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The integration of IoT with other emerging technologies in smart manufacturing

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Abstract

The incorporation of IoT technology into production procedures and industrial systems represents a significant shift towards Industry 4.0, where Productivity, efficiency, and new ideas are propelled by data collected in real-time via interconnected devices. Focusing on how linked equipment and smart sensors improve operational efficiency, decrease downtime, and allow predictive maintenance, this research investigates the effects of the Internet of Things (IoT) on the industrial sector.

Keywords: Utilising, IoT, efficiency, better, acceleration, etc.

Introduction

Looking forward, 5G is going to be the game-changer for how the Internet of Things develops. According to Gartner (Citation 2021), the market's anticipation of 5G's present and future potential is evident from the fivefold growth in the number of patent applications for the technology from 2015 to 2021. This trend is expected to continue in the coming years. With 5G networks, manufacturers have access to new possibilities, such as the acceleration of the Internet of Things (IoT) via improved device connection and communication and quicker data transfer rates. However, cyber security threats are present with this potential (Citation 2018). There will be a transition from hardware to software networks, and 5G will need a physical makeover of networks with more IoT devices. Nevertheless, the software will bring new vulnerabilities to the network and worsen current threats, as these networks include collecting sensitive data in enormous numbers that are shared across an expanding number of linked devices. Further, IoT advancements in the future will heavily include machine intelligence, edge computing, and adaptable supply chains. As a result, the expansion of the Internet of Things is certain to happen, and the opportunities for study are vast.

There has been a steady increase in both the number of articles on IoT and the number of projects incorporating it into various industries over the last decade, thanks to the rapid development of digital transformation tools. Some of the current literature on the uses of the Internet of Things is based on reviews that have looked at it from different fields. Brites *et al*. (Citation 2022) laid the framework for future research in the medical sector by reviewing the literature on the uses of the internet of things (IoT) in illness detection using cardiac sounds. Ghosh, Edwards, and Hosseini (Citation 2020) identified knowledge gaps in current research by outlining the main drivers of IoT growth in the construction sector, namely the organisational and economic-related obstacles. According to Hipsher and Duffy's (Citation 2021) literature analysis on the topic of Internet of Things (IoT) in manufacturing, the sector has made significant strides forward while still facing some serious challenges. Katoch (Citation 2022) indicated the function of the Internet of Things (IoT) in logistics-related supply chain management and found possible avenues for further study. Additionally, Gupta (Citation 2021) investigated the current state and future directions of the IoT scientific literature by cataloguing publishing patterns, top institutions, journals, and nations, as well as the most prolific writers. Despite the abundance of literature based on reviews, none have examined the Internet of Things (IoT) from an industrial management perspective. This means that the current assessment of industrial management knowledge is lacking some important information. The need for literature reviews in this field is growing in tandem with the industry's adoption of IoT applications. It is necessary to compile the pertinent literature in order to facilitate practitioners' access to knowledge and to enable relevant researchers detect future trends. Consequently, a scientific description of the Internet of Things' uses in manufacturing management is required.

From smart buildings and cities to smart factories, Industry 4.0 encompasses the use of smart sensors, the Internet of Things (IoT), and big data. Banking, commerce, government, education, information transmission, the service sector, and many more fields have found extensive uses for the Internet. Another new concept that has emerged with the advent of the fourth industrial revolution and is having a significant influence on the manufacturing industry is the internet of things. Smart Factories, made possible by the widespread use of the Internet of Things, allow for the interconnection and communication of various production resources and equipment. That can be accomplished if all of an enterprise's machine tools, resources, and current IT tools are linked to the internet, either directly or via external adapters. The sensors built into industrial equipment facilitate data collecting in an IoT-enabled system. Beacon technology and radio frequency identification are two crucial components of wireless sensor networks (WSNs) that allow devices to communicate with one another. Utilising data analytics made possible by the Internet of Things is crucial in smart manufacturing for increasing efficiency and making better use of assets. The industrial workforce will be more equipped to handle the growing complexity of markets and the unpredictable nature of consumer demand if they have access to data that is both new and old, as well as data generated by analytics.

Literature Review

Paya Ghashghaee (2016) [1] Process optimization in the manufacturing area within a business-to-business setting is the main emphasis of this study. The purpose of the research is to identify problems that manufacturers encounter on the production floor and to provide solutions to those problems. Many researchers and industry professionals have begun to pay close attention to the IoT in the last 10 years. The significance of physical things transmitting data via software and the Internet is highlighted by the Internet of Things (IoT). There is an obvious need for firms to concentrate on how they can use IoT to help their company and generate new business and market prospects based on current global trends. Through the Internet of Things (IoT), a wide variety of everyday items may be linked and made to communicate with one another. Connecting stakeholders and end-users is just one more way that IoT technologies bridge the gap between various industrial systems and supply chains. The purpose of this thesis is to delve into detail about the Internet of Things (IoT) and its applications in production. Internet of Things (IoT) applications in manufacturing facilities were the subject of a single empirical case study. Being an early adopter of Internet of Things (IoT) technology in manufacturing and having highly optimised output at some plants were the two criteria used to choose the examples. Internet of Things (IoT) technology, and RFID solutions in particular, play a significant role in the future generation of smart factories, as these scenarios illustrate.

Weng Chun Tan *et al*. (2022) [2] Both the complexity and the rate of change in supply chain management (SCM) are on the rise. The supply chain is anticipated to rely heavily on radio frequency identification (RFID) and the Internet of Things (IoT) to meet client demands. The term "RFID-IoT" is used to describe the combination of radio frequency identification and the internet of things in this study. By linking IoT devices across the internet, RFID-IoT aspires to create systems that automatically sense, are seamless, interoperable, and very secure. This study presents the results of a literature review that focused on RFID-IoT and its potential uses in supply chain management. This study makes a contribution by surveying the existing research and future directions on the use of RFID-IoT in supply chain management. To maximise production, minimise cost, and improve the efficiency of the management system, a thorough evaluation of current literature is required. In addition, the evaluated articles discuss the present difficulties of RFID-IoT deployment in the supply chain. The four main key SCM viewpoints—product production, shipping and distribution, inventory, and retail shop—have been used to perform the conceptual framework model. More work on building RFID-IoT technologies should be possible in the future thanks to the insights and suggestions highlighted in this assessment.

Mohsen Soori *et al*. (2023) [3] The Internet of Things (IoT) is playing a significant role in the transformation of traditional factories into smart factories in Industry 4.0 by using network of interconnected devices, sensors, and software to monitor and optimize the production process. Predictive maintenance using the IoT in smart factories can also be used to prevent machine failures, reduce downtime, and extend the lifespan of equipment. To monitor and optimize energy usage during part manufacturing, manufacturers can obtain real-time insights into energy consumption patterns by deploying IoT sensors in smart factories. Also, IoT can provide a more comprehensive view of the factory environment to enhance workplace safety by identifying potential hazards and alerting workers to potential dangers. Suppliers can use IoT-enabled tracking devices to monitor shipments and provide real-time updates on delivery times and locations in order to analyze and optimize the supply chain in smart factories. Moreover, IoT is a powerful technology which can optimize inventory management in smart factories to reduce costs, improve efficiency, and provide real-time visibility into inventory levels and movements.

Tahera Kalsoom *et al*. (2021) [4] Although the idea of the fourth industrial revolution has come to fruition with the Internet of Things (IoT), research into its potential uses in manufacturing has been limited and has mostly ignored contextual factors. Addressing this gap, our study delves into a comprehensive critical analysis of IoT applications in manufacturing from an Industry 4.0 viewpoint. on order to conduct critical assessments that contribute to the development of future research topics grounded on empirical studies, we follow the methodology of Denyer and Tranfield (2009) and conduct a systematic literature review. We identify six major distinctions between conventional and manufacturing Industry 4.0, ten facilitators and eleven inhibitors of IoT applications, and we detail important gaps in the current body of literature and empirical research by investigating the primary contributor categories. up conclusion, eleven study fields are suggested as a roadmap for future studies to fill up the identified gaps.

This study provides a systematic empirical assessment of state-of-the-art smart manufacturing technologies, with a focus on data analytics, robots, the Internet of Things (IoT), and machine learning and artificial intelligence (AI). There has been a considerable improvement in the workers' skills, according to the studies. Employee 2's machine learning competency increased by a staggering 30%, while Employee 3's robotics proficiency increased by 50%. Line B's 0.7% efficiency increase suggests that process improvements are still possible, whereas the rest of the production lines demonstrated room for advancement in terms of line efficiency. To ensure optimal machine performance, continuous monitoring and maintenance are necessary, as shown by sensor data analysis. Stricter standards were needed to decrease product problems, according to data from quality control. Smart manufacturing technologies have the ability to revolutionize several aspects of production, such as workforce development, technology adoption, and process optimization. This research adds to our understanding of these possibilities and their consequences for improved quality and efficiency.

The industrial internet of things: A conceptual framework

One idea that is changing the face of manufacturing is the IIoT, or Industrial Internet of Things. In this context, "Internet of Things" means the seamless combination of analogue and digital infrastructures, allowing for the simultaneous transmission and reception of data. Increased output with less waste and lower operating expenses are the end outcomes.

Connectivity, sensors and devices, data analytics, and applications make up the four main pillars of an IIoT conceptual architecture. For the IIoT to work, each of these parts is essential.

Sensors and Devices

The first component of the IIoT is sensors and devices. These devices are embedded with sensors that collect data about the physical world, such as temperature, pressure, vibration, and motion. They can be anything from simple sensors to complex machines that perform specific tasks. The data collected by these sensors is then transmitted to the next component of the IIoT, connectivity.

Connectivity

The second component of the IIoT is connectivity. This refers to the various networks and communication protocols that allow the sensors and devices to transmit data to other devices or systems. These networks can be wired or wireless, and they can use various communication protocols such as Bluetooth, Wi-Fi, or cellular networks. The data transmitted over these networks is then processed by the next component of the IIoT, data analytics.

Data Analytics

The third component of the IIoT is data analytics. This component is responsible for processing and analyzing the data collected by the sensors and devices. This analysis involves identifying patterns, trends, and anomalies in the data to generate insights that can be used to improve productivity, efficiency, and safety. Data analytics can also be used to predict equipment failures and other operational issues before they occur, allowing for proactive maintenance and reducing downtime.

Applications

The final component of the IIoT is applications. This refers to the software and tools that are used to interpret and act on the insights generated by the data analytics component. These applications can be anything from a simple dashboard displaying real-time data to a complex system that automatically adjusts production processes based on the data collected by the sensors and devices.

In the Industrial Internet of Things (IIoT) is a powerful concept that is transforming the manufacturing industry. It is built upon four key components: sensors and devices, connectivity, data analytics, and applications. These components work together to enable real-time communication, data analysis, and decision-making, resulting in improved productivity, efficiency, and safety.

The Industrial Internet of Things (IIoT) has the potential to revolutionize the way manufacturing operations are conducted. By connecting devices and machines to digital networks and analyzing data in real-time, manufacturers can gain greater visibility into their operations and make data-driven decisions that lead to improved efficiency, increased productivity, and reduced costs.

Sensors and Devices

Sensors and devices are at the heart of the IIoT. They collect data about the physical world and transmit that data to other devices or systems. Sensors can be used to monitor everything from temperature and humidity to equipment performance and energy consumption. By gathering this data, manufacturers can gain a better understanding of their operations and make more informed decisions.

Connectivity

Connectivity is the glue that holds the IIoT together. It enables devices to communicate with one another and transmit data over a variety of networks and communication protocols. For example, devices can use Wi-Fi or Bluetooth to communicate with one another within a facility, or they can use cellular networks to transmit data over long distances.

Data analytics

Data analytics is where the magic happens in the IIoT. By processing the vast amounts of data generated by sensors and devices, manufacturers can gain insights into their operations that were previously unavailable. This can include identifying patterns and trends in data, predicting when equipment will fail, and optimizing production processes to improve efficiency and reduce costs. Applications are the final piece of the IIoT puzzle. They provide manufacturers with the tools they need to interpret and act on the insights generated by data analytics. Applications can include dashboards that display real-time data, machine learning algorithms that automatically adjust production processes, and augmented reality tools that enable workers to visualize data in new ways. Together, these four components create a powerful framework for the IIoT that can transform the way manufacturing operations are conducted. By leveraging the IIoT, manufacturers can gain a competitive edge by improving their efficiency, reducing costs, and delivering better products to their customers.

The case of additive manufacturing: applied conceptual framework

We use the established dual axis model to portray our conceptual framework in a broader context by using additive manufacturing, a revolution taking place across many sectors. A technical advancement known as additive manufacturing has recently received increasing interest and is proven to be a feasible path for technological advancement across all industries. Although it is unquestionably a hot topic, academic research on the issues raised by this breakthrough has mostly focused on optical engineering or architecture and design from a technical standpoint. The originality of our article lies in the use of the conceptual framework created in this paper to approach this innovation from a management viewpoint.

Additive Manufacturing

Digital manufacturing, generally understood as the integration of digital and manufacturing technologies through the automated control of machinery and computers, encompasses additive manufacturing, which entails building things by stacking materials. Internet expansion has allowed for more information exchange, which in turn has improved the Big Data environment's use of this data. The use of process innovation to additive manufacturing has been suggested by Kruth *et al*. (1998) [14]. One method of production that uses many technologies to fabricate goods by creating and adding successive layers of material is known as additive manufacturing. Our process involves subtractive manufacturing, in which we remove material from a solid rather than adding it, as is the case with many traditional production processes like as turning and milling. This innovation is derived from new technology, such 3D printers, which may be used for both prototyping and the direct production of completed or semi-finished things. Lipson and Kurman (2013) [13] classify three primary forms of additive manufacturing: powder, liquid, and solid. To begin, powders of metal, silicate, or thermoplastic may be sintered (fused) using the Selective Laser Sintering (SLS) method. The apparatus fuses particles in successive layers on a surface that is lowered in stages. A wide range of raw materials with high mechanical and thermal yields may be used with this technology, which is its main advantage.

Second, stereolithography (SLA) uses optical equipment to concentrate a laser on a work surface, which polymerizes liquid resin and allows for the layer-by-layer construction of things. After retrieval, the product will be heated in a UV oven to solidify the substance and get it ready for further processing. Due to the time required to make each item, SLA is currently only used for small numbers (such as personalized jewelry) even though it is superior than other additive processes in generating components with difficult geometries and surfaces (Dimitrov, Schreve, and De Beer, 2006) [12]. Finally, Fused Deposition Modelling (FDM) is comparable to an inkjet printer, except that thermoplastic polymer is used in place of ink. On the different layers, they are solidified. Here, the machine builds a three-dimensional item along the X, Y, and Z axes using plastic material, so it's instantly usable or colorable. Some examples of solid materials include plastics and rubbers, such as ABS, PLA, PPSF, polycarbonate, and politermide. The most enthusiastic adopters of this technology have been those associated with the "makers" movement, who have made it a pillar of digital manufacturing because to its affordability (Zein *et al*., 2002) [11]. The first uses of additive manufacturing were in prototyping. This technology has lately made great strides and is now being used in production. Many people now think that producing completed goods is the most important "frontier" for the future expansion of 3D printing.

Additive manufacturing and the IoT

Since every linked device produces data that can be collected and analyzed, the relationship between data flow and the IoT is easy to understand. More consideration is required before drawing any conclusions about the connection between 3D printing and the Internet of Things. Because of this, we suggest that the developed conceptual framework might be a useful resource for understanding this connection and for generating new research on the topic. Stage 1 of our framework states that all additively made and 3D printed objects must include a unique identifier, such as an RFID tag, to aid in the identification of Internet of Things devices (IoT). 3D printing is used to create it. One possible application for the item's substance is to generate unique 3D codes (Lakafosis *et al*., 2010) [10]. The ability to include readily readable codes into the goods makes it possible for any item manufactured in this manner to join the IoT straight immediately. Plus, RFID's continual price drops have enticed companies all over the globe to incorporate it into new product and process development, substantially increasing its use. The second stage involves products that are both uniquely recognizable and equipped with active sensors; these sensors are linked directly via a pre-embedded code. If readable programs could be immediately integrated into any item generated in this fashion, it may be readable.

Future manufacturing using internet of things

The future of manufacturing lies in the integration of the Internet of Things (IoT) into the production process. By connecting devices and machines to digital networks, manufacturers can gain greater visibility into their operations and make data-driven decisions that lead to improved efficiency, increased productivity, and reduced costs. Let's take a look at some of the ways IoT will transform the manufacturing industry:

a. **Predictive Maintenance:** The IoT can be used to monitor machines and predict when maintenance is required. By collecting data on machine performance, manufacturers can identify when a machine is likely to fail and schedule maintenance before a breakdown occurs. This can help reduce downtime and increase productivity.

- **b. Real-Time Quality Control:** The IoT can also be used to monitor the quality of products in real-time. By connecting sensors to machines, manufacturers can monitor the quality of products as they are being produced. This can help identify quality issues early on and enable manufacturers to take corrective action before a large number of faulty products are produced.
- **c. Supply Chain Optimization:** The IoT can also be used to optimize the supply chain. By collecting data on inventory levels, production schedules, and shipping times, manufacturers can optimize their supply chain to reduce costs and improve efficiency. This can include everything from optimizing shipping routes to adjusting production schedules based on inventory levels.
- **d. Autonomous Robots:** The IoT can also enable the use of autonomous robots in manufacturing. By connecting robots to digital networks, manufacturers can program them to perform tasks autonomously, such as moving materials or assembling products. This can help increase efficiency and reduce the need for human labor.
- **e. Smart Factories:** Finally, the IoT can enable the creation of smart factories. By connecting all machines and devices in a factory to a digital network, manufacturers can create a fully integrated and automated production process. This can help increase efficiency, reduce costs, and improve product quality.
- **f. Personalized Products:** With the IoT, manufacturers can produce more personalized products to meet the demands of individual customers. By collecting data on customer preferences, manufacturers can tailor products to meet their specific needs. This can include everything from custom colors and sizes to unique product features.
- **g. Energy Efficiency:** The IoT can also be used to make manufacturing operations more energy-efficient. By collecting data on energy usage, manufacturers can identify areas where energy is being wasted and take corrective action. This can include everything from adjusting production schedules to using more energy-efficient equipment.
- **h. Enhanced Safety:** The IoT can also enhance safety in manufacturing. By collecting data on worker behavior and machine performance, manufacturers can identify potential safety hazards and take corrective action before accidents occur. This can include everything from adjusting machine settings to providing workers with additional safety training.
- **i. Digital Twins:** Finally, the IoT can enable the creation of digital twins of manufacturing operations. A digital twin is a virtual replica of a physical asset or system that can be used to simulate and optimize its performance. By creating digital twins of manufacturing operations, manufacturers can test new processes and identify potential issues before implementing them in the physical world.

In the IoT has the potential to transform the manufacturing industry in numerous ways, from improving efficiency and productivity to enhancing product quality and safety. As IoT technologies continue to evolve, we can expect to see even more exciting innovations in the future of manufacturing the integration of IoT into manufacturing processes is the future of manufacturing. By leveraging the power of IoT, manufacturers can optimize their operations, reduce costs, and improve product quality.

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. 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.

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