of 80 m/ min with 0.8 G acceleration.

Chapter 9: Webinar on Advanced Micro-engineered devices and systems for Clinical Research.

The knowledge we have gathered from this webinar are categorized into some key points and sub-points:

Firstly, the webinar is based on some research clinical devices with their detailing. The challenges of these medical devices are to ensure that we can cure critical and fatal diseases in human society. Day by day, research is going on to find out the solution for those fatal diseases and these clinical devices are helping in this process.

The clinical devices are ECoG, Micro –Electrode three shank Cannula arrays, Microneedles, Device specification of devices to record LEP.

Clinical Challenge: Epilepsy

- Epilepsy is a disease of the brain characterized by recurrent seizures, which are brief episodes of involuntary movement that may involve a part of the body (partial) or the entire body (generalized). The seizures are sometimes accompanied by loss of consciousness and control of bowel or bladder function**.**
- More than 7000000 patients are there in India
- Mainly clinical research devices work on two systems: one is the cognitive process and another is the effective process.
- The reports are showing that the no. of operations on epilepsy increases by 58% from 1990 to 2016, for which this initiative is taken to get an efficient way of operation.
- The process involves Structural Brain Lesions, Functional Brain Lesions, Epileptic activity, anti-epileptic medication, Psychiatric Comorbidities, Developmental Trajectories.

Clinical Challenge: Human Brain Tumor

- Human Brain tumours are one of the most fatal and critical diseases in India and abroad. These have the greater clinical challenge to solve this major human disease and make human society free from it.
- Mainly there are two major types: metastatic brain tumour and primary brain tumour. The metastatic brain tumour is far more dangerous than primary brain tumours.
- Now there is a definite protocol for the diagnosis of brain tumours and their treatment. The steps of the treatment are as follows:

    1. Tumour diagnosis
    2. Grading with chemotherapy and radiation
    3. Pre-operative imaging and surgical planning
    4. Awake Craniotomy
    5. Chemotherapy and radiation

Clinical Challenge: Breast Cancer anatomy

- Breast cancer is one of the deadliest diseases which has to be faced by women and female society.
- There are different types of breast cancer are Non – invasive In – situ Cancer (20% of newly diagnosed cases), Invasive Ductal Carcinoma (70%-80%), Invasive lobular carcinoma (5%-10%), Inflammatory Breast Cancer (1% - 5%), Paget's disease (1% - 4%)
- So, new devices are coming to improve the operation process.

Chapter 10: Video tour on AR/VR/Haptics

The key points that we get from this video tour on AR/VR/Haptics are as follows:

- Mainly the research is based on the I3D lab, IISc.
- The first demonstration is shown here an interactive HUD which is one of the funded projects of IISc. In that video, we can see the project in which there is a display present in the front glass of the car and can be controlled by human gestures.
- It helps in safe driving
- The leap motion controller is also used for the controlling purpose of the car
- Real-time distraction detection of drivers is there which is mainly used to detect the motion of the eye of the driver. Due to this feature, many accidents can be stopped
- They also simulate the total system with a Virtual reality car simulator that gives an animated vibe of the driving car system
- A virtual agent is there to control the car and some neural system helps to determine the other vehicles on the road.

Chapter 11: Webinar on Med-tech startup journey by Dr Abhijit Biswas

The knowledge we have gathered from this webinar are categorized into some key points and sub-points:

Dynocardia :

1. Dr . Abhijit Biswas is the Co-founder and CTO of this start-up company Dynocardia. This startup mainly deals with a modern technology that is Vitrack technology which gives a new dimension in measuring Blood pressure. This technology gives the value by monitoring the intraarterial pressure waveform in a large artery which is directly connected to systolic and diastolic BP.

2. Dynocardia has developed a proprietary method to directly measure systolic and diastolic BP based on spatiotemporal-force distribution on blood vessel walls and surrounding tissue.

3. As Per FDA standards, ViTrack methodology is as accurate as gold-standard methodology.

Abhipsita Technologies :

1. The co-founder of this start up company is Dr. Abhijit Biswas .

2. Mainly the company deals with R&D to the front end companies of renewable sector , Health Care, Automobile, Education and Agriculture.

3. The focus of this division of **Abhipsita** Group is in **technology** and market ready prototype development for its front-end companies and business partners with transparent strategic relations

Gears Energy Solutions :

1. Dr . Abhijit Biswas worked with this startup to gather various knowledge about the energy sector . This company deals with the R&D and edge-cutting technology , technical training , low volume manufacturing support and others.

2. They promote renewable energy support to utilize the clean and green energy to save human life .

Robotic Solutions :

1. Robotic Solutions Inc. is a unique company that specializes in customizing your robotic milling needs
2. RSI has built and installed hundreds of robots since the beginning of 2004, giving us unmatched experience in this field
3. Dr Biswas had also become the part of this company

Merkel Haptic Systems :

1. Dr. Biswas had also become a part of this company.
2. This company deals on Design and development of hardware and software for healthcare simulators using advanced virtual reality systems along with haptic feedback technology for training of clinical skills in an immersive environment

Chapter 12: Webinar on CPDMED CEFC Design Manufacturing

The knowledge we have gathered from this webinar are categorized in some key points and sub-points:

1. Some of the key emerging technologies that are discussed in the webinar are :
    - Additive manufacturing may accelerate the introduction of smart material for the fabrication.
    - Printing innovation takes place in the field of printing hydraulics in which solid and liquid materials are printed simultaneously.
    - The fabrication of multifunctional structures will allow the fabrication of the complex parts , enhance the design freedom and will enhance innovative solutions .
2. Also AM makes a great change in the textile field and cellulose key characteristics relevant for AM :
    - Shear thinning behaviour
    - Suitable for the 3-D links
    - High molecular weight cellulose dissolved by the solvents has a high viscosity.
    - Hydrophilic nature / controlled swelling on the contact with water making cellulose potentially relevant for drug delivery and 4-D applications.
3. Smart sensors are also discussed in this webinar. Here the application of smart sensors in the agricultural field is discussed. The major sensor is Sentinel (a multi–layer biosensor) which is directly involved in indirect fabrication and direct fabrication.
4. There are different advanced printing method technology : Direct repellent clothing (self cleaning), Shape changing and colour changing clothing , Climate regulating clothing .
5. Various designs for additive manufacturing are also discussed such as casting and milling.
6. Personalized healthcare care system in which lost bone part of human body can be re-built by using biodegradable and biocompatible modular pieces (bone bricks).

Chapter 13: Video tour on Smart Factory Robotics

The key points that we get from this video tour on Smart Factory Robotics are as follows:

1. This video tour includes robotic part of Smart Factory which includes types of equipment like :

   - Autonomous Guided vehicle (AGV) using LIDAR technology and real sense camera detection is being used to transport parts in the shop floor from one machine to another . Payload of 500 kgs
   - A collaborative robot is used for a lightweight pick and place operation and it is mounted on the top of AGV. This collaborative robot has payload of 5 Kg and maximum extension of 792 mm.
   - An arc–welding robot with a payload of 12 kg is being used for assembly operation .It is fixed and requires an enclosure during its operation as it does not have obstacle detection like the AGV and cobots.
   - A two level bi – directional conveyor along with lifts on each end is used to automate the movement process along with workstations.

2. **Digital factory details** : The details elements of the system are Smart AGV , Electrical cable tray , assembly fixture , conveyor , pick to light , lathe , electrical control panel , 3-D printer , UPS , server , control room , mining machine , CNC machine and laser router .

3. **Digital and physical flow system** : Product , product design , product planning, product DMU, Manufacturing process simulation , Plant designing and simulation and finally approved by MES.

Chapter 14: List of Knowledge events

1. Introduction to IISc Smart Factory
2. Webinar 1, Medtech Startup Journey
3. CNC machine video tour
4. Introductory briefing on individual topics
5. Video tour on Metal AM
6. Webinar on Construction of a digital twin framework
7. Video tour on Plastic AM
8. Video tour on Metal Laser Cutting Machine (SIL 3015)
9. Webinar on Advanced Micro-engineered devices and systems for clinical research.
10. Video tour on AR/VR/Haptics
11. Webinar on Med-tech startup journey by Dr Abhijit Biswas
12. Webinar on CPDMED CEFC Design Manufacturing
13. Video tour on Smart Factory Robotics