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Manufacturing Smart Industry Perspective an Overview

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Abstract: Within the past few decades, the increasing use of advanced technology in the manufacturing industry has drawn extensive study attention from all around the world. Smart technology is technology that gives previously thought-to-be-inanimate objects cognitive awareness through the application of artificial intelligence, machine learning and big data analysis. Smart Technology (ST) involves many emerging technologies like the internet of things, Industrial Internet of Things (IoT), cyber-physical production system artificial intelligence, blockchain and systematic data analysis. We provide an overview of different smart technologies to control the intensive features of computer and sensor technologies to diminish the gap between humans and machines. This research paper shows the complete literature review of ST to increase the production and maintenance of machinery equipment and future threats faced by ST. This study also includes the survey report of the rate of adoption today as compared to the past five years, to obtain real-time results, cost-effective techniques and the use of different sensors to reduce human workload in the manufacturing sector.

Keywords: Block Chain, Cloud Computing, Artificial Intelligence, Cyber-Physical Production System, Internet of Things, Big Data Analytic

Introduction

Smart technology is a technology that uses big data analysis, machine learning and artificial intelligence to provide cognitive awareness to objects that were in the past considered inanimate. Smart Technology (ST) has a basic origin in Information Communication Technology (ICT) and intelligent manufacturing. It involved many terminologies including time synchronization, AI and network communication associated with accuracy with rapid and blistering work. Many manufacturing sectors developed their own Smart Technologies (ST) to turn their raw work into quality-derived work with great and brisk production. The intention of Smart Technologies (ST) is meteoric development and vanguard technologies like energy saving/efficiency, cloud manufacturing, Cyber-Physical Production Systems (CPPS) smart factories, intelligent manufacturing and advanced manufacturing. Smart manufacturing has attracted attention from industry, government organizations and academia. Various consortia and discussion groups are formed to develop architectures, roadmaps, standards and research agendas. The overall concept of smart manufacturing systems in Fig. 1 has to be translated into architectures that are quite specific. Efforts are under thanks to develop such architectures (Kusiak, 2018). Because the world is beyond the fourth generation, we are going towards the integrated and collaborative system of ICT; moreover, every field of science has its own tools and mechanisms to use. So as to leverage automation control data, Industry 4.0 manufacturing systems require industrial devices to be connected to the network. Potentially, this could increase the chance of cyber-attacks, which might compromise connected industrial devices to accumulate production data or gain control over the assembly process.

Globally the huge automated data and network operating system is significant, though in smart technologies the issue of cyber security arises many web search engines are utilized to direct the cyber-attack Sentient Hyper-Optimized Data Access Network (SHODAN) is also utilized. Manufacturing operations can be closed somewhere around a cyber-attack, along these lines, organizations have money losses, yet the fundamental issue is that cyber-attack

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targeting systems require safety operations and represent a serious risk for the safety of the operations. Smart manufacturing is a broad idea that is something that will be executed during a production process directly with some tools and technologies with diversified technologies and solutions which simultaneously if evaluated in a manufacturing industry is termed as smart manufacturing. We also call these technologies problem solver which assists in boosting the whole manufacturing process and this will enhance the profit.

Smart Technologies (ST) collects manufacturing site data analyses it and then provides summarized better decision-oriented and optimized results. The benefits of IOT are goof off and enhance the production. The core concept behind smart technologies in manufacturing means to establish a smart factory to derive accurate and efficient results. To acquire productive, energetic, efficient manufacturing some steps that should be followed, consider the following steps that are shown in the given Fig. 1.

It's been nearly 260 years since the start of the initial age, thought to have started around 1760 in the USA. The most recent iteration of this process, the fourth technological revolution, has been called "smart manufacturing," while in Europe it's referred to as "Industry 4.0." IOT, 5G, Artificial Intelligence (AI), blockchain, edge computing, predictive analysis and digital twins are coined together smart technologies that derive long-term savings, safety and security and increase productivity as shown in Tables 1-2.

The structure of this research paper includes the introduction:

- A new definition of smart technology is advised
- The state of art research literature review
- Structure of any smart manufacturing technology
- Various technologies related to the manufacturing sector
- Challenges in smart technology
- Conclusion

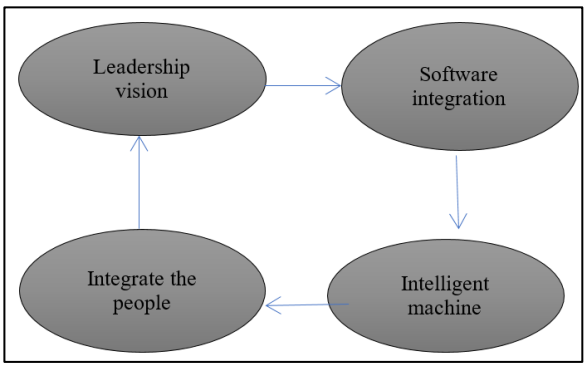

Fig 1: Step-by-step smart IOT

Table 1: Theme of the survey

Sr no.	Theme of survey
1	Article shows the industrial Internet of Things, recent advances, enabling technologies and open challenges
2	Massive internet of things for industrial applications: Addressing wireless IoT connectivity challenges and ecosystem fragmentation
3	Articles show a brief description of smart manufacturing
4	This article presents a systematic review of determinants of information and digital technology implementation for smart manufacturing
5	These articles show technology using graphs to link data across the product lifecycle for enabling smart manufacturing digital threads
6	This article shows a complete literature review of a smart manufacturing adoption framework for SMEs
7	This article shows digitally driven smart technology prioritization challenges towards the development of smart manufacturing using the BWM method
8	This study shows the fundamentals of smart manufacturing, a multi-thread perspective
9	This article shows the literature review of the conceptual framework of enablers for smart manufacturing tools
10	This article shows smart manufacturing based on cyber-physical systems and beyond

Table 2: Abbreviation of technologies used in manufacturing sectors

Terms used in ST technology	Abbreviation
CPPS	Cyber-Physical Production System
ML	Machine Learning
CAPEX	Capital Expenditures
OPEX	Operating Expense
CNC	Computer Numeral Control
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
IOT	Internet of Things
IIOT	Industrial Internet of Things
RFID	Radio Frequency Identification
MEMs	Micro-Electrical-Mechanical Sensor
SNA	Social Network Analysis
CCT	Computer and communication technology
AI	Artificial Intelligence
MBE	Model-Based Enterprise
MIOT	Manufacturing Internet of Things

Khan *et al*. (2020a) show IIOT the latest technology in the manufacturing sector, which includes the latest framework communication and protocols and also highlight the different heterogeneous technologies that are involved in meeting the challenges of ST. Kusiak (2018) also elaborated on the solution how to make smart manufacturing more effective and more productive, he also discussed the pillar of smart manufacturing. Liu *et al*. (2020) also discussed the issues of digital twin-deriving techniques in view of Industry 4.0 and its future challenges in smart manufacturing and also defined industrial communication twining tools. The literature review of smart manufacturing (Kusiak, 2019) that smart

manufacturing is not a single domain but this is a multi-domain that shows the different perspectives of smart manifesting using hardware and communication tools, showing the difference between resilient manufacturing and Sustainable manufacturing. Hedberg Jr *et al.* (2020) researchers also elaborate on the graph cycles and linking of different diagrams for accessing the different technologies for designing and quality domains for increasing the lifecycle of the product also defined the term Model-Based Enterprise (MBE). Also elaborated on the research about the cost analysis of smart manufacturing technology like digital twin is affordable (Yao *et al.*, 2019). Giving attention to the trending technology in smart manufacturing like CPPS also defined the SCPS including eight tuples of CPS-based smart manufacturing to society. Tao *et al.* (2018) also elaborated the terms like cloud computing, fog computing and edge computing.

During the past decade, we have boosted our technologies and techniques with the assistance of communication, networks and artificial intelligence to reduce the cost of Capital Expenditures (CAPEX) and Operating Expenses (OPEX). The advances in the communication and computer intelligence industry enhance the accuracy towards the perfection of automation in the manufacturing sector. Published a journal on automatic manufacturing in 1995 the work of an intelligence manufacturing system started for the support of the industrial industry. Well-reputed companies from different countries like Japan, Korea and the USA started the intelligence manufacturing system to give worth to their industrial sector. Smart technology is a technology that uses big data analysis, machine learning and artificial intelligence to provide cognitive awareness to objects that were in the past considered inanimate. Some of Smart Technologies (ST) is discussed the Fig. 2.

Smart technology is the term that is used to reduce human load, error-free and highly productive industries along with productive and predictive maintenance using artificial intelligence and the Internet of Things. Industry 4.0 is the recent technology used to run efficient collection and maintenance of data, technical and skilled full staff is required to run these computer sensing machines and communication networks.

Fig. 2: Smart technologies

Materials and Methods

Manufacturing Led Design

This smart technology is used to give direction to design, making early decisions and efficient industry. This smart technology officially decides the right things at the right time. The integrated CAD/CAM software was used, to provide a solution for the integrated complex design with the help of computer network protocols are used.

3D Printing

3D Printing is additionally clear as additive manufacturing mainly focuses on the hardware. Numerous companies utilize compulsive technologies for improving their products, to meet the product application and material necessity. Its name 3D originates from three measurements. 3D printing begins by making a virtual plan of the article you wish to frame. The virtual structure is utilized as a format for the article to be made. This virtual plan will be made by utilizing a 3D modeling program like Computer-Aided Design (CAD) to form a design from scratch as shown in Fig. 3. On the other hand, a 3D scanner will be utilized for an existing object. This scanner makes a 3D digital copy of a product and places it into a 3D modeling program.

The abridgment of CNC is computer numerical control, the purpose of this Smart Technology (ST) is to run and control machinery in the manufacturing sector through computer software, whereas it is used to discipline and supervise machinery parts and their cutting tools through material removal.

Cloud Computing and Storage

Cloud computing storage devices involve the handling of data, this also involves the collision of cyber security intelligence and many other machine-elated smart techniques to make effective and reduce the cost by using many efficacious data storage techniques. The main idea behind cloud computing is to create bonding between chain suppliers to make the product. Distributed devices are used for cloud computing, there are three formats that are mostly used for cloud computing named as PAAS, SAAS and AAS (Xu *et al*., 2018).

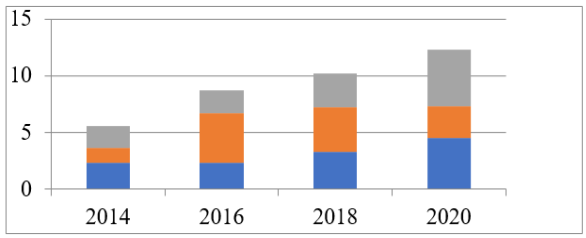

Fig. 3: Chart of 3D printing in different years

Internet of Things (IoT)

This smart technology includes sensor technology and a coin of many internet technologies like artificial intelligence, network and immutable communication. There is a central system on which the data is delivered and then provided to a central system many researchers used different protocols at different topologies using different hardware and software with different designs for different industries. The main issue is to cover the different problems of the industry to provide the connectivity between the manufacturing software tools and hardware, to support the company terms related to the computer wireless device to reduce the labor cost. This smart technology starts from the collection of raw data implementation of smart using Computer-Aided assistance (CAD) and manual system management. This smart technique also requires a platform of technical staff to run the smart technologies to meet the challenging task (Khan *et al*., 2020b)

Cyber-Physical Production Systems

Cyber-Physical Production System (CPPS) is a smart technology that is proposed for artificial intelligence, this system is a collection of collaborative technologies with this global world and its ongoing process related to the further development of Computer and Communication Technologies (CCT), this become the cause of fourth generation industry named as 4.0. The heap of raw data that is collected for industrial manufacturing from different sensors is very helpful for the detection of faults or to prognosticate equipment wear. There are different five-level architectures of CPPS that produce an efficient productive system. The five C levels of architecture are described in the following Fig. 4.

These five 5C surface levels of CPPS show the close bonding from the 1st level to the 5th level. All levels start from C, CPPS starts from the connection of self-senses and collection of data that has to be obtained from this system to network implementation to produce cost-reducing products. The main architecture of a cyber-physical production system is given below.

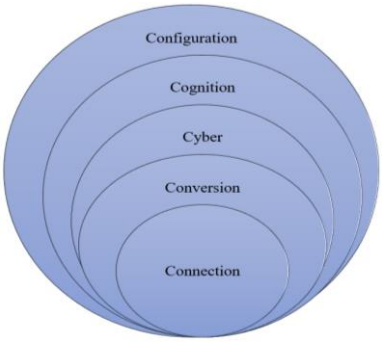

Fig. 4: Cyber-physical production system

Sensors and Automatic Identification

Different types of sensors are used in the automatic identification of different factors like cost, temperature, motion and environment, however, the most popular sensor that is used in automation is called Radio Frequency Identification (RFID), these sensors are used to meet the complete quality of the products in manufacturing sectors. The tags are used in the RFID technology to control wireless technological devices, every product is labeled with different tags, however, these tags are used to perform all particular activities including storing and retrieving data. Cyber security and privacy issues always involved in RFID, the tags that are used in RFID that are used in these sensors have some range and can be easily hacked from other RFID sensor tags. There are many sensors that are used in the industrial and automation industry like temperature sensors, pressure sensors, Micro-Electro-Mechanical (MEMs) Sensors, motion sensors and torque sensors.

Big Data Analytics

There is A colossal amount of data also requires a highly productive computing system, the demand of high amount of data that is collected and then analyzed how to handle, how to work with this data, some specific data collection techniques are used in the smart manufacturing technique to reduce the cost, time constraints and budget issue, there is also need of collection of correct raw data, big data analytic system play as a key role in the manufacturing sector (Wang *et al*., 2018) made research on the big data analytic industries and their challenges in his research he also defined the term Manufacturing Internet of Things (MIOT) perform the big analytic data technologies and give comprehensive reviews of different big analytic data in smart manufacturing and give enhanced briefing on how to get productive results.

Figure 5 CPPS system it consists of cooperative computational systems that are closely linked to the real world and its ongoing activities. They also provide and utilize internet-based data processing and access services. Automated pilot avionics, robotics, industrial control systems, smart grid, autonomous car systems, medical monitoring, robotics and recycling are a few examples of CPS.

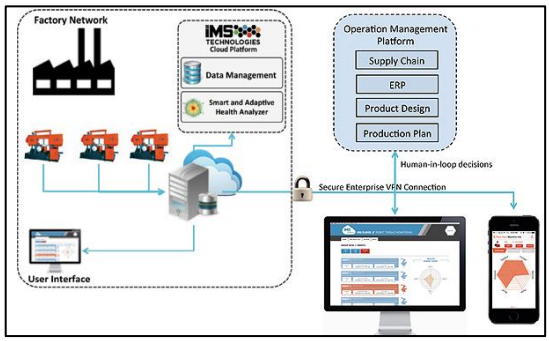

Fig. 5: CPPS system works

Block Chain Technology

In the latest smart technologies, blockchain has a key role in IIOT leading towards the next generation in the manufacturing industrial sector. Blockchain technology is not involved not only in the manufacturing sector but also in healthcare, finance supply chain and car insurance. The unique characteristics of blockchain technology are dispense nature, discoverability, durability, trust, security and cost-effective characteristics making it the trending smart technology in IOT. Ethereum is a term that is defined by the researcher as a blockchain platform, the user can sign the Ethereum, this Ethereum is decentralized and runs not only by one person but also by a peer. Ethereum Virtual Machine is also established, mainly the nodes that are present in ork. Latest research shows how blockchain can be developed for Digital Twins (DT) to produce authentic, efficient and securing manufacturing.

Artificial Intelligence

Artificial intelligence is a key element of ST, due to AI industry 4.0 coming into exist, without artificial intelligence there may be no concept of ST, the success of any smart technology depends upon the rate at which level of AI is involved in that technique, the term AI and Machine Learning (ML) are related to each other. The motivation behind the AI and ML to create ST is to increase the fast process of analysis and decision-making, Social Network Analysis (SNA) derived from the social network theories. In 2018, MHI and his team took a survey of different STs that are used in the whole world, this survey takes a long time of five years.

Sensing devices, such radar, cameras and microphones, are also necessary for the CPPS to gather environmental data. This information can be utilized to track the flow of commodities, spot irregularities and streamline manufacturing procedures. Cyber-Physical Production Systems (CPPS) refer to industrial automation systems that integrate digital components like databases, networks and software with physical components like machines, robots and sensors (Fig. 6).

Table 3 was discussed about survey report of MHI was given in the 2018. Rate of adoption in manufacturing sector was given in the percentage. Cloud computing was used as 57%, similarly Inventory and network optimization and sensor automatic detection was used 44-45% vice versa.

Fig. 6: Some type of sensors

Table 3: Survey report of MHI in 2018

Name of ST	Rate of adoption in manufacturing sector (%)
Cloud computing	57
Inventory and network optimization	44
Sensors and automatic detection	45
Predictive analysis	20
Internet of things	22
Robotics and automation	34
Blockchain	6
Driverless vehicles and drones	11
3D printing	16
Artificial intelligence	6

Discussion

Present and Future Challenges

Due to the diverse and complex nature of ST due to the diversity of communication and network intelligence, there are many challenges that are present in this sector that should be resolved. Some of these challenges are given below.

Technical Staff

The technical staff is required to run this complex and compatible architecture, however processing of efficient ML, understanding of communications networks and smooth running of these topologies over the network with a better understanding of fast data-driven techniques and operating systems. If the staff is technical, then it is easy to handle data managing schemes and machine integration with the software strategies to gain efficient results of ST IN manufacturing sector to meet the security and sustainability of computer-related results.

Difficult to Handle Huge Data Analytic and Management Techniques

There are many data analytic techniques to cover the collection of data, sensing of data and process of future decisions on the basis of these data management techniques, the running of different IIOTs run in an effective way by handling and retrieving a large amount of data.

System Integration

The compatibility of different smart technologies with machine learning and the new manufacturing system required IPV6 connectivity for smooth running of different interfaces. In the previous decades many technologies and platforms have been used to attain productive results for the manufacturing sector, but this is a bit difficult to integrate all the platforms. The technology moved from mechanical manufacturing to man production and then proceeded further to Information Technology (IT) and now a day's physical production system is used.

Big Data Analytic Tools

This is difficult to handle a large amount of data and then analysis of that data has occurred, many data analytic tools are used and the big issue behind these tools is sharing and maintaining that record on different networks.

Robustness and Security Issues

To cover the security issue, cyber and many artificial intelligence tools are used but lack of security is also occurring in different technologies over the network, the trust issue in the use of smart technology arises because all the data between different resources are through the use of different communication networks.

Use of Wireless Technologies and Different Protocols

This is not easy to use the different technologies by use of wireless, all the communication between the machine and human is done through the use of networks by using different topologies over the centralized or distributed network. There are many communication networks and wireless technologies that are used, but this is not easy to make a decision about which communication network is better for the productive manufacturing system. There are many technical issues that are related to communication networks like latency bandwidth and many more factors.

Invention of a Specific Operating System

There is a need for specific operating systems that are used in manufacturing sectors. TinyOS and Contiki are the most commonly used operating systems that meet the requirements of smart manufacturing techniques. There is a need to design the operating system that has characteristics of running smooth traffic, smart grid, intelligent communication framework, bandwidth consumption and interoperability.

Supply Chain is Complex

There are many heterogeneous systems used in the smart manufacturing industries that are interconnected one to another and there is a long chain of stakeholders and systems and suppliers. The challenge behind the smart manufacturing system is to handle large supply chains between different stakeholders and technologies that are involved in ST all over the world and there is a requirement to remove all the conflicts in the communication between different platforms that are used in the smart industrial manufacturer.

Customer Trust Involvement

The product that should evolve from smart manufacturing should be system integrated, reliable and durables techniques are used in this term, there are many wireless technologies including many challenges that are used in IOT and industrial 4.0. The customer should be aware of these technologies by making effective software models that are human-to-machine oriented.

Conclusion

This research paper gives a perspective review of smart technologies that produce energetic and profitable products, involving wireless communication by using different operating systems using reliable and effective systems and communication protocols. However, smart technologies are also emerging towards robotic technology to reduce the involvement of human machines and human workload. Digital twins involve the use of sensor technologies and have many benefits in reducing the cost of the products and enhancing the quality of products.

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Author's Contributions

All authors equally contributed to this study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

References

Hedberg Jr, T. D., Bajaj, M., & Camelio, J. A. (2020). Using graphs to link data across the product lifecycle for enabling smart manufacturing digital threads. *Journal of Computing and Information Science in Engineering*, *20*(1), 011011. https://doi.org/10.1115/1.4044921

Khan, S., Khan, M. I., & Haleem, A. (2020a). Prioritisation of challenges towards development of smart manufacturing using bwm method. *Internet of Things (IoT) Concepts and Applications*, 409-426. https://doi.org/10.1007/978-3-030-37468-6_22

Khan, W. Z., Rehman, M. H., Zangoti, H. M., Afzal, M. K., Armi, N., & Salah, K. (2020b). Industrial internet of things: Recent advances, enabling technologies and open challenges. *Computers and Electrical Engineering*, *81*, 106522. https://doi.org/10.1016/j.compeleceng.2019.106522

Kusiak, A. (2018). Smart Manufacturing. *International Journal of Production Research*, Vol. *5* (6), No 2, 508-517. https://doi.org/10.1080/00207543.2017.1351644

Kusiak, A. (2019). Fundamentals of smart manufacturing: A multi-thread perspective. *Annual Reviews in Control*, *47*, 214-220. https://doi.org/10.1016/j.arcontrol.2019.02.001

Liu, C., Kevin, I., Wang, K., Huang, H., & Xu, X. (2020). Digital Twin-driven smart manufacturing: Connotation, reference model, applications and research issues. *Robotics and Computer-Integrated Manufacturing*, *61*, 101837. https://doi.org/10.1016/j.rcim.2019.101837

Tao, F., Qi, Q., Liu, A., & Kusiak, A. (2018). Data-driven smart manufacturing. *Journal of Manufacturing Systems*, *48*, 157-169. https://doi.org/10.1016/j.jmsy.2018.01.006

Wang, J., Ma, Y., Zhang, L., Gao, R. X., & Wu, D. (2018). Deep learning for smart manufacturing: Methods and applications. *Journal of Manufacturing Systems*, *48*, 144-156. https://doi.org/10.1016/j.jmsy.2018.01.003

Xu, H., Yu, W., Griffith, D., & Golmie, N. (2018). A survey on industrial Internet of Things: A cyber-physical systems perspective. *IEEE Access*, *6*, 78238-78259. https://doi.org/10.1109/ACCESS.2018.2884906

Yao, X., Zhou, J., Lin, Y., Li, Y., Yu, H., & Liu, Y. (2019). Smart manufacturing based on cyber-physical systems and beyond. *Journal of Intelligent Manufacturing*, *30*, 2805-2817. https://doi.org/10.1007/s10845-017-1384-5