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The impact of IoT integration on the performance of smart manufacturing

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Abstract

The Internet of Things (IoT), artificial intelligence (AI), and robots are some of the state-of-the-art technologies that are being integrated into industrial processes as part of Industry 4.0 in order to boost efficiency and adaptability. In industry 4.0, a smart factory is a fully automated production facility that optimizes its operations and improves quality, productivity, and efficiency via the use of modern technologies like robots, the Internet of Things (IoT), and artificial intelligence (AI). The report highlights the revolutionary power of the Internet of Things (IoT) in changing the face of production and opening the door to better, more efficient industrial systems.

Keywords: Power, Internet, production, better, systems, etc.

Introduction

For Industry 4.0 to be really implemented, a number of limitations must be removed. A substantial financial outlay for state-of-the-art infrastructure and technology is necessary for the deployment of Industry 4.0. This might be especially challenging for less well-funded or smaller companies. In order to implement Industry 4.0, a highly skilled labour force familiar with digital technology is required. Businesses should invest in staff training or recruiting to find qualified candidates for these positions. As more and more systems and devices become internet-connected, the risk of cyber-attacks on the data stored in the network increases. To ensure the safety of sensitive data and intellectual property, robust security measures are required to implement Industry 4.0. The success of Industry 4.0 depends on the availability of fast and reliable communication networks. It may be challenging to implement Industry 4.0 in many businesses in areas without the necessary infrastructure. Companies might think about how to apply industry 4.0 to their component manufacturing processes in order to overcome these limitations. Prior to deploying Industry 4.0 technologies on a large scale, organisations might begin by implementing them on a smaller scale to gather experience and knowledge. Businesses may equip themselves to manage and repair Industry 4.0 equipment by funding training and reskilling programmes for employees. To reduce the dangers of data collecting and analysis, businesses should have strong data privacy and security measures in place.

The Internet of Things (IoT) is the backbone of a smart factory, linking all the equipment, gadgets, and sensors to one big network. As a result, the production process is improved and downtime is decreased. A smart factory is the improved, versatile, and environmentally friendly production process that comes with industry 4.0. It helps businesses stay competitive in challenging marketing environments. Automation, efficiency, and adaptability in manufacturing are the hallmarks of a "smart factory," wherein networked machinery and systems exchange data and coordinate their actions. Therefore, smart factories may oversee and manage different parts of the manufacturing process with the help of Internet of Things devices. The manufacturing facility's temperature, humidity, and pressure can be monitored via sensors, and the condition and performance of linked equipment can be updated in real-time. Artificial intelligence (AI) and machine learning algorithms may be used to analyse the collected data, find trends, and optimise industrial processes.

Manufacturers may save money in the component manufacturing process with the aid of Internet of Things devices by optimizing operations and decreasing downtime in smart factories. In addition to detecting and alerting workers to possible safety dangers, IoT sensors may help identify these hazards and avoid accidents and injuries. On the other hand, it may be difficult and resource-intensive to manage and integrate a large number of IoT devices. Furthermore, assaults on IoT devices pose a threat to sensitive data and the manufacturing process as a whole. It might be challenging to connect several Internet of Things devices into a unified system due to the fact that they may employ multiple communication protocols. It may be somewhat challenging to handle and analyse the massive volumes of data produced by IoT devices.

Literature Review

Bhavesh Chandrayan *et al*. (2020) [1] The purpose of this paper is to shed light on the Internet of Things (IoT) from a managerial point of view. The IoT connects existing advanced manufacturing methods to the core idea of cyber computing, allowing for truly wireless communication that is both agile and used to carry out operations in the industrial sector. The paper lays out the connection between creating a wireless domain framework to enable smart manufacturing, with a focused emphasis on the most recent innovation in the same area, as well as the obstacles and potential future evolution of Supply Chain Management (SCM). This will bring together manufacturing methods with a framework to support processes in real-time and provide greater control over current technologies. The article presents the results of several IoT researchers and lays the groundwork for IIoT and collaborative manufacturing. Furthermore, the study sheds light on the characteristics of the evolution and the future growth of IoT services, which have the potential to integrate with SCM components in a way that controls industrial activities fluidly and with little delay.

Hui Yang et al. (2019) [2] The modern manufacturing sector is embracing new technology like cybersecurity, cloud computing, big data analytics, and the Internet of Things (IoT) in order to manage complex systems, gain better visibility into information, boost production efficiency, and gain a competitive edge in the global market. These developments are quickly paving the way for the next generation of smart manufacturing, which is a cyber-physical system that intimately integrates actual manufacturing firms with virtual ones in cyberspace. In order for cyber-physical systems to reach their maximum potential, new approaches based on the IoMT for data-enabled engineering breakthroughs need to be developed. This article provides an overview of the Internet of Things (IoT) systems and technologies that underpin and drive data-driven advances in smart manufacturing. We go over the history of the internet, covering its transition from computer networks to human networks and finally to the current age of internet of things (IoT) in manufacturing, including materials, sensors, equipment, people, products, and supply chain systems. Our new framework also builds a virtual machine network by combining IoMT with cloud computing. Beyond that, we broaden our scope to include cybersecurity concerns related to the Internet of Things (IoT) and smart manufacturing as outlined by governments globally for the development of smart factories in the future. We conclude by outlining the possibilities and threats that IoMT poses. In order to enhance IoMT technologies, we anticipate that our study will serve as a catalyst for further thorough studies and collaborative research efforts across disciplines.

This empirical study provides a data-driven examination of the game-changing implications of merging IoT and AI in smart manufacturing, in keeping with the industry 5.0 paradigm. Results reveal a significant 1.52% improvement in production efficiency, which is explained by a 36.2°C rise in temperature and a 44.8% drop in humidity after the implementation. There was a 0.76% improvement in quality scores (93.1) for quality control as a result of a reduction in errors discovered (2). Maintenance procedures were more efficient, resulting in 2.3 less hours of work and 52 minutes less downtime. Smart manufacturing is at the forefront of the transformative landscape of Industry 5.0, and these findings demonstrate the tangible benefits of combining IoT and AI. It improves maintenance, quality, and efficiency.

Innovations in smart manufacturing and the internet of things (IoT) have altered the production, assembly, and upkeep of commonplace goods. To improve the quality of products used around the home, this chapter delves into how the Internet of Things (IoT) has revolutionized smart manufacturing processes. Among the many aspects covered are data-driven insights, predictive maintenance, product customization, and sustainability, among others, that make up this revolutionary journey. With the help of the Internet of Things (IoT), factories can improve efficiency, save costs, and provide customers with better home goods that can adapt to their changing needs.

The industrial sector is being compelled to radically change its present course for future prosperity by the rapid digital revolution. Industry 5.0 is here, and it's causing a revolution in many different sectors because to the incredible merging of digitization and manufacturing. The advent of digital manufacturing and smart factories, made possible by this paradigm shift, has signaled a fresh beginning in the production of commodities. A plethora of new possibilities in manufacturing might be unlocked by the convergence of additive manufacturing, internet of things (IoT), artificial intelligence (AI), robots, big data analytics, cloud computing, virtual reality (VR), and augmented reality (AR). Digital innovation in manufacturing is beckoning practitioners, researchers, visionaries, and pioneers to go into unexplored frontiers. Mechanical and electrical engineers, computer scientists, industrial economists, and business strategists are all part of the book's target demographic since it covers a wide range of topics in emerging technologies in digital manufacturing and smart factories.

AI'S impact on smart manufacturing

Checks for quality

In order to ensure that only high-quality products make it to market, quality checks are an essential part of every production cycle. But it's not easy to find effective ways to do thorough quality inspections. The problem with manual inspections is that they take time and, due to the inherent fallibility of humans, may lead to inconsistent and inaccurate product quality. Consequently, for consumer satisfaction and loyalty, it is essential to conduct very thorough quality checks all the way through the supply chain, in addition to inspections performed in the production line. Robots, autonomous devices, and machines can now perceive, recognize, and analyze pictures autonomously thanks to machine vision, an inspection technique based on imaging. In addition to automating product quality checks, these devices may transmit production line data to the warehouse, which in turn can be used to fulfill orders and send them to the distribution center.

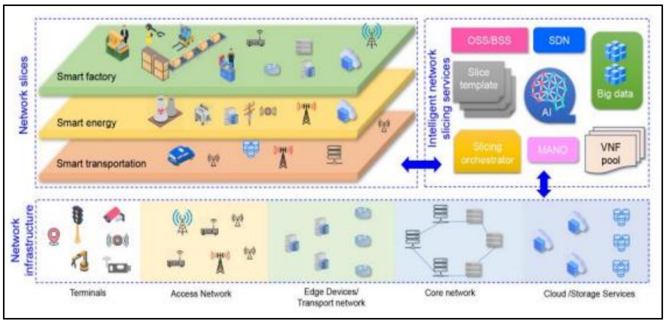

Fig 1: Intelligent network slicing management architecture for smart factories, smart energy, and smart transportation

Machine vision integrates AI, high-resolution smart cameras, and edge computing. Incorrect or incomplete packaging or labeling may be detected by AI-powered machine vision systems, which can then respond appropriately. Although it may detect issues, standard machine vision cannot classify them or determine what to do about them. 243 takes the right action after gathering additional photographs, classifies the fault, and AI-based machine learning improves. Industry cannot function without machine vision-based automatic optical inspection (AOI), which improves not only product quality and productivity but also competitiveness, according to study. A standard AI-based machine vision system, consists of a smart camera that has all the necessary sensors and software for AI integration. The camera is also connected to an online photo album. Everything is prepared to take a photo. The working distance is automatically adjusted while zooming in and out. This approach is called pre-processing automation. In real time, the image is being processed by the image processor. During this step, the pictures undergo a series of adjustments, such as reducing the color to grayscale and adjusting the sizes so they all seem the same. In order to provide predictions, the data extracted from the image is then processed using a number of algorithms. The program will reject many low-quality elements during picture processing.

Automated Optical Inspection (AOI) in smart manufacturing

In this day and age of Industry 4.0, one of the most essential aspects of any manufacturing facility is highly accurate quality control. This is due to the fact that inspecting the items before they are sold is an effective method to minimize delays in the supply chain and to maintain high quality standards. The AOI system is the one that is used most often for the examinations since it is a non-destructive approach. (NDT). The human eye is capable of picking up electromagnetic waves with wavelengths ranging from 390 to 770 nanometers (nm), and this range is called the human visual spectrum. Video cameras, on the other hand, are amenable to being altered such that they can detect a far wider spectrum of wavelengths.

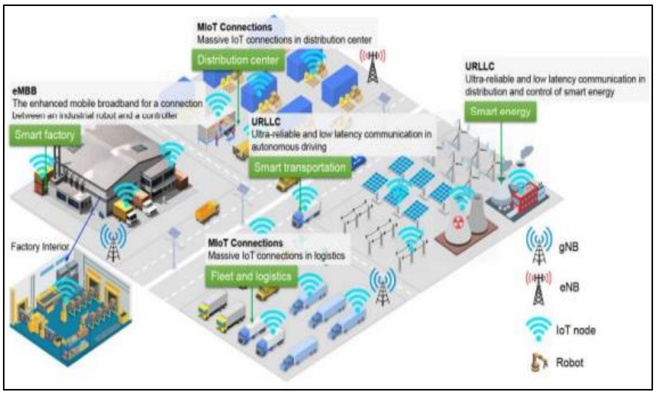

Fig 2: Critical requirements of IoT applications.

AI-Powered AOI

Electrical and electronic device designs have evolved over time, making them more difficult to examine using traditional AOI methods for quality checks. An AI-based AOI system picks up knowledge from a huge quantity of picture data from both successful and unsuccessful goods. The ruleset-based model that the AI software creates enables the built-in algorithm to efficiently grasp where and what to seek for. The more goods it scans, the more accurate it gets. High-resolution cameras powered by AI can do quality checks at any point along the production line and detect flaws in real-time, which makes it easier to pinpoint the cause of flaws, if any, in the early phases of production. In order to enhance the outcome and speed of the detection process, several manufacturers have lately incorporated machine learning and deep learning methods with AOI systems in their smart factory production lines. As a result, AOI enabled by AI enhances yield and fabrication processes and drastically decreases human labour.

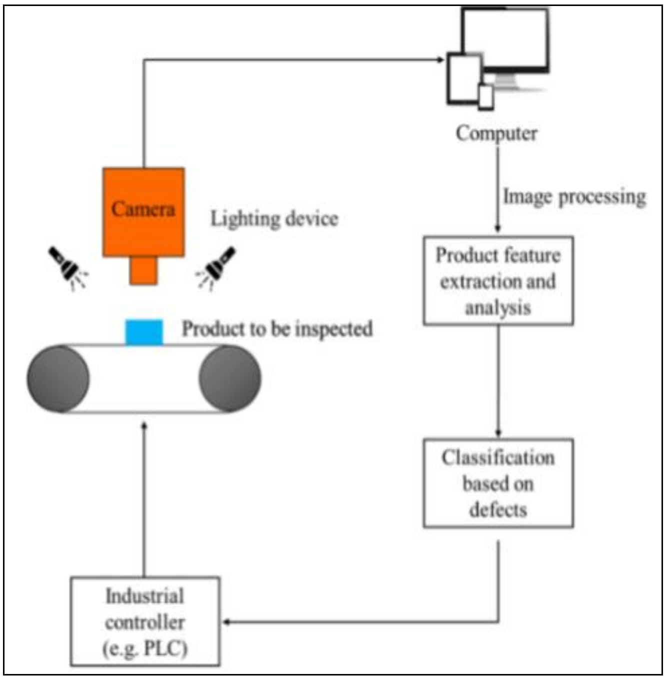

Fig 3: Schematic diagram of a basic AOI system

Challenges with smart manufacturing
No matter how sophisticated a system is, there are always significant security risks. Enterprises still encounter a number of difficulties even after using new, cutting-edge technologies in several plants to achieve smart manufacturing. Smart manufacturing capabilities are built on levels of technological complexity, integration, and automation that are well above those of conventional manufacturing processes, so there will always be new hazards. It is also disturbing because there is no consensus on security. The increase in cyber-attacks on smart factories shows that even present systems are vulnerable to several poorly understood security dangers. As a result, businesses are ill-equipped to deal with current security threats. Due to their limited financial resources, SMEs in particular have a very difficult time overcoming such impediments.

Data security
Ensuring data security is crucial for the widespread adoption of smart factories, which use IIoT and IoT to combine operational technology (OT), information technology (IT), and intellectual property (IP). By combining physical and virtual technology, smart factories enable interoperability and real-time operation. Cyberattacks are possible, however. A data breach might happen at any time during an online data exchange. Misuse of this sensitive information poses a continual threat to the industrial sector. One study found that 65% of companies think that cybersecurity is the main issue with IoT technology. Smart factory features like supply chain management, predictive maintenance, and real-time data monitoring might be completely disabled by only one hack.
This highlights the critical need for bulletproof cybersecurity in smart infrastructures. A report published in 2019 by Deloitte and the Manufacturers Alliance for Productivity and Innovation (MAPI) exposed several dangers linked to smart factories. Among these dangers, 48% of the factories polled saw operational risks, such as cybersecurity, as the most significant, a threat that could quickly derail production, company operations, and the market as a whole. Along with smart manufacturing practices, manufacturers should also offer cybersecurity training for all employees. Organizations should implement layered security measures to protect all networks and quickly react to external assaults on IT and OT systems.

System Interoperability and Integration
The gear of "smart factories" often incorporates modern technologies. But there can be issues with interoperability between more recent and older gadgets. The biggest obstacle is figuring out how to get machines talking to each other. For example, IPv6 connections are ideal for modern production systems since they allow for several devices to be linked simultaneously, which would not have been possible with older technology. When it comes to smart manufacturing, the biggest problems with autonomous machine interactions are the pervasive machine-to-machine connections and machine understanding. Furthermore, manufacturers are hesitant to make substantial expenditures due to their uncertainty about the new technology's return on investment (ROI). On top of that, smart manufacturing isn't always better when leveraging cutting-edge IIoT and AI technology. Studying their real experience providing solutions will be much more important in building an efficient smart factory and introducing new technology hardware and software. It is believed that these technologies would enhance system compatibility. When it comes to machine-to-machine communication, the following factors matter: Misunderstandings of the terminology used to transmit data between devices, inconsistent data formats, Internet of Things connections, and software compatibility are all problems. This is true even when different versions of the same vendor's product are considered. Smart manufacturing is an essential paradigm for the fourth industrial revolution because it promises end-user customization, higher product quality, and more factory efficiency. An integral part of Industry 4.0, smart manufacturing has emerged in recent years, and this article takes a look at its history and current status. We have also highlighted the influence of AI technology on the whole manufacturing process and provided extensive information on many smart manufacturing technologies. The highlighted topics are also topical and could provide academics and practitioners ideas for new research projects.
Manufacturers are opting to completely automate their factories in order to save labor expenses and accelerate output. Technology that uses artificial intelligence to analyze products for quality also helps ensure that only the best products make it to store shelves. Furthermore, smart manufacturing processes have been greatly enhanced by innovative concepts such as CPS, immersive technologies, additive manufacturing, IIoT/IoT, and additive manufacturing. Since these technologies are not commonly used in most industrial sectors, the concept of smart manufacturing varies substantially from the real production system. Perhaps this is because people are worried about the possible returns on investments in smart manufacturing technologies and don't fully grasp the difficulties and complexities of implementing such technology. Businesses and consumers alike stand to gain substantially from smart manufacturing's eventual implementation, despite the fact that the transition could be challenging at first.

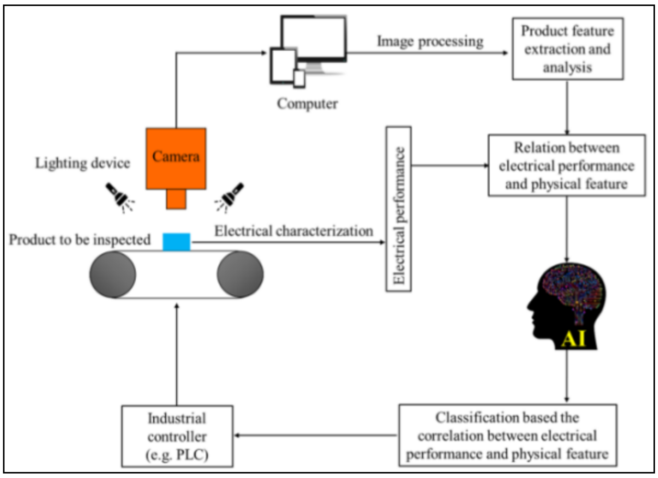

Fig 4: Schematic diagram of an AI-powered AOI system

Conclusion
In the future, there is great potential for Smart Water Metering to be integrated with other smart city technologies,

machine learning, blockchain, remote sensing, and Internet of Things devices to develop water management systems that are more intelligent and sustainable. The capacity of these systems to resolve environmental issues and guarantee data privacy and security while balancing the demands of many stakeholders-including water utilities, customers, and regulatory bodies-will determine their success. We can make sure this important resource is managed carefully for future generations by keeping inventing and developing innovative technology and methods for water management. Smart water metering systems promote more conscientious and responsible water use by giving users real-time feedback on their water usage. This, in turn, leads to lower water usage and conservation efforts. Utilities are able to respond quickly and effectively to water loss issues when smart water metering systems identify leaks and other distribution system irregularities in real-time.

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