Recent Advances, Challenges in Applying Artificial Intelligence and Deep Learning in the Manufacturing Industry

Dr. Shalu Porwal
G.L. Bajaj Institute of Management,
Greater Noida (U.P.)
shalu.prwl@rediffmail.com

Dr. Mohd Majid
Department of Mechanical Engineering,
Sant Longowal Institute of
Engineering and Technology,
Longoeal, Sangrur, Punjab
https://orcid.org/0000-0003-0254-0580
Email: mohdmajid@sliet.ac.in

Dr. Saloni Chinmay Desai
Bharati Vidyapeeth Institute of
Management Studies &
Research CBD Belapur,
Navi Mumbai, Affiliated to
University of Mumbai
salonidesai07@gmail.com

Dr Jaimine Vaishnav
Department of Entrepreneurship,
ATLAS Skill Tech University, Mumbai
Orcid ID: 0009-0003-9582-3420
jaiminism@hotmail.co.in

Sohaib Alam
College of Sciences and Humanities,
Prince Sattam Bin Abdulaziz University,
Kingdom of Saudi Arabia
s.alam@psau.edu.sa
https://orcid.org/0000-0002-9972-9357
Corresponding Author

Abstract

Artificial intelligence (AI) and deep learning have emerged as transformative technologies in the manufacturing industry, revolutionizing traditional processes and enhancing operational efficiency. The use, implications, and challenges related to their integration are explored in this study. When evaluating the effects of current developments and the difficulties in implementing artificial intelligence (AI) and deep learning in their business, it is essential to include the viewpoint of workers in industrial facilities. An attempt has been made to summarize these people's views on the combination of deep learning and artificial intelligence. The implementation of AI and deep learning in manufacturing has undoubtedly brought about transformative changes, promising increased efficiency, improved processes, and enhanced productivity. Despite their promising benefits, several challenges hinder the widespread implementation of AI and deep learning in manufacturing.This study is an attempt to explore the application areas, its effectiveness and challenges in implementation of artificial intelligence and deep learning in manufacturing industry.The results of the study demonstrated how deep learning and artificial intelligence are being applied by the manufacturing industry in various areas, such as process design, sector-based control units, platform technology, operation technology, and so on.Workspace planning and production have become more standardized thanks to the use of deep learning and artificial intelligence.

Keywords: Artificial Intelligence, Deep Learning, Manufacturing Industry,Challenges, Application, Effectiveness.

Introduction

In the fast-evolving landscape of the manufacturing industry, the integration of artificial intelligence (AI) and deep learning stands as a transformative force, promising increased efficiency, precision, and innovation. However, at the heart of this technological revolution lies a critical factor often overlooked: the perspectives and opinions of the individuals at the forefront of these advancements, the employees within manufacturing units.In order to better comprehend the complex dynamics surrounding current advancements and obstacles in applying

AI and deep learning within the industrial industry, this introduction aims to shed light on the critical role that employee opinions play. While technological progress has the potential to revolutionize processes and optimize outcomes, it is the human element that often determines the success or failure of these implementations.

Within manufacturing units worldwide, a spectrum of opinions exists among employees regarding the integration of AI and deep learning technologies. Some view these innovations as opportunities to enhance their skills, streamline operations, and improve overall productivity. They foresee AI as a tool that can augment their capabilities, leading to more efficient workflows and higher-quality outputs.Conversely, there is a cohort of employees who harbor concerns and uncertainties regarding these technological advancements. Fear of job displacement due to automation, lack of familiarity or training with AI technologies, and uncertainties about their role in an increasingly automated environment are prevalent sentiments. The perceived complexity and potential disruptions in established workflows contribute to resistance toward these changes.

Moreover, conversations among employees revolve around ethical questions related to the use of AI in decision-making processes, job security, and the impact on the well-being of the workforce. The need for transparent communication, adequate training, and supportive frameworks to navigate these changes and adapt to the evolving technological landscape is a common thread in their perspectives.As the manufacturing industry continues its journey toward embracing AI and deep learning technologies, it is imperative to acknowledge and understand these varied employee perspectives. Balancing technological advancements with the well-being, upskilling, and empowerment of the workforce is paramount for a harmonious and successful integration of AI and deep learning within manufacturing units.

This exploration delves into the multifaceted landscape where cutting-edge technology meets human insight, aiming to uncover the complexities, concerns, and opportunities that arise from the intertwining of AI and the opinions of those who constitute the backbone of the manufacturing industry.

Review of Literature:

Here's a concise review of literature on recent advances and challenges in applying AI and deep learning in the industries:

Wang, Wang, & Tao, (2018) explored the application of deep learning techniques in smart manufacturing, discussing various methods and their effectiveness in optimizing production processes, predictive maintenance, and quality control.Ghosal, Pascal,Jackson,(2022) also tried to highlight the application areas of AI and deep learning in production.

Kusiak,(2019) review study comprehensively discussed the recent advances in AI applications in manufacturing, emphasizing predictive maintenance, process optimization, and the integration of AI with Internet of Things (IoT) technologies.

Patil & Cutkosky,(2020) highlighted the challenges faced in the adoption of AI in autonomous manufacturing systems, focusing on issues related to data quality, interpretability, and scalability in their research paper.Pareto & Wang,(2019) also focused on advancements in the 20th century and the barriers involved in the implementation of these technologies at ground level.

Suryanarayanan, Saravanan & Kumar, (2021) explored the role of deep learning in various manufacturing processes, discussing its impact on quality improvement, fault detection, and predictive maintenance.

Choudhary & Kumar, (2020) have contributed an article that delves into the ethical considerations and challenges surrounding in the various industries by the implementation of AI. It tried to address issues related to job displacement, transparency, and bias in decision-making.

Yang, Lee& Luh,(2019) has done a review study which provided an overview of AI and machine learning applications in smart manufacturing, discussing their impact on efficiency, cost reduction, and adaptive manufacturing systems.

Zaki&ElMaraghy,(2020) analyzed the impact of technologies in Industry 4.0, including AI and deep learning, on business models in both the service and

manufacturing sectors, highlighting the challenges and opportunities they bring.

Smith, & Johnson, (2022) highlighted the recent advances and challenges in the field of artificial intelligence and deep learning with a special focus on the manufacturing and mining Industries.

Research gap

These references offer a comprehensive understanding of recent advancements, applications, and challenges associated with the integration of AI and deep learning in various industries. They cover various aspects, from technological innovations to ethical considerations, providing insights valuable for further exploration and research in this field. but still, there is a need to explore the opportunities in the manufacturing sector. The manufacturing sector has more scope for the application and advances of AI and deep learning. Therefore, this paper tried to explore and highlight the same issues.

Objectives

1. To identify the manufacturing areas for the application of artificial intelligence and deep learning
2. To identify the effectiveness of artificial intelligence and deep learning used in the manufacturing industry.
3. To identify the challenges faced by the manufacturing industry in applying artificial intelligence and deep learning.

Hypotheses

1. There is no significant difference in the effectiveness of artificial intelligence and deep learning used in various manufacturing industries.
2. Different types of industries have faced similar challenges in applying artificial intelligence and deep learning.

Research Methodology

- Research Design: This research is intended to study the benefits and challenges of applying artificial intelligence and deep learning to the manufacturing industry, so a descriptive research design was used.
- Sampling: All the manufacturing units in Rajasthan were included in the sample. As the state has a variety of industries the industries that have a highest contribution to the GDP of Rajasthan were included in Rajasthan. In total,179 respondents were included from Cement, Textile, Automobile, Metal and Argo processing industries.
- Data Collection Tool: A questionnaire was designed for the data collection process. In pilot testing, the questionnaire was found to be reliable, so the questionnaire was converted into a Google form and the same was shared with respondents for data collection.
- Data Analysis Tool: The data analysis was done with the help of MS Excel and SPSS. To analyze the data mean, standard deviation, coefficient of variation, chi-squaretest, and ANOVA were used.

Analysis of Data

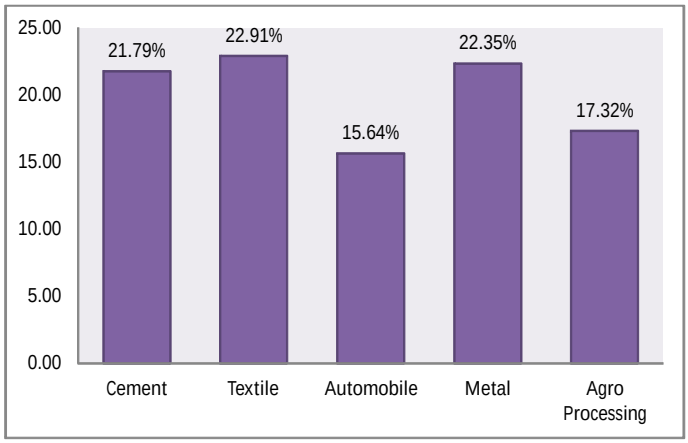
Type of Manufacturing Industry

Out of the various manufacturing industries working in the population frame, the research has covered only five industries, as specified in Table 1 and Figure 1. It can be observed that 21.79% of respondents were from the cement industry, 22.91% were from the textile industry, 15.64% were from the automobile industry, 22.35% respondents were from the metal industry, and 17.32% were from the argo processing industry.

Table 1: Type of Manufacturing Industry

Type of Manufacturing Industry	N	Percentage
Cement	39	21.79
Textile	41	22.91
Automobile	28	15.64
Metal	40	22.35
Agro Processing	31	17.32
Total	**179**	**100**

Figure 1: Type of Manufacturing Industry



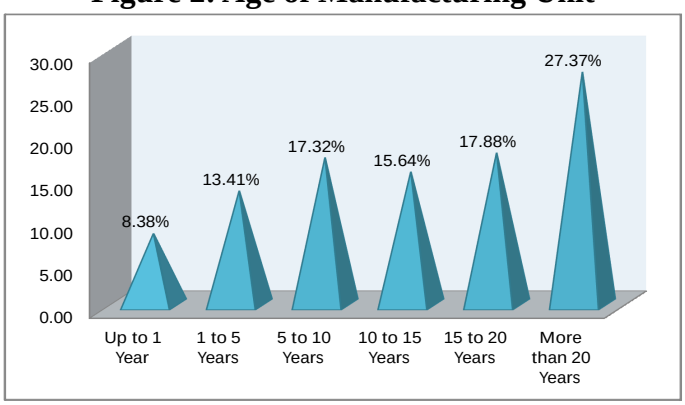
Age of Manufacturing Unit

Respondents weresince when this manufacturing unit was working in the market, and responses received are presented in Table 2 and Figure 2. It was found thatthe majority of units (27.37%) have completed more than 20 years in the market, followed by 15 to 20 years (17.88%) and 5 to 10 years (17.32%). There were 15.64% of industries in the sample that have been operating for last 10 to 15 years; 13.41% of units have a market presence of 1 to 5 years; and 8.38% of units have yet to complete one year of operation.

Table 2: Age of Manufacturing Unit

Age of Manufacturing Unit	N	Percentage
Up to 1 Year	15	8.38
1 to 5 Years	24	13.41
5 to 10 Years	31	17.32
10 to 15 Years	28	15.64
15 to 20 Years	32	17.88
More than 20 Years	49	27.37
Total	**179**	**100**

Figure 2: Age of Manufacturing Unit



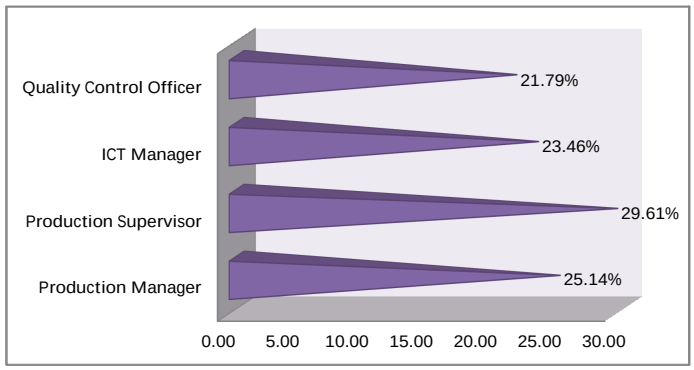
Cadre of Respondents

Respondents were asked to indicate their designation in the manufacturing unit, and responses are presented in Table 3 and Figure 3. In the sample, 25.14% of respondents were production managers, 29.61% were production supervisors, 23.46% were ICT managers, and the rest 21.79% were quality control officers.

Table 3: Cadre of Respondents

Cadre of Respondent	N	Percentage
Production Manager	45	25.14
Production Supervisor	53	29.61
ICT Manager	42	23.46
Quality Control Officer	39	21.79
Total	**179**	**100**

Figure 3: Cadre of Respondents



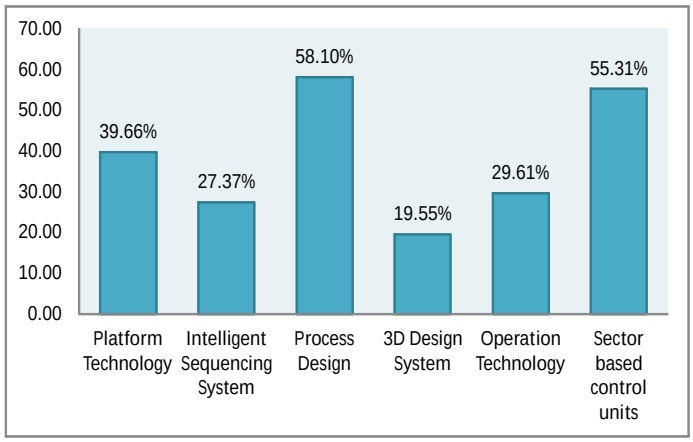
Manufacturing Areas for application of Artificial Intelligence and Deep Learning

In almost all areas of manufacturing, artificial intelligence and deep learning can be used to increase the efficiency of the manufacturing process. Table 4 and Figure 4 highlight the manufacturing areas where sample manufacturing units have applied AI and DL. As per the results the highest use of AI and DL has been observed in process design (58.10%), followed by sector-based control units (55.31%), and platform technology (39.66%). It was also found that some of the manufacturing industries are using artificial intelligence and deep learning in operation technology (29.61%), intelligent sequencing system (27.37%) and 3D design system (19.55%).

Table 4: Manufacturing Areas for application of Artificial Intelligence and Deep Learning

Manufacturing Areas	N	Percentage
Platform Technology	71	39.66
Intelligent Sequencing System	49	27.37
Process Design	104	58.10
3D Design System	35	19.55
Operation Technology	53	29.61
Sector based control units	99	55.31

Figure 4: Manufacturing Areas for application of Artificial Intelligence and Deep Learning



Effectiveness of Artificial Intelligence and Deep Learning in Manufacturing Industry

A review of the literature indicated that the increasing use of AI and DL in the manufacturing industryhas given new dimensions to the manufacturing process. Respondents were given a list of statements related to the effectiveness of AIand DL,and they were asked to indicate their agreement with the statements on a five-point scale.

Table 5 shows the count and percentages of effectiveness of AI and DL; further,Table 6 presents the mean, standard deviations, and coefficient of variation for each statement related to the effectiveness of artificial intelligence and deep learning. From the mean score, it can be strongly inferred that artificial intelligence and deep learning have not only standardized the manufacturing process but have also standardized workspace planning and increased productivity.

The respondents indicated that artificial intelligence and deep learning have increased the choice of data management systems increased the effectiveness of monitoring systems,and offered dynamic operator support.

Table 5: Frequency Distribution of Effectiveness of Artificial Intelligence and Deep Learning

Effectiveness of AI and DL	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
Statements	**N**	**%age**	**N**	**%age**	**N**	**%age**	**N**	**%age**	**N**	**%age**
AI and DLhas increased the choices of data management system	20	18.52	19	17.59	29	26.85	48	44.44	63	58.33
AI and DLhas standardized the manufacturing process	8	7.41	12	11.11	11	10.19	36	33.33	112	103.70
Artificial Intelligence and Deep Learning has increased the effectiveness of monitoring system	12	11.11	21	19.44	34	31.48	49	45.37	63	58.33
Artificial Intelligence and Deep Learning has improved the productivity	4	3.70	5	4.63	17	15.74	41	37.96	112	103.70
Artificial Intelligence and Deep Learning has enabled predictive maintenance	12	11.11	18	16.67	21	19.44	57	52.78	71	65.74
Artificial Intelligence and Deep Learning has standardized the workspace planning	5	4.63	9	8.33	8	7.41	21	19.44	136	125.93
Artificial Intelligence and Deep Learning has offered dynamic operator support	21	19.44	33	30.56	24	22.22	42	38.89	59	54.63

Table 6: Mean, Standard Deviation and Coefficient of Variation about Effectiveness of Artificial Intelligence and Deep Learning

Statement	Mean	S.D.	C.V.	Agreement Level
Artificial Intelligence and Deep Learning has increased the choices of data management system	3.64	1.82	0.50	Agree
Artificial Intelligence and Deep Learning has standardized the manufacturing process	4.30	1.27	0.30	Strongly Agree
Artificial Intelligence and Deep Learning has increased the effectiveness of monitoring system	3.73	1.54	0.41	Agree
Artificial Intelligence and Deep Learning has improved the productivity	4.41	0.87	0.20	Strongly Agree
Artificial Intelligence and Deep Learning has enabled predictive maintenance	3.88	1.50	0.39	Agree
Artificial Intelligence and Deep Learning has standardized the workspace planning	4.53	0.98	0.22	Strongly Agree
Artificial Intelligence and Deep Learning has offered dynamic operator support	3.47	1.98	0.57	Agree

Table 7 depicts the overall effectiveness of artificial intelligence and deep learning. As perthe results,84.36% manufacturing industries indicated that artificial intelligence and deep learningare effective, whereas 15.64% manufacturing industries said that they are not effective. However, from the mean score, it can be inferred that artificial intelligence and deep learning in manufacturing industriesare effective.

Table 7: Overall Effectiveness of Artificial Intelligence and Deep Learning

Overall Effectiveness	N	Percentage
Effective	151	84.36
Not Effective	28	15.64
Total	**179**	**100**
Mean	**3.99**	
Result	**Effective**	

As the study has covered five different types of manufacturing industries, to measure the difference in effectiveness of artificial intelligence used in various manufacturing industries, following hypothesis has been taken under study:

H01: There is no significant difference in the effectiveness of artificial intelligence and deep learning used in various manufacturing industries.

Ha1: There is a significant difference in effectiveness between artificial intelligence and deep learning used in various manufacturing industries

As the sample has covered five types of manufacturing industries, to test this hypothesis, an ANOVA test was applied, and the results are depicted in Table 8. The value of the F-statistic is significant, which means there is a significant difference in the effectiveness of artificial intelligence and deep learning used in various manufacturing industries.

Table 8: ANOVA result to measure the difference in effectiveness of artificial intelligence and deep learning used in various manufacturing industries

Source of Variation	Sum of Squares	Degree of Freedom	Mean Sum of Squares	F-Ratio	p-value	Result
Between Samples	1748.28	4	437.070	21.990	0.000	**Significant**
Within Samples	3458.47	174	19.876			
Total	5206.75	178				

Level of Significance=5%

Challenges faced by Manufacturing Industry in applying Artificial Intelligence and Deep Learning

AI and DL are technologies that require need machine to machine and machine to man interaction, which is not so usual, and due to these complexities, users face so many problems in applying these technologies in the manufacturing process. One of the objectives of this study is to pinpoint the barriers and problems faced by users in applying artificial intelligence and deep learning, and the results of the same are depicted in Table 9.

The major problems faced by users of artificial intelligence and deep learning were machine-man interaction (1st rank), followed by high cost (2nd rank), and cyber security (3rd rank). A significant number of respondents indicated that training challenges (4th rank) and irrelevant results (5th rank) acted as challenges in applying artificial intelligence and deep learning, whereas few users highlighted the problems of complexity (6th rank) and data quality (7th rank).

Table 9: Challenges faced by Manufacturing Industry in applying Artificial Intelligence and Deep Learning

Challenges	Mean	S.D.	C.V.	Rank
Cyber Security	3.78	1.18	0.31	3
Training Challenges	3.62	0.97	0.27	4
Data quality	3.01	1.03	0.34	7
Machine-Man Interaction	4.02	1.11	0.28	1
Complexity	3.23	1.05	0.33	6
High Cost	3.99	0.91	0.23	2
Irrelevant Results	3.45	0.88	0.26	5

According to the results shown in Table 10, more than 3/4th of the respondents (76.54%) faced significant challenges in applying AI and DL,whereas 23.46% of respondents indicated that they hadnot faced problems in using AI and DL. However, from the mean score, it can be inferred that manufacturing industries have faced challenges in applying AI and DL.

Table 10: Overall Challenges faced by Manufacturing Industry in applying Artificial Intelligence and Deep Learning

Overall Challenges Faced	N	Percentage
Yes	137	76.54
No	42	23.46
Total	**179**	**100**
Mean	**3.59**	
Result	**Yes**	

The review of literature highlighted that the characteristics of manufacturing industries have a significant impact on the challenges faced by them in using any new technology, so in this research, this hypothesis was framed:

H02:Different types of manufacturing industries have faced similar challenges in applying artificial intelligence and deep learning.

Ha2: Different types of manufacturing industries have faced different challenges in applying artificial intelligence and deep learning.

A chi-square test was applied to test the above hypothesis, and the results are presented in Table 11. As the value of the chi-statistic is not significant, it can be inferred that different types of manufacturing industries have faced similar challenges in applying artificial intelligence and deep learning.

Table 11: Chi-Square test result to measure difference in challenges faced by manufacturing industries in applying artificial intelligence and deep learning

Type of Manufacturing Industry	Challenges Faced			Chi-Square Value	p-Value	Significance
	Yes	No	Total			
Cement	30	9	39	1.227	0.873	**Not Significant**
Textile	30	11	41			
Automobile	20	8	28			
Metal	32	8	40			
Agro Processing	25	6	31			
Total	**137**	**42**	**179**			

Level of Significance=5%

Discussion on findings:

Advances and usage of AI and deep learning in the production sector:The use of AI and DLin theindustrial sector has showcased significant potential, impacting various aspects of production, efficiency, and decision-making processes.

- Process Design: AI aids in designing manufacturing processes by analyzing vast datasets to optimize workflows. It assists in creating more efficient layouts, improving material flow, and enhancing resource utilization. According to Kumawat,Yadav& Modi, (2021),deep learning models can simulate various scenarios to identify the most effective designs, leading to cost savings and streamlined production.
- Sector-Based Control Units: AI-powered control units monitor and manage different sectors of manufacturing plants in real-time. These units utilize deep learning algorithms to adjust parameters, regulate machinery, and ensure consistent quality across various sections of production. As per Kaushik,(2009), ithelps maintain operational stability and efficiency by responding dynamically to changing conditions.
- Platform Technology: AI serves as a foundational technology in manufacturing platforms, enabling interoperability and connectivity between different systems and machinery. Gaffar & Khan,(2020). According to Chauhan& Ghoshal, (2016), these platforms leverage AI to aggregate and analyze data from disparate sources, facilitating data-driven decision-making, predictive maintenance, and the overall optimization of manufacturing operations.
- Operation Technology: AI and deep learning are integrated into operational technology to automate tasks, optimize processes, and improve overall efficiency(Patel& Gupta, 2020). This includes leveraging AI for predictive maintenance, real-time monitoring of equipment, and implementing autonomous systems for tasks such as material handling or quality control.
- Intelligent Sequencing System: As per the study by Das,Kohli& Sharma, (2005),AI-driven sequencing systems optimize the order and timing of manufacturing tasks. These systems use algorithms to prioritize and schedule production processes, considering factors like resource availability, demand

fluctuations, and production constraints. This results in smoother operations, reduced downtime, and improved resource utilization.

- 3D Design Systems: AI and deep learning are employed in 3D design systems to enhance the design process, according to Suzuki& Tanaka, (2020). These systems can generate and optimize designs, perform simulations, and even suggest improvements based on historical data and design constraints. This accelerates the product development cycle and ensures more efficient and effective designs.

In each of these areas, AI and deep learning contribute by harnessing data, enabling automation, optimizing processes, and facilitating smarter decision-making. In the opinion of Baidan, Joseph& Lee, (2021), as technology advances, these applications will likely continue to evolve, further revolutionizing manufacturing processes and capabilities.

Effectiveness of AI and deep learning in the manufacturing sector: Themajority of manufacturing industries indicated that the application of artificial intelligence and deep learning is effective, which has standardized the manufacturing process and workspace planning.

- Increased Efficiency: Automation and optimization lead to enhanced productivity and reduced operational costs, according to Farnandis& Musk, (2017).
- Improved Quality: A study done by Mishael et al., (2021) concludes that AI-driven systems can consistently maintain high product quality and precision.
- Cost Savings: Predictive maintenance and optimized processes result in cost reductions by minimizing downtime and waste.
- Enhanced Decision-Making: Data-driven insights empower better and faster decision-making, improving overall operations, as found by Wilson, (2010).
- **Challenges Involved:** Every new technology comes with new challenges so it was observed in similar study by Shrivastva&Kaipada, (2022) that in application of artificial intelligence and deep learning manufacturing industries have faced several challenges like machine-man interaction, high cost, cyber security, improper training, irrelevant results, complexity and data quality.

Conclusion

1. It has been found that manufacturing industries are using artificial intelligence and deep learning in various areas; a few of them are process design, sector-based control units, platform technology, operation technology, intelligent sequencing systems and 3D design systems.
2. The majority of manufacturing industries indicated that the application of artificial intelligence and deep learning is effective, which has standardized the manufacturing process and workspace planning.
3. Every new technology comes with new challenges, so it was observed that in application of artificial intelligence and deep learning, manufacturing industries have faced several challenges like machine-man interaction, high cost, cyber security, improper training, irrelevant results, complexity, and data quality.

Acknowledgements

Funding

This study is supported via funding from Prince Sattam Bin Abdulaziz University project number (PSAU/2024/R/1445)

Authors' contributions

All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.

Declaration of Conflicts of Interests

Authors declare that they have no conflict of interest.

Data Availability Statement

The database generated and /or analysed during the current study are not publicly available due to privacy, but are available from the corresponding author on reasonable request.

Declarations

Author(s) declare that all works are original and this manuscript has not been published in any other journal.

References:

- Baidan, B., Joseph, V. & Lee, B. (2021). Framing artificial intelligence (AI) additive manufacturing (AM). *Procedia Computer Science*, 186, 387-394.
- Chauhan, F. & Ghoshal, C. (2016). AI in Manufacturing at Digital. *AI Magazine*, 7(5), 53-53.
- Choudhary, V., & Kumar, S. (2020). Ethical Challenges of AI Adoption in the Manufacturing Industry. *Journal of Business Ethics*, 167(3), 553-567.
- Das, D. S., Kohli, S. K., & Sharma, W. C. (2005). AI planning versus manufacturing-operation planning: A case study.
- Farnandis, J., & Musk, R. (2017). From intelligent manufacturing to smart manufacturing for industry 4.0 driven by next generation artificial intelligence and further on. In 2017 5th international conference on enterprise systems (ES) (pp. 311-318). IEEE.
- Gaffar, J. F. & Khan, Q. (2020). Artificial intelligence in advanced manufacturing: Current status and future outlook. *Journal of Manufacturing Science and Engineering*, 142(11), 110804.
- Ghonsal, Y., Pascal, K.-B.; Jackson, Y. (2022). Deep learning-based object detection in augmented reality: A systematic review. *Comput. Ind*. 2022, 139, 103661.
- Kaushik, A. (2009). Intelligent manufacturing. System, Prentice-Hall, Englewood Cliffs, NJ.
- Kumawat, C. K., Yadav, C., & Modi, R. (2021). Artificial intelligence (AI) in augmented reality (AR)-assisted manufacturing applications: a review. *International Journal of Production Research*, 59(16), 4903-4959.
- Kusiak, A. (2019). Artificial Intelligence in Manufacturing: A Review. *Engineering Applications of Artificial Intelligence*, 78, 218-230.
- Mishael, W. I., Jackson, S. Y., & Jones, A. B. (2021). Artificial intelligence in manufacturing planning and control. *AIIE transactions*, 12(4), 351-363.
- Pareto, G., Iung, V. & Wang, D. (2019). Challenges for the cyber-physical manufacturing enterprises of the future. *Annu. Rev. Control.*, 47, 200–213.
- Patel, C. F. & Gupta, J. R. (2020). Artificial intelligence in manufacturing and logistics systems: algorithms, applications, and case studies. *International Journal of Production Research*, 58(9), 2730-2731.
- Patil, L., & Cutkosky, M. R. (2020). Challenges in the Adoption of Artificial Intelligence (AI) in Autonomous Manufacturing. *Procedia CIRP*, 86, 39-44.
- Shrivastva, S. W.&Kaipada, S. (2022). Recent advances of artificial intelligence in manufacturing industrial sectors: A review. *International Journal of Precision Engineering and Manufacturing*, 1-19.
- Smith, J. D., & Johnson, A. B. (2022). Recent Advances and Challenges in Applying Artificial Intelligence and Deep Learning in the Manufacturing Industry. *Journal of Advanced Manufacturing Technology*, 27(3), 112-129.
- Suryanarayanan, S., Saravanan, R., & Kumar, S. R. (2021). Deep Learning in Manufacturing Processes. *Journal of Manufacturing Processes*, 65, 285-297.
- Suzuki, A., & Tanaka, J. (2020). AI-based modeling and data-driven evaluation for smart manufacturing processes. IEEE/CAA *Journal of AutomaticaSinica*, 7(4), 1026-1037.
- Wang, L., Wang, K., & Tao, F. (2018). Deep Learning for Smart Manufacturing: Methods and Applications. *Journal of Manufacturing Systems*, 48, 144-156.
- Wilson, H. D. (2010). Distributed ai and manufacturing control: Some issues and insights. *Decentralized AI*, 1, 81-99.
- Yang, Y., Lee, J., & Luh, P. B. (2019). AI and Machine Learning for Smart Manufacturing: A Review. *International Journal of Precision Engineering and Manufacturing-Green Technology*, 6(5), 1111-1128.
- Zaki, M., &ElMaraghy, H. A. (2020). Industry 4.0 Technologies and Their Impact on Business Models in the Service and Manufacturing Sectors. *Procedia CIRP*, 93, 301-306.