

Artificial Intelligence's Use and Effects in Manufacturing: A review

Ms. Priyanka Arjun Salunke

Assistant Professor, Department of Mechanical Engineering
Yashoda Technical Campus (Faculty of Engineering), Satara, Maharashtra, India

Abstract: *In recent times, Artificial Intelligence (AI) is expected to play a significant role in many areas, especially in enhancing manufacturing efficiency and productivity. This review paper focuses on examining the applications of AI in the manufacturing sector and its impact. It offers a comprehensive overview of how AI is applied in manufacturing, along with the challenges and issues that come with its implementation, such as human resource management, security concerns, infrastructure requirements, and difficulties in implementation. Despite these challenges, AI proves to be beneficial in various applications like process optimization, quality control, predictive maintenance, intelligent robotic systems, automation, smart manufacturing systems, supply chain management, and monitoring systems. AI is transforming the way products are designed, developed, and produced. Therefore, it is important to take into account the specific needs and capabilities of the manufacturing industry when integrating AI. Future research is likely to focus on developing broader and more integrated AI applications in this field.*

Keywords: Process improvement, Ensuring product quality, Predictive maintenance techniques, Implementing intelligent robotic systems, Achieving automation, Developing smart manufacturing solutions

I. INTRODUCTION

Artificial intelligence (AI) refers to an automated and intelligent system that can carry out various tasks without requiring human intervention. The application of AI in the manufacturing industry has opened up new opportunities for automation, optimization, and innovation. AI technology plays a crucial role in enhancing productivity, efficiency, and decision-making processes. AI-driven predictive maintenance helps in optimizing maintenance schedules and reducing downtime by predicting potential issues and analyzing equipment data. The use of AI in supply chain management systems increases efficiency through machine learning algorithms that estimate demand, manage inventory, and simplify logistics. AI-powered machines, such as robots, enable automation on assembly lines, improving accuracy and speed in response to changing production demands. These robots enhance efficiency, productivity, reduce costs, and improve overall performance. AI-powered quality control systems are able to detect defects with greater accuracy. AI systems are also used in smart manufacturing to monitor processes in real-time and make necessary adjustments, thus improving efficiency and reducing waste. In recent years, AI has become increasingly important in manufacturing due to the integration of machine learning and computer vision technologies.

II. LITERATURE SURVEY

Siby Josh Plathottam et al. (2022) A review on the use of artificial intelligence in manufacturing operations covers various applications of AI in manufacturing, along with the potential benefits and challenges. The review also highlights future directions for AI and machine learning in solving manufacturing-related problems, identifying current developments and opportunities. It further points out areas where more research could bring significant transformation for the industry. This review is based primarily on academic literature and uses other sources to illustrate specific use cases.



Kim et al. (2022) Recent Advances of Artificial Intelligence in Manufacturing Industrial Sectors: A Review focuses on the application of AI in product development, such as autonomous vehicles, batteries, robotics, and wind turbines. It also addresses the use of AI in improving manufacturing processes. This paper summarizes the achievements of AI in manufacturing industries, highlighting how it contributes to increased productivity.

Mito Kehayova et al. (2020) In their paper titled “Application of AI Technology in the Manufacturing Processes and Supply Management,” the authors provide an overview of recent developments in AI. The extensive amount of data generated in manufacturing enables the integration of new analytical tools within the supply chain, thereby optimizing production methods. This paper discusses the application of AI systems in manufacturing and supply chain processes, contributing to the development of smart factories and smart manufacturing, as well as promoting reform and digital transformation in production.

Satabda Chaudhuri et al. (2022) The impact of AI in manufacturing industries is analyzed through statistical methods, focusing on the influence of AI in the manufacturing sector. Using quantitative approaches, structured questionnaires were distributed to individuals from various sectors, including manufacturing, HR, IT, finance, and education. The collected data were used for statistical analysis. A random sample was then tested on the SPSS (Statistical Package for the Social Sciences) platform for quantitative analysis.

Woschank M et al. (2020) A Review of Further Directions for Artificial Intelligence, Machine Learning, and Deep Learning in Smart Logistics. Sustainability provides a conceptual framework based on the results of a systematic literature review, offering valuable suggestions in the fields of AI, ML, and deep learning. This paper presents a framework for the implementation of advanced technologies, integrating various research areas such as IT, logistics, industrial engineering, mathematics, and statistics into future research projects.

Mohd Javaid et al. (2022) Artificial Intelligence Applications for Industry 4.0: A Literature-Based Study focuses on the significant technological features, identifies advancements and challenges in implementing AI for Industry 4.0, and explores the applications of AI in this context.

III. AI SYSTEM

1. Learning:

Computer programs learn in various ways. One such method is trial-and-error. The learning part of AI involves memorizing specific items, which is known as rote learning. This type of learning is later applied through generalization.

2. Reasoning:

The ability to distinguish between different things is key to reasoning. Reasoning allows a system to make inferences that align with a given solution.

3. Problem Solving:

This enables the program to reduce the differences between the current state and the desired goal in a step-by-step manner.

4. Perception:

This component allows the system to scan its environment using either real or artificial senses. One of the earliest systems to combine perception and action was FREDDY, a stationary robot capable of recognizing various components.



5. Language Understanding:

This involves using different types of language to convey natural meaning, as seen in the use of overstatements.

Types of Models:

- a. Deep Learning
- b. Machine Learning
- c. Neural Networks

Software/Hardware for Training and Running Models:

- a. Graphics Processing Units (GPUs)
- b. Parallel Processing Tools (like Apache Spark)
- c. Cloud-Based Data Storage and Compute Platforms

Programming Languages for Building Models:

- a. Python
- b. Java
- c. C
- d. TensorFlow

Applications:

- a. Image Recognition
- b. Speech Recognition
- c. Chatbots
- d. Natural Language Generation
- e. Sentiment Analysis

IV. APPLICATIONS OF AI IN MANUFACTURING

4.1. Robotics and Automation

AI-powered robots and automation systems are used to perform repetitive and dangerous tasks. This helps reduce costs, increase efficiency, and improve safety. Combining AI with robotics increases productivity. AI is integrated into robotics through machine learning, which enables robots to learn and perform tasks by observing and imitating human actions. AI gives robots computer vision, allowing them to navigate, detect objects, and make decisions. AI is also used through edge computing, which provides real-time awareness, enabling robots to act faster than humans. AI helps robots perform tasks by using various sensors such as time-of-flight optical sensors, ultrasonic sensors, vibration sensors, temperature and humidity sensors, among others. These sensors make robots more intelligent and allow them to react to different situations. With AI, robots can perform customer service through chatbots, assembly, packaging, imaging, and other tasks.

4.2. Predictive Maintenance

Unexpected failures cause serious problems for organizations, leading to production slowdowns and equipment breakdowns. To prevent this, algorithms analyze data from sensors to predict when maintenance is needed. This reduces downtime and improves production rates. AI solutions compare current operational conditions with baseline data. This requires historical and current data to evaluate machine performance and determine maintenance needs. The data includes information on how machines operate and variations from standard performance. The algorithms are sets of instructions and predefined rules that guide the analysis of data sets. AI-based predictive maintenance is an extension of total productive maintenance (TPM) and planned preventive maintenance (PPM). It helps improve equipment effectiveness, lower costs, enhance processes, and extend the lifespan of equipment.



4.3. Quality Control

In the manufacturing industry, product quality is crucial as defects can lead to financial losses and damage to a company's reputation. AI-powered testing and inspection ensure products meet high-quality standards, increasing sales and improving customer satisfaction. AI-powered quality control detects defects, flaws, and other issues that human inspectors may miss. Traditionally, quality inspectors examine products visually, but this method has limitations. AI-powered machine vision technology allows computers to see and interpret images and videos using cameras, sensors, and specialized algorithms. Cameras and sensors capture product images, and AI algorithms analyze them to detect defects such as cracks, dents, and imperfections. Machine vision equipped with AI can also measure critical product dimensions with high accuracy. Implementing a machine vision system involves collecting high-quality data for AI algorithms. Data is pre-processed, including image enhancement and noise reduction, before being fed into AI models. The algorithms are trained using images of both defect-free products and those with various defects, enabling them to learn how to differentiate. This includes real-time analysis and feedback loops.

4.4. Supply Chain Optimization

Supply chain management uses machine learning algorithms to estimate demand, control inventory, and simplify logistics. This leads to improved productivity, increased output, better demand forecasting, and prevention of overstocking or understocking. AI-driven supply chain management handles large amounts of data, quickly analyzing and interpreting huge datasets to provide timely guidance on forecasting demand and supply. It also predicts consumer habits, seasonal demand, and trends in demand.

4.5. Digital Twins

Digital Twins visualize infrastructure, products, or services and allow for the design and testing of equipment virtually. They pair virtual and physical attributes and analyze data collected from sensors or cameras.

4.6. Industrial Sector

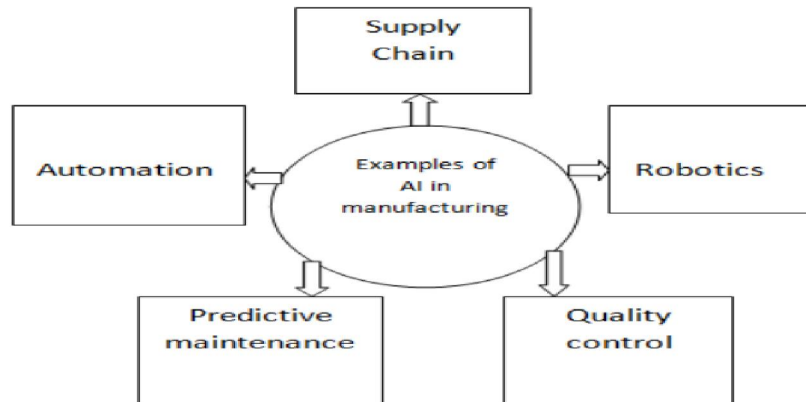
AI plays an important role in manufacturing operations, processes, and product design. It is used in machine learning, computational experimentation, and automation, and plays a major role in Industry 4.0. It assists human operators in planning, making real-time decisions, and improving manufacturing efficiency and safety. Various industries use AI to enhance operations and processes.

a) Automobile Industry: AI-powered robots are used for assembly and inspection of car parts. AI also aids in the design of vehicles. AI systems help with steering and pedestrian detection, monitor blind spots, and alert drivers accordingly. AI enables security features such as lane departure warnings, autonomous emergency braking, and adaptive cruise control. It also supports supply chain management by predicting demand for car parts. AI in the automobile sector improves safety, enhances driver experience, enables autonomous driving, and reduces costs.

b) Consumer Electronics: AI algorithms help electronic devices identify and interpret images and speech. AI is used in the production of smartphones, computers, and other electronic devices. Voice-controlled AI assistants such as Alexa and Google Assistant are used in smartphones, speakers, smart TVs, and other devices. AI-powered robots and vacuum cleaners can clean areas autonomously. AI-based facial recognition and biometric authentication are also used in various consumer electronics.

c) Chemical Industry: Advanced algorithms control complex chemical reactions and optimize the use of raw materials, ensuring product quality and improving safety.





4.1 Applications of AI in manufacturing

V. IMPACTS OF AI IN MANUFACTURING

The following are the impacts of AI in manufacturing:

a) Impact on employment:

AI in manufacturing performs routine and repetitive tasks or jobs that are typically done by humans, which can lead to reduced employment and a lower need for human personnel.

b) Workforce training:

Implementing AI requires technical and analytical skills to operate and maintain the system. For this, the workforce needs ongoing training.

c) Safety:

AI may raise major concerns regarding safety when machines and robots are working in close proximity to humans.

d) Ethics:

The implementation of AI may increase ethical concerns regarding data privacy and accountability.

5.1. Advantages of AI

1. Reduces human errors
2. Every decision is rational
3. Automates repetitive tasks and operations
4. Improves accuracy, efficiency, productivity, quality, and safety
5. High speed

5.2 Limitations of AI

1. Leads to unemployment
2. Human becomes lazy
3. No ethics or emotions
4. This technology is not creative



VI. CHALLENGES IN IMPLEMENTATION OF AI

AI in manufacturing involves challenges in terms of data acquisition, decision validation, energy consumption, implementation, security, and privacy.

1. Data acquisition:

One of the challenges in implementing AI is acquiring data of high quality and accuracy to train supervised and unsupervised learning models. This requires data preprocessing before it can be used to ensure that AI algorithms are reliable and effective. Labelled data is costly due to the time required to prepare it. Sometimes exposure to adverse manufacturing environments can cause sensor drift, which may bias the collected data. Also, taking regular measurements is costly due to the associated costs of data storage and transfer.

2. Integration with existing systems:

To enable communication and interaction between AI systems and existing systems and workflows, careful planning and coordination are needed. Since existing systems often use outdated technologies and formats, it can be difficult to integrate them with AI models.

3. Decision validation:

The lack of interpretability of output from AI models makes it challenging to use them for planning. AI algorithms can be responsible for existing biases and discrimination, leading to unethical and unfair outcomes. Higher-level decisions made by AI/ML applications may not be trusted.

4. Data privacy and security:

As AI requires a large amount of data for training and operation, it is essential to ensure data security and privacy to prevent misuse and leaks.

5. Cost of implementation:

AI is expensive to implement in the early stages, making it difficult for small manufacturers who lack the financial resources to invest.

6. Implementation:

There are difficulties in establishing the foundation of infrastructure and personnel, determining the right dataset, complex algorithms, and training AI. New workflows introduced by AI/ML applications may not be readily accepted.

VII. CONCLUSION

The use of AI in manufacturing offers several benefits, such as improved efficiency, better quality control, and lower production costs. However, it also brings about some negative effects, like changes in job roles, the need for workforce retraining, safety issues, and ethical dilemmas. Implementing AI in manufacturing also presents various challenges, including difficulties in collecting reliable data, ensuring accurate decision-making, integrating new technologies with current systems, and managing the associated costs. Successfully implementing AI in manufacturing requires thorough planning, investment in infrastructure and employee training, and close cooperation between the IT and production departments.

REFERENCES

[1] A review of artificial intelligence applications in manufacturing operations Siby Jose, Plathottam, Arin Rzonca, Rishi Lakhnori, Chukwunwike O. Iloeje. (2022)



- [2] Jha, A. K. (2021). Artificial Intelligence (AI) in Manufacturing. International Journal of Innovative Research in Engineering & Multidisciplinary Physical Sciences, 9(3), 155-160. ISSN: 2349-7300.
- [3] Kim, S.W., Kong, J.H., Lee, S.W. et al. Recent Advances of Artificial Intelligence in Manufacturing Industrial Sectors: A Review. Int. J. Precis. Eng. Manuf. 23, 111–129 (2022). <https://doi.org/10.1007/s12541-021-00600-3>.
- [4] Woschank M., Rauch E., Zsifkovits H. A Review of Further Directions for Artificial Intelligence, Machine Learning, and Deep Learning in Smart Logistics. Sustainability; 2020. 1-23. <https://doi.org/10.3390/su12093760>.
- [5] Mito Kehayova , Lukas Holdera , Volker Kocha “Application of AI technology in the manufacturing processes and supply management”3rd International Conference on Industry 4.0 and Smart Manufacturing Procedia Computer Science 200 (2022) 1209–1217.
- [6] Satabda Chaudhuri, Krishnan LRK, Poorani S” Impact of using ai in manufacturing industries” October 2022 Journal of the International Academy for Case Studies 28(S4):1-10
- [7] Mohd Javid, Abid Haleem, Ravi Pratap Singh, and Rajiv Suman “Artificial Intelligence Applications for Industry 4.0:A Literature-Based Study” Journal of Industrial Integration and Management Vol. 07, No. 01, pp. 83-111 (2022)

