

Applications and Impact of Artificial intelligence in manufacturing: A review

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Abstract –

In recent days, Artificial Intelligence (AI) is going to play a major role in various fields and becoming major source in improving manufacturing efficiency and productivity . This review paper, is all about review of applications of AI in manufacturing and its influence. This review provides an overall viewpoint on applications of AI in manufacturing field and also challenges and issues such as human resource, security ,infrastructure, implementation challenges etc. Regardless of these challenges AI is helpful in applications of process optimization , quality assurance, predictive maintenance, intelligent robotic system, automation, smart manufacturing systems, supply chain management ,monitoring system etc . AI in manufacturing transform the way product are designed, developed and manufactured. So it is necessary to consider needs and capabilities of manufacturing while using AI. Future research can be expected towards developing wide combined AI applications.

Key Words: Process optimization ,quality assurance, predictive maintenance, intelligent robotic system, automation, smart manufacturing systems, supply chain management

1.INTRODUCTION

Artificial intelligence (AI) is automated and intelligent system capable of performing various task without human interruption .Use of Artificial intelligence (AI) in the manufacturing sector, create new opportunities for automation, optimization, and innovation. AI technology plays an important role in improving productivity, efficiency and decision making processes.AI driven predictive maintenance optimize maintenance schedule as well as minimize downtime by predicting possible faults and analyzing equipment data. Use of AI in supply chain management system makes more efficient through machine learning algorithms which estimate demand ,control inventory and simplify logistic.AI machines, such as robots, which enables automation in assembly lines improves accuracy and speed in accordance with changing production demands. These robots improves efficiency, productivity, reduce cost and improve efficiency. AI powered QC system finds defects more accurately.AI system is also used in smart manufacturing monitoring the process in real time and make necessary adjustment improving efficiency and reducing waste. In recent years, AI has become increasingly

important in manufacturing due to use of machine learning and computer vision.

1. Review of literature

Siby Jose Plathottam, Arin Rzonca, Rishi Lakhnori, Chukwunwike O. Iloeje "A review of artificial intelligence applications in manufacturing operations" cover manufacturing applications of AI, potential benefits, challenges.The review also identifies future directions of AI/ML available for solving problems related to manufacturing and opportunities ,current development, and also it identifies areas where further research leads to transformational returns for the industry. In this literature review focused on academic literature and used other sources for specific use case illustration.

Kim, S.W., Kong, J.H., Lee, S.W. et al. Recent Advances of Artificial Intelligence in Manufacturing Industrial Sectors: A Review .This focuses on application of AI for product enhancement like autonomous vehicles ,battery ,robotics ,wind turbine. This paper also focus on applications of AI in process enhancement. This paper thus summarize achievements of AI in manufacturing industries making it productive

Mito Kehayova , Lukas Holdera , Volker Kocha in their paper "application of AI technology in the manufacturing processes and supply management" give us idea about recent developments in AI extensive amount of generated "big data" related to manufacturing allow integration of new analytical tool in the supply chain optimize the way the goods are produced. This paper give information about applications of AI system in manufacturing, supply chain process in industries makes them smart factories and smart manufacturing and the reform and digitalization on the production.

Satabda Chaudhuri, Krishnan LRK, Poorani S in their

"Impact of using AI in manufacturing industries conducts statistical analysis and influence of AI in field of manufacturing. Using quantitative methods, survey of questionnaires with well structured questions distributed to persons from manufacturing sector, HR, IT ,financial ,education and many more. The data so collected used for statistical anylysis. A random sample drawn was then tested on the SPSS(Statistical Package for the Social Sciences) platform for quantitative analysis.

Woschank M., Rauch E., Zsifkovits H. "A Review of Further Directions for Artificial Intelligence, Machine Learning, and Deep Learning in Smart Logistics. Sustainability" provide a conceptual framework based on results of systematic literature review fruitful suggestion in the field of AI, ML and deep learning .This paper provide framework for implementation of state of the art technologies to integrate different research areas like IT ,logistic, industrial engineering ,mathematics ,statistic etc. into future research projects.

Mohd Javaid , Abid Haleem , Ravi Pratap Singh , and Rajiv Suman "Artificial Intelligence Applications for Industry 4.0:A Literature-Based Study" focuses on the significant technological features, identify advancements and challenges in implementing AI for industry 4.0 ,applications of AI for industry 4.0

2. Components of AI

1.Learning:

Computer program learns in different manner. It includes the trial- and- error method. The learning component of AI includes memorizing individual items (i.e. rote learning).This learning method is later implemented by using generalization method

2.Reasoning

The ability to differentiate makes reasoning important..To reason is to allow the platform to draw inferences to fit with provided solution.

3.Problem solving

It allows the program to include step by step reduction of difference given between goal and current state.

4.Perception

The element scans any environment using sense organ either real or artificial. One of the earliest systems to integrate perception sand action was FREDDY a stationary robot to recognize a variety of components.

5.Language Understanding

It uses distinctive types of language over different forms of natural meaning, exemplified overstatements.

Types of models

- Deep learning
- Machine learning
- Neutral networks

Software /Hardware for training and running model

- GPUs
- Parallel processing tools (Like spark)
- Cloud data storage and compute platforms

Programming languages for building models

- Python
- Java
- C
- TensorFlow

Applications

- Image recognition
- Speech recognition
- Chatboats
- Natural language generation
- Sentiment analysis

3. Applications of AI in manufacturing

3.1. Robotics and automation

AI powered robots and automation system used to perform repetitive and dangerous task. This will reduce cost, increase efficiency ,improve safety. The combination of AI and robotics leads increased productivity. AI is used in robotics through machine learning which helps robots to learn and perform tasks by observing and doing human actions. AI gives robot computer vision to navigate, detect, and determine their reactions. AI used through edge computing which provide real time awareness to act on decision quicker than human capabilities. Use of AI also helps robot to perform task using various sensors like time of flight optical sensor, ultrasonic sensors, vibration sensors, temperature and humidity sensors etc. These sensors helps robot to become more intelligent and react in different scenarios. Through AI robot can perform customer service through AI powered chatbots , Assembly ,packaging ,imaging etc.

3.2.Predictive maintenance

Unexpected failures leads to serious headache for organizations which results in production slowdown and failures. In this algorithms are used to analyze data from sensors for predicting when the maintenance is to be needed to reduce downtime and breakdown of the equipment resulting improved production rate .AI solution analyze current operational conditions against baseline data. For this historical and current data is needed to evaluate machine performance and maintenance need. This include information about machine performance ,how it work and data about variation from the norms. The algorithms are set of instructions and predefined rules that describes the process of analyzing data sets. This AI based predictive maintenance is extension of total productive maintenance (TPM) & planned preventive maintenance (PPM) This is

helpful for improved equipment effectiveness, lower cost, process improvement ,extend lifecycle of equipment etc.

3.3 Quality Control

In manufacturing industry quality of product is important as product defects result not only financial losses but also reduce company’s reputation. AI powered testing and inspection assure production meet higher quality of standards resulting increased sales of product and improve customer satisfaction. This AI powered quality control detect defects, flaws & other issues which human inspectors missed to find out. In traditional way quality inspector examine defects of products visually. Human based quality inspection has limitations. AI powered machine vision technology which enables computer to see and interpret images and videos by using cameras, sensors and specialized algorithms to analyze the visual data. In this cameras and sensors capture product image and AI algorithms analyze image to detect defects such as crack, dents, imperfections etc. Machine vision equipped with AI vision also measure critical dimensions of product with high degree of accuracy. Implementation of machine vision system involve high quality data collection as input for AI algorithms, data preprocessing before feeding to AI models involves image enhancement ,noise reduction etc. ,Algorithms training by providing images of both defect less product and products having various types of defects which learn to differentiate, Real time analysis, feedback loop etc.

3.4 Supply chain optimization

Supply chain management use machine learning algorithms, to estimate demand, control inventory, and simplify logistics. This is result in improved productivity, increased output, improved demand forecasting , prevent overstocking and prevent inadequate stocking etc.AI driven supply chain management handle mass data and quickly analyze ,interpret huge datasets providing timely guidance on forecasting demand and supply. It also predict consumer habits, seasonal demands and demand trends.

3.5. Digital Twins

It visualize the infrastructure ,products or services and also design and test equipment virtually .It pairs virtual and physical attributes and analyze data collected by sensors or cameras.

3.6 Industrial sector

AI plays important role in manufacturing operation ,process and product design, machine learning ,computational experimentation and automation. It play major role in Industry 4.0 .It help human operator in planning ,real time decision making ,improve manufacturing efficiency and safety. There are various industries which use AI to improve operation and processes.

a) Automobile Industry :It use AI powered robots for assembly and inspection of parts. It also enable the design of vehicles.AI system also help steering and pedestrian detection, monitor blind spots, and alert the driver accordingly.AI enables security systems such as lane departure warning, autonomous emergency braking and adaptive cruise control. It also help in supply chain management to predict demand of car parts. AI in automobile helps in predictive maintenance, improved safety, enhanced driver experience, autonomous driving, cost saving.

b)Consumer electronics: AI algorithms helps electronic device to identify and interpret images and speech. It is used in production of smart phones ,computers and other electronics devices. Voice controlled AI assistance such as alexa, google assistance etc are used in smart phones, speakers, smart tv’s and other devices.AI robots and vacuum cleaners can clean space autonomously. AI powered facial recognition ,biometric authentication also used in various consumer electronics.

c) Chemical industry: Advanced algorithms control complex chemical reactions and optimize raw materials ensuring quality, improve safety

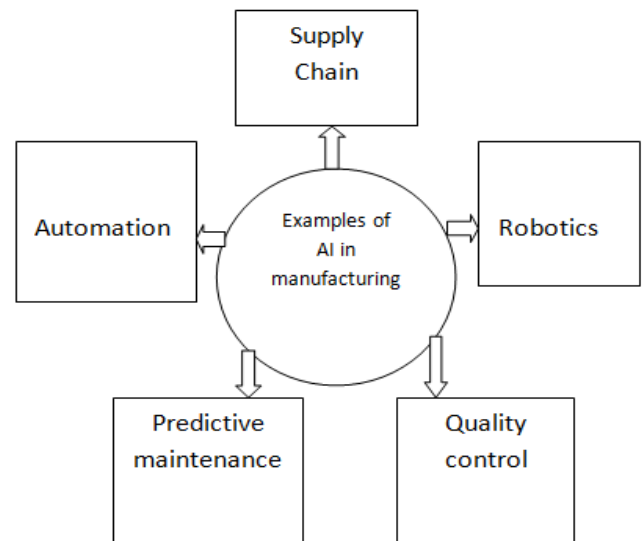


Figure 1 Applications of AI in manufacturing

AI Technology	Applications
Expert systems	Design Maintenance Process control Monitoring Process planning Equipment diagnosis Scheduling
Machine Vision	Inspection Identification Measurement

Robotics	Welding Material Handling Parts Positioning Assembly Spray Painting
Natural Language Understanding	Data base information retrieval
Voice Recognition	Data entry Inventory control Quality Inspection
Speech synthesis	Control room alarms

Table 1 AI technology and its applications

4. Impacts of AI in manufacturing

Following are the impacts of AI in manufacturing

a) Impact on employment:

AI in manufacturing perform routine and repetitive tasks or jobs which are done by humans which leads to unemployment minimise need of human personnel

b) Workforce training:

Implementation of AI needs technical and analytical skills to operate and maintain . For this require ongoing training of workforce.

c) Safety:

AI may leads to major concern around safety when machine and robots are working in close proximity to human.

d) Ethics:

Implementation of AI may increase ethical concern regarding data privacy and accountability.

4.1. Advantages of AI

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

4.2 Limitations of AI

- 1.Leads to unemployment
- 2.Human becomes lazy

3.No ethics or emotions0

4. This technology is not creative

5. Challenges in implementation of AI

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

1. Data acquisition :

One of the challenge in implementation AI is data used to train supervised and unsupervised learning model is of high quality and accuracy which requires acquiring data require preprocessing before used to ensure that the AI algorithms are reliable and effective. Labeled data is costly due to time required to do so. Sometimes exposure to some adverse manufacturing environment leads to sensor drift which bias collected data. Also taking regular measurement is costly due to associated cost of data storage and transfer.

2) Integration with existing system:

In order to communicate and interact AI system with existing systems and workflow require careful planning and coordination. Since existing systems use outdated technologies and formats makes it difficult to connect with AI models.

3) Decision validation:

Lack of interpretability of output from AI models makes it difficult to use for planning. AI algorithms can be responsible for existing biases and discriminations leading to unethical and unfair outcomes. Higher level decisions from AI/ML applications may not be trusted

4) Data privacy and security:

Since AI requires huge amount of data for training and operation .To avoid misuse and leaks one must ensure data security and privacy.

5) Cost implementing

AI is expensive in early stages for small manufacturers who are not able to invest due to lack of financial resources.

6) Implementation

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

Challenges	Opportunities
Data privacy	Edge computing, generative models
Energy consumption	Energy efficient AI/ML models
Implementation	Edge computing, large language models
Decision validation	Explainable AI
High initial cost	Reduce time spent on repetitive task
Security and reliability	Increase the consistency in project related work

Table 2 Challenges and opportunities for AI/ML in manufacturing

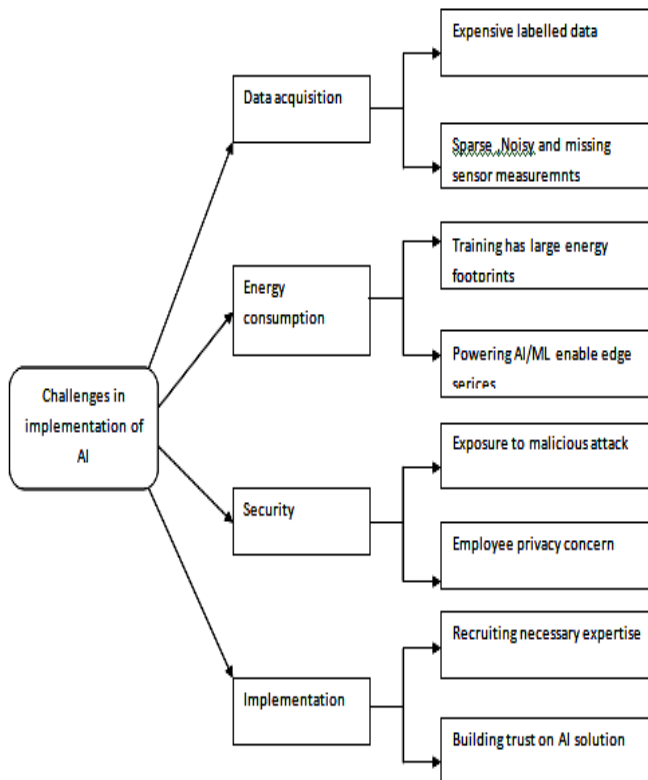


Figure 2. Challenges in implementing AI

5 Conclusion

The implementation of AI in the manufacturing has many advantages, including increased efficiency, quality control, and reduced costs.

The implementation of AI in manufacturing also leads to negative impacts, such as changes in employment and workforce training, safety concerns, and ethical

considerations. There are also many challenges in implementing AI in manufacturing that may related to data acquisition, decision validation, integration with existing systems, and cost.

For implementation of AI in manufacturing requires careful planning, investment in infrastructure and workforce training, and collaboration between IT and manufacturing departments..

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