Volume (2) No (2), 2026
Journal of Global Research in Multidisciplinary Studies (JGRMS)
Review Paper/Research Paper
Available online at https://saanvipublications.com/journals/index.php/jgrms/index

Survey on Integration of IoT with Artificial Intelligence (AI) Technologies for Smart Manufacturing Operations

Dr. Prithviraj Singh Rathore
Assistant Professor
Department of Computer Sciences and Applications
Mandsaur University
Mandsaur
prathviraj.rathore@meu.edu.in

***Abstract*—The IoT and AI are assisting in the development of smart, interconnected, and flexible industrial systems, which in turn are facilitating the evolution of manufacturing. Through its network of interconnected sensors and devices, the Internet of Things (IoT) facilitates the automation of various stages of the manufacturing process. AI adds value by providing detailed analysis, making predictions, and helping with decisions that make workflows smoother, cut down on stops in production, and improve product quality. Together, these technologies form the base of Industry 4.0, which supports eco-friendly practices, better use of resources, and gives companies an edge in the global market. Recent studies show that combining IoT data with AI insights is used in areas like predicting equipment failures, making processes more efficient, managing energy use, building reliable supply chains, and using smart robots. All these improvements help manufacturers be more adaptable, lower the chances of problems, and make products that meet customer needs. This overview shows how combining IoT and AI is making manufacturing more self-sufficient, driven by data, and stronger, which greatly helps in the ongoing development of modern industrial practices.**

Keywords—IoT integration, Artificial Intelligence, Smart Manufacturing, Industry 4.0, Industrial Automation

I. Introduction

The implementation of state-of-the-art digital technology, sometimes called "Industry 4.0," is a typical shift in the manufacturing industry. The other category of industrial transformation is smart manufacturing where the operations are based on connectivity, automation and smart decision making [1]. This is due to the fact that this change is inevitable as there is increasing demands of efficiency, economies of scale and price competition in the global markets [2]. In that regard, the IoT and AI became priceless sources of new ideas that would enable manufacturers to transition to the paradigm of totally data-driven and flexible systems, as opposed to streamlining processes.

Smart manufacturing relies on the interconnection of many devices, sensors, and production lines to form an ecosystem. The Internet of Things has quickly become a crucial component of this model. Businesses may learn a lot about the efficiency of their operations from the data collected in real-time, the health of their equipment monitored, and the automated processes given by the Internet of Things [3]. Manufacturers can use IoT to improve resource utilization, establish supply chain visibility, and accomplish predictive monitoring [4]. Furthermore, IoT devices are crucial for reducing downtime and enhancing workplace safety by creating an atmosphere that allows digital and physical systems to freely communicate. However, despite these advancements, concerns about data security, interoperability, and scalability remain pertinent.

The Internet of Things benefits greatly from AI's data analytics and decision-making capabilities. Artificial intelligence (AI) methods like deep learning, reinforcement learning, and machine learning have numerous potential uses, including quality control, production scheduling, defect identification, and predictive maintenance [5]. Because they enable systems to automatically adapt to changing conditions and streamline procedures, these applications increase productivity. The IoT collects massive amounts of data, which artificial intelligence systems may then use to make sense of complicated and unpredictable production environments [6]. The application of AI in industrial settings has also made it easier for humans and machines to collaborate, which has increased productivity and reduced operational risks.

A state-of-the-art concept in intelligent industrial processes, the merging of IoT and AI is known as Artificial Intelligence of Things (AIoT). This connection removes the need for a human operator and enables intelligent decision-making, disruption prediction, and real-time data analysis [7]. An Internet of Things (IoT) is necessary for the creation of cyber-physical systems, digital twins, and smart factories, where the virtual process mimics the physical one to optimise it. Integrating the connectivity of IoT with the intelligence of AI, manufacturers attain more adaptability and agility as well as resilience in their production processes.

A. Structure of the paper

The structure of the paper is the following: Section II dedicated to IoT in smart manufacturing, its architecture, components and challenges. Section III discusses AI applications, while Section IV presents IoT–AI integration frameworks and big data applications. Section V reviews key literature, and Section VI concludes with future research directions.

II. Internet of Things (IoT) In Smart Manufacturing

The three primary building elements necessary for IoT-integrated smart manufacturing are illustrated in Figure 1. Here have the sensing nodes as the initial component [8]. The sensing devices used in an Internet of Things (IoT) environment can vary significantly depending on their application. It could be anything from a simple thermocouple to a Radio Frequency Identification (RFID) reader that can tell if an object or person is there to a camera that can watch images [9]. The second element consists of embedded processing nodes, which are capable of real-time embedded processing and can be either microprocessors or hybrid microcontrollers. A communication node is a third component that can be wired or wireless. Data and instructions from the first two components must be relayed to it. It is frequently a node that permits bidirectional communication.

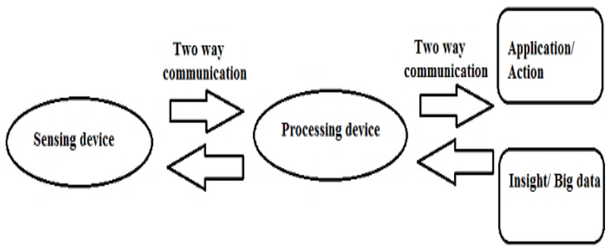

Fig. 1. Building Blocks of an Iot-Enabled Smart Manufacturing

A. IoT Architecture and Components

In order to fully understand the IoT paradigm, one must understand its architecture and constituent parts, with a focus on the interoperability, scalability, and extensibility of the numerous and ubiquitous IoT components. Platforms, IoT devices, and IoT gateways are the three primary parts of these elements [10]. The components that make up the IoT ecosystem are hardware and software that are connected by a variety of networking technologies and protocols. The actual gateways and networks that gather and transfer data make up the hardware.

- **Devices:** The IoT refers to intelligent machinery that can collect, receive, store, and process data as needed, as well as communicate with other systems and devices. It can follow directions with or without human assistance.
- **Gateways:** The gateway is a potentially important linked entity in an IoT ecosystem because it mediates data flows between end users and IoT devices and can mediate among networked devices using heterogeneous communication protocols.
- **Networks:** The IoT could be seen by network researchers as an interconnected set of disparate networks. In this category of networks, you'll find mobile networks, WLANs, LPWANs, and WSNs, or wireless sensor networks. They facilitate communication, data sharing, and internet connectivity among Internet of Things (IoT) devices, of which they are a part. Better decision-making by customers is aided by all of these.

B. Industrial IOT For the Manufacturing Sector

The growing impact of high-tech technology on the manufacturing sector informed the German strategy initiative Industry 4.0, which aims to dominate the market and provide advanced manufacturing solutions. The Industrial Internet of Things is considered by academics to be one of the most crucial parts of Industries 4.0. I also investigated how local New Zealand manufacturing SMEs might gain from IoT implementation [11]. Local companies may be able to benefit from the IoT by modelling their operations after Industry 4.0, which incorporates the IoT. This model holds the potential to improve and change small and medium-sized firms in the future. So that understand how the Fourth Industrial Revolution differs from the Third. The German Electrical and Electronic Manufacturers' Association (ZVEI) has introduced RAMI 4.0, which is a major win for industry 4.0 initiatives. As a result of the proposal's global success, top firms have begun creating their own reference models to implement Industry 4.0 initiatives.

C. Challenges of IoT Adoption in the Manufacturing Sector

IoT technology has indisputable advantages, but before a fully operational IoT system can provide those advantages, it is necessary to address the obstacles to IoT adoption [12], Table I below, Several difficulties with the implementation of the IoT in manufacturing have been recognized:

TABLE I. CHALLENGES OF IOT ADOPTION IN THE MANUFACTURING SECTOR

Sr. No.	Challenges to Adopt IOT
1	Privacy and security concerns
2	Changes to the company model and the risks they entail
3	High initial investment cost for implementation
4	Lack of Standardization
5	Lack of SMEs related concepts
6	Data Safety and System Reliability
7	Lack of skilled / expertise Manpower
8	Staff members' resistance to embrace innovative technology

A big worry about data security is the constant sharing of massive amounts of data through the Internet of Things. To reduce risks to data security, authentication, authorization, and access control systems are necessary. Data privacy is also an important issue because of the amount of personally identifiable information (PII) and industry-specific data shared by these interconnected devices.

III. Artificial Intelligence (AI) In Smart Manufacturing

Artificial Intelligence (AI) in intelligent manufacturing is radical and radical [13]. Industry 4.0 focuses on these technologies which are facilitating the shift towards smart manufacturing rather than the traditional manufacturing. An analysis of their responsibilities reveals the following:

A. Data Analysis and Decision-Making

Artificial intelligence systems are highly effective at handling and analyzing the enormous volumes of data produced by industrial operations. The sources of such data may include sensors, machine, and others. They are able to establish patterns, anomalies, and correlations in the data and make decisions using data. In the form of real-time insights, manufacturers are able to streamline operations, quality management, and resource allocation.

B. Predictive Maintenance

AI are used to predict maintenance. These technologies can be used to forecast the need to perform maintenance by examining past and current data utilizing machinery and equipment [14]. This proactive strategy is minimized unplanned downtimes and minimized maintenance costs because maintenance work is carried out when needed and not on a set schedule.

C. Process Optimization

AI algorithms have the capability to optimize manufacturing operations by adjusting them on-the-fly. An example is that they are able to set machines to maximize energy usage or change production plans in response to changes in demand. Additionally, these technologies can highlight bottlenecks and inefficiencies on production lines and make recommendations.

D. Quality Control

AI is used to improve the quality control process. It checks photos, sensor data, and other information related to quality. This helps identify issues or problems that don't meet quality standards. By catching these problems early in the production process, faulty items can be fixed before they become bigger issues. This results in less waste and better-quality products overall.

E. Supply Chain Management

Artificial intelligence helps make supply chain operations faster and easier. It can manage the best amount of inventory, predict customer demand, and stop problems in the supply chain before they happen. Because of this, the supply chain runs better and cheaper, which shortens the time it takes to get products to customers and makes the whole process more flexible.

1) AI Techniques and Algorithms

DL, GA, fuzzy logic, NN, and ML are all components of AI Modern electrical automation control systems couldn't function without these technologies, which enable complex data processing, pattern identification, and decision-making.

a) Machine Learning (ML)

Machine learning (ML) is an important artificial intelligence technology that shows how computers may learn and get better with time. Critical areas in electrical automation include fault detection, energy management, predictive maintenance, load forecasting, and process optimization.

b) Neural Networks (NN)

Neural networks, which are computing models inspired by the brain, are very good at finding complex patterns in big sets of data. They are used in making processes more efficient, predicting how much load will be needed, fixing problems before they happen, and finding issues in electrical automation systems.

c) Fuzzy Logic

A method called fuzzy logic is used to make smart guesses instead of strict yes-or-no choices. It helps in managing control systems, finding faults, and making decisions when conditions are not constant. This technique is especially useful in electrical automation to handle situations where things are not clear, not exact, or behave in complex ways.

d) Genetic Algorithms (GA)

Genetic algorithms are types of optimization methods that work like natural and genetic selection in nature. They are frequently used in electrical automation to address a variety of complex optimization issues, such as resource allocation, fault detection, load scheduling, and control parameter tuning.

e) Deep Learning (DL)

The term "deep learning" (DL) refers to a method of data analysis and interpretation that makes use of neural networks with multiple layers. Anomaly detection, predictive maintenance, intelligent control systems, and energy demand forecasting are some of the uses of electric automation.

2) Applications of AI in Manufacturing

Industry 4.0 relies heavily on AI and related concepts, which are finding increasing use in areas such as industrial automation, scientific machine learning, computational experimentation, process and product design, and optimal production operations [15]. Figure 2 shows the variety of AI/ML uses in several business domains, including design, automation, operations, and more. Designing processes and products is farther down the road in terms of industrial demonstration and adoption than scientific machine learning and real-time AI-driven automation. AI end goal is to facilitate process automation, data pattern and insight discovery, and improved decision-making for operational and product development enhancement by enterprises. In this section, take a look at the goal, possible advantages, and difficulties of AI techniques in manufacturing strategies.

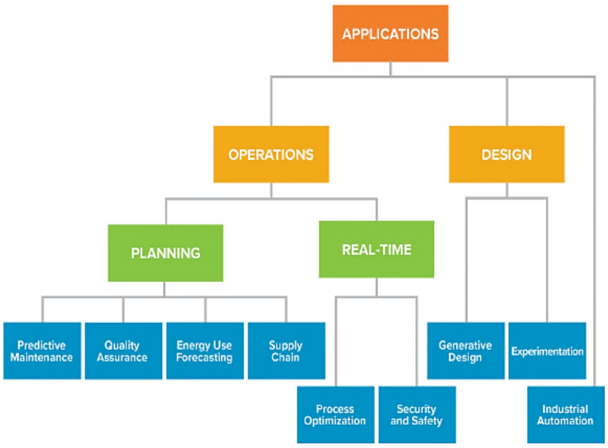

Fig. 2. AI Applications in the Manufacturing Industry

3) Challenges of AI in Manufacturing

The global scientific development of AI for industrial purposes brings with it a number of possibilities and threats [16]. While research output is growing rapidly, disparities across regions and infrastructure limitations hinder the equal adoption of research worldwide. Several key considerations are outlined below:

- **Inequality in scientific production**: There is a significant disparity among countries in the quantity and quality of AI in manufacturing publications, leading to uneven adoption.
- **Risk for less-developed countries**: Countries that produce less research and have a smaller impact may struggle to keep up with other nations in terms of industrial strength because they aren't using AI in their manufacturing processes as much.
- **Technical and infrastructure difficulties**: Integration into Industry 4.0 is hindered for many nations due to a lack of comprehensive data monitoring and analysis capabilities.
- **Regional concentration of research**: Research from the Americas, Africa, and Oceania is few compared to that from Europe and Asia, limiting its global application.

- **Commercial viability issues**: A lack of facilities and poor acceptance of new technology make advancements like predictive maintenance impractical in many places.

IV. IOT AND AI INTEGRATION FRAMEWORK FOR SMART MANUFACTURING

AI and the IoT have revolutionized numerous industries over the past decade. These industries include medicine, farming, transportation, finance, and smart cities. IoT leverages sensors, smart devices, cloud storage, and connectivity to enable real-time data exchange, while AI employs algorithms like machine learning to derive insights and support intelligent decision-making [17]. In smart manufacturing (Industry 4.0), their integration creates highly efficient and adaptive systems by combining manufacturing processes with advanced communication and information technologies [18]. IoT facilitates interconnection among smart devices for seamless data flow, whereas AI enables process optimization, fault detection, predictive maintenance, and feedback control. Unsupervised learning techniques further enhance data analytics, enabling real-time adaptability and continuous improvement in smart factories.

A. IoT-Enabled Data Acquisition in the Built Environment

The flexibility of automated sensing systems to adapt to various living contexts is a significant asset. The proliferation of Internet of Things (IoT) devices that can sense, identify, and communicate is forcing a revaluation of numerous manual and semi-automated facility systems. Based on previous studies, we've learned that IoT devices have been considered useful in a variety of situations [19] and for limited purposes. Secretiveness (of the sensor): obtaining the information about the corresponding parameter for which the sensor was actually installed is one of the criteria among multiple ones leading into sensor selection [20]. For instance, to monitor the air quality inside the structure, sensors are used to detect (but not limited to) measures such as air velocity, particulate matter presence, volatile organic compounds, and gaseous components such as carbon dioxide and others. Temperature and humidity sensors can provide better knowledge of how the environment in your building's indoor space would be affected by temperature and humidity. Photometric sensors also make it possible to automatically regulate the intensity of luminaires to ensure both light and ideal visual comfort levels. The capacity of sound pressure sensors and accelerometers to monitor the intensities of pressure waves and vibrations makes them useful tools for assessing vibrational disturbances and noise pollution.

B. Iot Enabling Technologies

IoT systems are made up of functional blocks that help the system do different things, like recognizing, identifying, acting, communicating, and managing [21]. Thus, various types of technologies that facilitate the IoT can be grouped into various types of hardware, software, cloud platforms, communication, positioning, data processing, energy storage, identification and recognition, power, security, etc. The technologies that enable the Internet of Things are outlined in a functional block format, with four primary domains. The purpose of this categorization is to offer a clear and succinct summary of current concerns and outstanding issues. Each of these areas, or system layers, contains a unique set of software, hardware, and other technologies. To fully deploy IoT technology, these domains must be integrated into the IP infrastructure. Internet of Things (IoT) platforms are well-suited to incorporate a number of technologies that make IoT possible. These platforms separate the software running on the things from their physical components and act as an intelligent layer between the things and the network; this allows for the establishment of services.

C. Applications of Big Data in Manufacturing

Manufacturing firms frequently utilize manufacturing data for operational objectives. There are various ways big data can be used in manufacturing, such as [22]:

1) Preventive Maintenance

Regular machinery availability is critical to operational efficiency. Minimizing downtime and maximizing total production, manufacturers can use big data analytics to track equipment health in real-time, anticipate possible problems, and plan maintenance proactively.

2) Product Design

Big data analytics can help lower development risks by sifting through mountains of data in search of patterns, consumer tastes, and shifts in the market. Smarter, data-driven decisions and more competitive innovations can be achieved by incorporating these insights into the product design process.

3) Production Management Automation

The most difficult use of big data to manufacturing operations is likely to be the automation of production management. Manufacturing management automation is exemplified by GE's wind turbines. The wind turbine's blade pitch is adjusted based on data collected from sensors that measure energy generation and wind direction. This allows the turbine to operate at peak efficiency.

4) Customer Experience

Customer experience is a crucial factor in modern business success [23]. Companies can gain a better understanding of consumer behaviour, preferences, and overall happiness using big data analytics, which collects customer information from many sources and conducts in-depth research.

V. LITERATURE REVIEW

This literature review describes various IoT and AI smart manufacturing applications, with an emphasis on digital transformation, predictive maintenance, and efficiency gains. It also discusses problems with interoperability, data quality, and explain ability, and looks ahead to future directions for Industry 4.0 solutions that are transparent, scalable, and adaptable worldwide.

Sharma et al. (2025) The manufacturing industry is going through a major shift as a result of the incorporation of technologies like AI, PdM, BDA, and the IoT, all of which are based on the concepts of Industry 4.0. Efficiency, downtime, and product quality can all be significantly improved with the help of this state-of-the-art technology. However, manufacturing processes are complex, making it difficult to leverage AI-driven capabilities for prediction and preservation due to challenges in scalability, interoperability, and model unpredictability. This in-depth feature explores the progress of AI and PdM in manufacturing and the challenges associated with its smooth integration into the overall manufacturing workflow [24].

Zeiser et al. (2024) AI models can be studied more closely to understand how they make decisions and to improve existing processes, even for people who don't have special training. Although many methods are widely used in AI models, there are no clear rules or standards for this area yet. There are still practical, legal, and personal trust challenges to deal with. Using these methods is important in the long term, but it's often hard to do without strong AI systems in manufacturing [25].

Leong et al. (2024) Smart manufacturing and the IoT will drastically change chicken farming in every conceivable way. Environmental Monitoring: With their automation and sensors, these systems can observe environmental factors like temperature, humidity, and air quality in real-time. Livestock tracking systems (which use RFID or GPS technology) work for animals, and it is now possible to understand more about how birds are behaving and if they are in poor health. With the help of automated feeding systems and smart feeders, it has become easier to feed hens at the correct time and almost consistently. IoT-enabled water quality monitoring provides access to clean water, a critical component to ensure the health of poultry Predictive and wearable medical sensing for early diagnosis and decision making. [26].

Liu et al. (2023) analysis from multiple angles, beginning with the building's framework and moving on to its platforms and individual components. An IoT-SPM ecosystem requires the following components a CPS and the IoT as base technologies; data from the IoT as foundational data; big data platforms as foundational data; a catalyst in the form of an improved computing paradigm; and data analysis based on machine learning as the main processor. In addition, this article explores the difficulties of utilizing analytical models on a real-world industrial IoT system, which is accompanied by data from the Internet of Things. The next step is to show the current best practices for IoT-SPM connections, and then to find the information gap regarding the reliability of IoT data [27].

Ahmed et al. (2022) The advent of AI—an integral aspect of the industrial revolution—has allowed smart machines to take on new functions such as self-monitoring, interpretation, diagnosis, and analysis. Manufacturers and industries can improve their ability to anticipate maintenance needs and minimize downtime by utilizing AI-based approaches, specifically ML and DL. Research and development in explainable artificial intelligence (XAI) focusses on methods, algorithms, and tools that can create human-readable explanations of data and decisions made by AI-based systems [28].

Maheswari and Brintha (2021) production procedure in an intelligent way in line with Industry 4.0 standards. Thanks to Industry 4.0, several formerly disparate technologies have come together, including VR/AR, the IoT, cybersecurity, big data, the cloud, automation, and more. The integration of AI and digital transformations into these technologies makes the production process smarter, improves operational efficiency, creates customized things, and develops and introduces new high-quality products [29].

Table II provides an overview of recent research on the combination of IoT and AI in smart manufacturing, emphasizing methods, important discoveries, difficulties, and potential paths forward to promote Industry 4.0-driven innovations and practices

TABLE II. SUMMARY OF A STUDY ON IOT–AI INTEGRATION FOR SMART MANUFACTURING OPERATIONS

Author	Study On	Approach	Key Findings	Challenges	Future Directions
Sharma et al., (2025)	AI, PdM, BDA, IoT in Industry 4.0	Review of AI and PdM integration in manufacturing	Efficiency, downtime, and product quality are all improved by technologies.	Unpredictable machine behaviour, interoperability issues, and scalability of AI solutions	Development of scalable AI-driven PdM systems for seamless manufacturing integration
Zeiser et al., (2024)	Explainability in AI models for manufacturing	Analysis of methods for understanding and improving AI decisions	AI can optimize processes even without expert knowledge	Lack of uniform standards, legal/technical hurdles, and trust issues	Establishing standardised frameworks for Explainable AI (XAI) in manufacturing
Leong et al., (2024)	IoT and smart manufacturing in poultry farming	IoT-enabled sensors, RFID, GPS, predictive analytics	Improved productivity, real-time monitoring, automated feeding, early disease detection	Infrastructure limitations in livestock management, cost of implementation	Broader adoption of IoT-enabled precision farming with advanced predictive analytics
Liu et al., (2023)	IoT-SPM ecosystem architecture	Multiview analysis of IoT, CPS, big data platforms, ML	IoT and CPS as core, big data as backbone, ML for analytics	Data quality issues in IoT systems	Research on IoT data quality improvement and reliable analytic models
Ahmed et al., (2022)	Utilizing AI for predictive maintenance	Maintenance prediction models powered by AI and XAI	AI enables autonomous diagnosis, prediction, and reduced downtime	Explainability and transparency issues	Development of human-understandable AI (XAI) for manufacturing
Maheswari et.al. (2021)	Industry 4.0 with cutting-edge tech	Review of IoT, AI, Cloud, Big Data, AR/VR, Cybersecurity	Enhanced operational efficiency, product customization, digital transformation	Integration complexity of multiple emerging technologies	Expansion of AI-driven digital transformation and smart manufacturing ecosystems

VI. CONCLUSION AND FUTURE WORK

Modern manufacturing is becoming smarter, more data-based, and more flexible because of the combination of IoT and AI. IoT ensures constant connection and continuous monitoring, while AI helps with better decision-making, improving processes, and predicting future needs. Collectively, the technologies are efficient, reduce downtime, and aid customization within dynamic production setups. An analysis of recent research indicates that automation, real-time data analytics, and interoperability are key factors in the revolution of many different types of companies. Concurrently, there are substantial obstacles to widespread adoption because to concerns about security, the expense of infrastructure, and the lack of common standards. Despite these limitations, the Internet of Things (IoT) and artificial intelligence (AI) continue to be game-changers in the fight for resilient and sustainable smart manufacturing, proving once and for all that they can boost industrial innovation and global competitiveness.

Future research needs to be oriented towards enabling mechanisms, towards economically viable frameworks, and towards increased interoperability if such layers are to be widely adopted. Additionally, it will be crucial to ensure that AI is used ethically and that decisions are made with an open mind in order to build trust among the various players in the intelligent manufacturing ecosystem.

REFERENCES

[1] K. D. Thoben, S. A. Wiesner, and T. Wuest, "'Industrie 4.0' and smart manufacturing-a review of research issues and application examples," *Int. J. Autom. Technol.*, vol. 11, no. 1, pp. 4–16, 2017, doi: 10.20965/ijat.2017.p0004.

[2] N. Patel, "Sustainable Smart Cities: Leveraging Iot And Data Analytics For Energy Efficiency And Urban Development," *J. Emerg. Technol. Innov. Res.*, vol. 8, no. 3, pp. 313–219, 2021.

[3] H. Morwani, J. Harshadray Jani, J. Jani, and A. Professor, "IoT-driven Smart Manufacturing (Industry 4.0): A Review of Challenges, Opportunities, and Future Directions," vol. 6, no. 1, pp. 2320–2882, 2018.

[4] A. Goyal, "Enhancing Engineering Project Efficiency through Cross-Functional Collaboration and IoT Integration," *Int. J. Res. Anal. Rev.*, vol. 8, no. 4, pp. 396–402, 2021.

[5] M. D. Kulkarni, "Applications and Impact of Artificial intelligence in manufacturing: A review," vol. 1, no. 1, pp. 12–47, 2024.

[6] V. Singh, "AI and ERP Integration for Adaptive Dynamic Costing Based on Consumer Demand Fluctuations in Manufacturing," *Eur. J. Adv. Eng. Technol.*, vol. 12, no. 3, pp. 1–7, 2025.

[7] W. Liu, "AIoT: The Integrating of Artificial Intelligence and the Internet of Things," *Appl. Comput. Eng.*, vol. 118, no. 1, pp. 64–68, 2025, doi: 10.54254/2755-2721/2025.20805.

[8] N. Santhosh, M. Srinivsan, and K. Ragupathy, "Internet of Things (IoT) in smart manufacturing," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 764, no. 1, 2020, doi: 10.1088/1757-899X/764/1/012025.

[9] N. Prajapati, "The Role of Machine Learning in Big Data Analytics: Tools, Techniques, and Applications," *ESP J. Eng. Technol. Adv.*, vol. 5, no. 2, 2025, doi: 10.56472/25832646/JETA-V5I2P103.

[10] S. Haddaoui, S. Chikhi, and B. Miles, "The IoT Ecosystem: Components, Architecture, Communication Technologies, and Protocols," *Lect. Notes Networks Syst.*, vol. 593 LNNS, no. October 2022, pp. 76–90, 2023, doi: 10.1007/978-3-031-18516-8_6.

[11] M. Hafidz, F. Fauadi, A. Abdullah, M. Damanhuri, R. H. Hambali, and A. Z. Mohamed, "Recent Applications of Internet of Things (Iot) in Manufacturing Sector – a Review," *Int. J. Sci. Technol. Res.*, vol. 9, no. 9, pp. 334–339, 2020.

[12] A. Gotmare and S. Bokade, "Internet of Things in Manufacturing: A Review on Applications, Challenges and Future Directions," *61St 5Th*, no. January, p. 431, 2019.

[13] M. Shivani *et al.*, "Applications Of Artificial Intelligence And Machine Learning In Quality Assurance," *Int. J. Res. Publ. Rev.*, vol. 4, no. 6, pp. 2917–2921, 2025.

[14] A. Goyal, "Optimising Software Lifecycle Management through Predictive Maintenance : Insights and Best Practices," *IJSRA*, vol. 07, no. 02, pp. 693–702, 2022.

[15] S. J. Plathottam, A. Rzonca, R. Lakhnori, and C. O. Iloeje, "A review of artificial intelligence applications in manufacturing operations," *J. Adv. Manuf. Process.*, vol. 5, no. 3, pp. 1–19, 2023, doi: 10.1002/amp2.10159.

[16] L. Espina-Romero, H. Gutiérrez Hurtado, D. Ríos Parra, R. A. Vilchez Pirela, R. Talavera-Aguirre, and A. Ochoa-Díaz, "Challenges and Opportunities in the Implementation of AI in Manufacturing: A Bibliometric Analysis," *Sci*, vol. 6, no. 4, 2024, doi: 10.3390/sci6040060.

[17] J. K. Kato, "Integrating AI and IoT for Smart Manufacturing," *Invent. J. Biol. Appl. Sci. 3*, no. September, 2024.

[18] R. Patel and P. Patel, "A Survey on AI-Driven Autonomous Robots for Smart Manufacturing and Industrial Automation," *Tech. Int. J. Eng. Res.*, vol. 9, no. 2, pp. 46–55, 2022, doi: 10.56975/tijer.v9i2.158819.

[19] X. Gao, P. Pishdad-Bozorgi, D. R. Shelden, and S. Tang, "Internet of Things Enabled Data Acquisition Framework for Smart Building Applications," *J. Constr. Eng. Manag.*, vol. 147, no. 2, pp. 1–15, 2021, doi: 10.1061/(asce)co.1943-7862.0001983.

[20] R. Patel and P. Patel, "Machine Learning-Driven Predictive Maintenance for Early Fault Prediction and Detection in Smart Manufacturing Systems," *ESP J. Eng. Technol. Adv.*, vol. 4, no. 1, 2024, doi: 10.56472/25832646/JETA-V4I1P120.

[21] A. Čolaković and M. Hadžialić, "Internet of Things (IoT): A review of enabling technologies, challenges, and open research issues," *Comput. Networks*, vol. 144, pp. 17–39, 2018, doi: 10.1016/j.comnet.2018.07.017.

[22] M. N. O. Sadiku, T. J. Ashaolu, A. Ajayi-Majebi, and S. M. Musa, "Big Data in Manufacturing," *Int. J. Sci. Adv.*, vol. 2, no. 1, 2021, doi: 10.51542/ijscia.v2i1.11.

[23] G. Modalavalasa and H. Kali, "Exploring Big Data Role in Modern Business Strategies: A Survey with Techniques and Tools," *Int. J. Adv. Res. Sci. Commun. Technol.*, pp. 431–441, Jan. 2023, doi: 10.48175/IJARSCT-11900B.

[24] A. Sharma, K. Y. Sim, and S. Chandrasekaran, "A Comprehensive Review of Challenges Using AI for Smart Manufacturing," in *2025 17th International Conference on Computer and Automation Engineering (ICCAE)*, 2025, pp. 405–413. doi: 10.1109/ICCAE64891.2025.10980576.

[25] T. Zeiser, D. Ehret, T. Lutz, and J. Saar, "Explainable AI in Manufacturing," in *2024 IEEE International Conference on Engineering, Technology, and Innovation (ICE/ITMC)*, 2024, pp. 1–8. doi: 10.1109/ICE/ITMC61926.2024.10794363.

[26] W. Y. Leong, Y. Z. Leong, and W. S. Leong, "Enhancing Poultry Farm Operations with IoT and Smart Manufacturing Systems," in *2024 22nd International Conference on ICT and Knowledge Engineering (ICT&KE)*, 2024, pp. 1–5. doi: 10.1109/ICTKE62841.2024.10787167.

[27] Y. Liu, W. Yu, W. Rahayu, and T. Dillon, "An Evaluative Study on IoT Ecosystem for Smart Predictive Maintenance (IoT-SPM) in Manufacturing: Multiview Requirements and Data Quality," *IEEE Internet Things J.*, vol. 10, no. 13, pp. 11160–11184, 2023, doi: 10.1109/JIOT.2023.3246100.

[28] I. Ahmed, G. Jeon, and F. Piccialli, "From Artificial Intelligence to Explainable Artificial Intelligence in Industry 4.0: A Survey on What, How, and Where," *IEEE Trans. Ind. Informatics*, vol. 18, no. 8, pp. 5031–5042, 2022, doi: 10.1109/TII.2022.3146552.

[29] M. Maheswari and N. C. Brintha, "Smart Manufacturing Technologies in Industry-4.0," in *2021 Sixth International Conference on Image Information Processing (ICIIP)*, 2021, pp. 146–151. doi: 10.1109/ICIIP53038.2021.9702613.

