Survey of Generative AI Use Cases in Manufacturing Industries

1Chinmaya Datt and 2A. K. Madan

1Student, Production & Industrial Engineering, Department of Mechanical Engineering,
Delhi Technological University, Bawana Road, Shahbad Daulatpur, Rohini, Delhi110042, India
2Professor, Department of Mechanical Engineering,
Delhi Technological University, Bawana Road, Shahbad Daulatpur, Rohini, Delhi110042, India.

ABSTRACT: Generative AI, also known as GenAI, is a type of artificial intelligence that can create diverse types of data, such as text, images, videos, audio, and 3D models. By learning patterns from existing data, GenAI can generate original and intricate outputs that resemble human creativity. This technology has a broad range of applications in various industries, including product design, scientific research, manufacturing, entertainment and arts. Generative design tools have emerged as a valuable solution to tackle complex design challenges across various technical fields. This article focuses on Generative AI and its application areas in manufacturing industries.

KEYWORDS: Artificial Intelligence, Machine Learning, Neural Nets, Generative Design, Generative Adversarial Network (GAN) model, CAD

I. INTRODUCTION

Artificial Intelligence (AI) has a great potential to transform the manufacturing industries. Big corporations have already started incorporating it in their workflow, thereby increasing their productivity, decreasing expenses, enhancing quality, and decreasing downtime. Small manufacturing business are also realising how easy it is to get their hands on high-value, low-cost AI solutions.

Some possible use-cases of AI in manufacturing are:- defect detection by using image processing, analysis of data generated by industrial IoT and smart factories, predictive maintenance and accurate demand forecasting. Manufacturers are relying increasingly on artificial intelligence solutions like machine learning (ML) and deep learning neural networks to better analyse data generated in their business environment and make informed decisions.

The general applications of AI are centered on several technologies, including machine learning, which utilizes algorithms and data to learn from patterns without direct programming, deep learning, a subset of machine learning that analyzes images and videos using neural networks, and autonomous objects, which are AI agents capable of independently managing tasks such as collaborative robots (Cobots) or connected vehicles.

This article focuses on Generative AI use cases in manufacturing industries. Section 2 discusses general AI use cases in manufacturing. Section 3 discusses about generative AI and Section 4 discusses its application in manufacturing. Section 5 elaborates about methods and technologies involved in Generative AI Design Manufacturing. Sections 6 discusses about tools available and widely used. Section 7 discusses about current trends in generative design, challenges and future potential of the technology.

II. AI IN MANUFACTURING

The manufacturing industry has undergone a significant transformation due to the impact of artificial intelligence. AI has revolutionized many areas of our lives, from healthcare to advertising, and even personalized recommendations on platforms such as e-commerce websites, streaming platforms, and social media networks, among others. The increased accessibility and advancement of AI technology has led to enhanced efficiency, reduced costs, decreased human error, and increased output in the manufacturing sector. This is primarily due to the abundance of analytical data in manufacturing, which is a perfect fit for AI and machine learning. The production process is influenced by numerous variables that are complex and challenging for humans to analyze, but

machine learning models can easily predict the impact of individual variables in such complex scenarios. However, in industries where language or emotions play a crucial role, machines still operate below human capabilities, hampering the adoption of AI in these areas.

Let's explore the role of artificial intelligence in various manufacturing industries and important technical areas.

a) Artificial Intelligence in Logistics

Artificial Intelligence (AI) in logistics refers to the application of AI and machine learning (ML) techniques to optimize logistics and supply chain operations. AI-powered logistics systems can automate many manual tasks, such as route optimization, demand forecasting, and inventory management, which can help companies save time, reduce costs, and improve customer satisfaction.

One of the key applications of AI in logistics is predictive analytics. By analyzing data from sensors, GPS devices, and other sources, AI algorithms can predict demand patterns and optimize transportation routes, which can help reduce fuel consumption, lower emissions, and improve delivery times. AI can also be used to track the movement of goods and provide real-time visibility into the supply chain, enabling companies to quickly respond to disruptions and minimize the impact of delays.

AI-powered logistics systems can also help optimize inventory management by predicting demand and automating replenishment. This can help reduce waste and improve the accuracy of order fulfillment, which can improve customer satisfaction and reduce costs.

b) Management of Supply Chains with Artificial Intelligence

Artificial intelligence (AI) has enabled factories to significantly enhance their supply chain management capabilities, from predicting and forecasting capacity requirements to efficiently managing inventory levels. By establishing a real-time and predictive model for assessing and monitoring suppliers, businesses can quickly detect and assess any disruptions in the supply chain and respond promptly to minimize their impact. This early warning system enables companies to address the issue and evaluate the severity of the disruption instantly.

c) AI Robots - Robotic Process Automation

The use of robotics in manufacturing, commonly referred to as "industrial robots," has revolutionized the industry by enabling the automation of repetitive tasks, minimizing or eliminating human error, and freeing up human labor for more complex and high-value activities. Industrial robots have a broad range of applications in manufacturing facilities, and many are equipped with machine vision technology, which enables them to navigate and operate precisely in chaotic environments.

d) AI for IT operations

AIOps stands for Artificial Intelligence for IT Operations. It is a term used to describe the integration of artificial intelligence (AI) and machine learning (ML) techniques into IT operations to improve efficiency, reliability, and scalability. AIOps leverages the vast amount of data generated by IT systems and applications to automate tasks, detect anomalies, and provide predictive insights. It combines data from various sources, including logs, metrics, events, and traces, to identify patterns, correlations, and root causes of issues. The goal of AIOps is to enable IT teams to respond faster to incidents, reduce downtime, and optimize resource utilization. Some examples of AIOps applications include network management, service desk automation, and security operations.

e) AI for Autonomous Vehicles

AI autonomous vehicles have the potential to transform the transportation industry by improving safety, reducing traffic congestion, and increasing mobility for people who cannot drive, such as the elderly and disabled. They could also have a significant impact on the environment by reducing carbon emissions from transportation.

Self-driving vehicles have the potential to revolutionize factory operations by automating everything from assembly lines to conveyor belts. The use of autonomous trucks and ships can optimize deliveries, enabling them to operate around the clock and complete shipments more efficiently. Connected cars equipped with sensors can also enhance the efficiency and safety of deliveries by providing real-time information on traffic congestion, road conditions, and accidents. This information can be used to better plan delivery routes, reduce accidents, and promptly notify authorities in the event of an emergency.

f) AI for Factory Automation

In traditional factory settings, operators rely on their experience and intuition to manually adjust equipment settings while monitoring multiple screens for various indicators. In addition to their regular responsibilities, operators are also

tasked with troubleshooting and testing the system, leading to an increased workload and potential for errors.

AI for factory automation refers to the use of artificial intelligence (AI) to automate and optimize manufacturing processes in factories. AI-powered systems can improve efficiency, reduce costs, and increase productivity by automating tasks such as quality control, predictive maintenance, and inventory management.
Internet-of-Things (IoT) devices equipped with sensors generate large amounts of real-time operational data. In the manufacturing sector, this concept is referred to as the "Industrial Internet of Things" (IIoT). When combined with AI technology, IIoT can significantly improve precision and output in factories.

Manufacturers are leveraging AI to analyse sensor data and predict equipment breakdowns and accidents. Synthetic intelligence systems help production facilities determine the likelihood of future failures in operational machinery, enabling preventive maintenance and repairs to be scheduled in advance. Predictive maintenance, enabled by AI, allows factories to increase productivity while reducing repair costs. Many industries are using artificial intelligence to predict when mechanical parts may require replacement. Machine learning, combined with historical data, creates an algorithm that identifies potential problems before they arise, enabling operational employees to take necessary measures to prevent issues that may slow or halt production.

g) Quality Assurance and Inspections Using AI

Computer vision can play an important role in improving manufacturing processes and ensuring worker safety. By using high-resolution cameras and AI algorithms, computer vision can detect flaws and abnormalities that might be missed by the human eye, allowing for quick intervention and reducing waste and recall rates. It can also monitor the work environment for potential hazards, such as gas leaks, and alert workers to take appropriate actions to avoid accidents.

h) AI for Purchasing Price Variance

AI-powered procurement systems can help manufacturers estimate the cost of raw materials and select the best vendors for their needs. These systems can also manage all procurement data in one place, providing manufacturers with greater visibility and control over their supply chain. With AI, manufacturers can analyse data from multiple sources to identify the best suppliers based on criteria such as price, quality, and delivery time.

Additionally, AI can help manufacturers forecast demand and plan procurement accordingly, which can lead to significant cost savings.

Effective order management necessitates flexibility in the market, demand, consumer expectations, and manufacturing strategy shifts. To summarise, factories that employ AI-based systemscan:
- Make use of inventory tracking sensors to generate purchase requests instantly.
- Handle the complication of many order types coming in from various sales channels.
- Streamline and improve the clarity of order and inventory management

i) AI for Cyber security

AI-powered cyber security systems can help manufacturers detect potential threats, such as unusual network activity or suspicious behavior, in real-time. By using machine learning algorithms, these systems can also learn from past attacks and continuously adapt to new and evolving threats. This can help manufacturers prevent cyberattacks before they happen and minimize the impact of any attacks that do occur.

j) Digital twin

Digital twins can be incredibly helpful in manufacturing, as they allow manufacturers to test and simulate products and production processes in a virtual environment before physically producing them. This can help manufacturers save time and money by identifying potential issues and optimizing production processes before physical implementation. By constantly collecting data from sensors and other sources, digital twins can also provide real-time insights into the performance of a product or production process, allowing for continuous improvement and optimization.
Here are some examples of applications of digital twins:
- Healthcare: Digital twins can be used to create personalised models of patients for diagnosis, treatment planning and monitoring.
- Transportation: Digital twins can be used to simulate traffic flow and optimise transportation systems, helping to reduce congestion and improve efficiency.
- Agriculture: Digital twins can be used to monitor crop growth and soil conditions, helping to optimise crop yields and reduce waste.
- Aerospace: Digital twins can be used to simulate the performance of aircraft, spacecraft and other vehicles, helping to improve safety and efficiency.

- Construction: Digital twins can be used to simulate building designs and predict construction outcomes, helping to improve efficiency and reduce costs.
- Manufacturing: Digital twins can be used to simulate the production line, test different scenarios and optimise production processes for greater efficiency.
- Maintenance: Digital twins can be used to monitor and analyse the performance of industrial equipment and predict when maintenance is required. This can help to reduce downtime and save costs.
- Energy management: Digital twins can be used to model and optimise energy usage in buildings, factories and other facilities, helping to reduce energy consumption and costs.

k) Design and Production with AI

AI has the potential to improve product design by generating multiple iterations that surpass the original. The software, commonly referred to as generative design software, receives input from designers on basic ingredients, measurements and mass, processing techniques, and limitations due to financial and other resources. The algorithm then generates an array of potential layouts based on these inputs. Through generative design, AI technology enables collaboration between human minds and robot technical capabilities. Human inputs on input elements, specifications, tolerances, etc. are used to build a complex algorithm. AI then runs simulations of all possible combinations of design inputs to create the optimal product design.

III. GENERATIVE AI

There are currently two categories of AI systems that have contributed to the success stories of AI. These are generative AI and discriminative AI.

Generative AI systems are responsible for creating things such as images, audio, and writing samples using computer-controlled systems like 3D printers. On the other hand, discriminative systems identify specific things like individuals in photos, words in speech or handwriting, and distinguishing between what is real and what is not.

These two types of systems are often combined within a generative adversarial network (GAN) model.

Traditional AI has traditionally been concerned with detecting patterns, making decisions, improving analytics, classifying data, and identifying fraud. In contrast, Generative AI utilizes neural network methods like transformers, GANs, and VAEs (variational autoencoders) to produce new content, chat responses, designs, synthetic data, and even deep fakes.

Generative AI is a form of artificial intelligence technology that can generate various forms of content, including text, images, audio, and synthetic data. The introduction of generative adversarial networks (GANs) - a type of machine learning algorithm - has enabled generative AI to create realistically convincing images, videos, and audio of actual people.

Generative AI models utilize a combination of different AI algorithms to process and represent content. For instance, to generate text, natural language processing techniques are utilized to convert raw characters (e.g., letters, punctuation, and words) into sentences, parts of speech, entities, and actions. These are then represented as vectors using multiple encoding methods. Similarly, images are transformed into different visual components, also expressed as vectors. However, it is essential to note that these techniques can encode biases, racism, deception, and exaggeration found in the training data.

Once the representation of the world is determined, a specific neural network is employed to create new content in response to a query or prompt. Techniques such as GANs and VAEs - neural networks with a decoder and encoder - are suitable for generating realistic human faces, synthetic data for AI training, or even replicas of specific individuals.

Recent advancements in transformers such as Google's Bidirectional Encoder Representations from Transformers (BERT), OpenAI's GPT, and Google AlphaFold have also led to neural networks capable of not only encoding language, images, and proteins but also generating new content.

Pharmaceuticals: Pharmaceutical companies along with academic researchers are utilizing generative AI in various fields. One area where generative AI is being applied is in the design of proteins for medicinal purposes. Predicting the folding of proteins has been a significant challenge for geneticists and pharmaceutical developers for several decades. However, GANs are now providing researchers with increased capabilities to understand and utilize protein synthesis.

Genetics Research: AI is also playing a significant role in genetics research. Geneticists are now able to understand gene expression better - the process of turning specific genes and combinations of genes on and off - as well as the functions of genes when they are active. With the help of AI,

researchers are now able to predict how gene expression will change when certain genes undergo specific modifications. This advancement in technology shows tremendous potential for the development of gene therapies, as well as for optimizing treatments by predicting which medications would be most effective based on a person's genetics.

Image Synthesis: OpenAI's Dall-E (short for "Drawing Artificial Intelligence Language Model - Encoder") is utilizing AI to generate images based on textual descriptions. These AI systems use natural language processing (NLP) and deep learning to interpret the text input and create images that match the provided descriptions. This technology has tremendous potential for various industries, including art and design, advertising, and e-commerce, among others.

Space synthesis: The use of AI can also occur in 3D spaces and objects, whether they are real or digital. In real-world scenarios, applications such as AutoDesk can aid in the design of buildings and urban landscapes by incorporating both built and natural elements. AI technology supplements the work of human designers by suggesting solutions that fit specific code requirements or space and material constraints, and filling in missing details. Meanwhile, numerous companies, including Meta and major game creators, are developing applications that generate virtual spaces for game designs.

Manufacturing: In the field of manufacturing, companies such as Autodesk and Creo are utilizing generative AI to design physical objects. These objects are often created through computer-controlled machining, additive manufacturing, or 3D printing. Generative AI is capable of creating machine parts and sub-assemblies of larger objects, while also optimizing designs for various aspects of the manufacturing process. For instance, it can optimize designs for materials efficiency by minimizing waste, for simplicity by using fewer parts, and for speed of production.

IV. GENERATIVE AI IN MANUFACTURING INDUSTRIES

Generative design, a type of computer-aided design (CAD), leverages Artificial Intelligence to generate product plans based on user input requirements and preferences. This technology helps manufacturers optimize their designs in terms of cost, performance, and sustainability, enabling them to create new products or redesign existing ones.

Generative AI design finds applications across a range of manufacturing industries, including automotive, aerospace, and medical equipment. It is particularly useful for designing complex parts and components, allowing manufacturers to optimize designs for weight, strength, or other critical criteria that are specific to their use case. The technology can also be leveraged to create custom parts or products, as well as for rapid prototyping. Overall, generative design offers a powerful tool for manufacturers to enhance their design processes and improve product performance.

The typical process for engineering design follows these steps:
- Ideation - Identify a problem and conceive a concept.
- Creation - Develop a rough prototype of the concept.
- Design - Elaborate on the specifics with a detailed plan.
- Validation - Test the product to confirm its functionality.
- Production - Manufacture the product on a large scale.
- Release - Introduce the product to the market.

The engineering design process outlined above is rather linear, and has several significant drawbacks:
- Technical Expertise Required - Each step of the process demands a high level of technical expertise. While sophisticated software tools may be utilized, complex domain-specific software is required to precisely define every dimension and feature of the design to ensure that it can be manufactured effectively.
- Negative Feedback Loop - There is a negative feedback loop that can occur if problems arise during the validation or manufacturing phases. This often results in product recalls, redesign efforts, and significant resource waste.
- Creativity Limitations - The ability of designers and engineers to generate new designs is constrained by their speed of iteration. When under tight schedules, innovative solutions may take a backseat, and non-creative solutions become the norm, impeding long-term innovation.

Although traditional engineering design software has made some improvements in addressing the challenges mentioned earlier, engineers still need to go through each development phase. However, new technologies

have the potential to boost productivity in the same way they have in other industries. Generative design is a great example of how digital tools can increase efficiency in product development, leading to further optimization of value chains, especially when implementing new manufacturing principles such as 3D printing. Generative design utilizes artificial intelligence and machine learning to transform tedious engineering design processes into a more natural interaction between computers and engineers. The computing unit automatically performs most of the topology optimization and simulation tasks. Furthermore, negative feedback loops are shortened by decreasing the design barriers.

Some of use cases of generative AI in manufacturing are: - Designing physical products and buildings, Optimizing new chip designs, and suggesting new drug compounds to test.

The optimal use of generative design is in combination with other technologies, particularly 3D printing, as the two complement each other in several ways. First, 3D printing allows for quick prototyping and testing of new designs without committing to a costly and time-consuming custom manufacturing run. This means that engineers can iterate designs more rapidly and with less waste, resulting in significant cost and time savings. Second, 3D printing has no geometrical limitations, making it possible to create extremely complex structures that traditional methods such as milling cannot manufacture. This opens up new possibilities for innovative designs that were previously impossible to produce. Third, 3D printing enables mass-customization, and allowing products to be tailored to the specific needs of individual customers. With generative design and 3D printing working together, AI can generate customized parts for a customer's bike, for example, with minimal economic drawbacks, as it can be produced only once, resulting in a more efficient and sustainable manufacturing process.

Generative design is a powerful approach to engineering design problems that leverages the capabilities of AI and ML to automate many of the tedious processes that create bottlenecks, ranging from optimization to aesthetics. While these technologies cannot fully replace human engineers (yet), they have the potential to significantly enhance their productivity and creativity. Many of these capabilities are already available in modern design tooling, making it easier for engineers to incorporate generative design into their workflow. There are various AI techniques utilized for generative AI, but recently, foundation models have gained significant attention. These models are pre-trained on general data sources in a self-supervised manner and can be adapted to solve new problems. Foundation models are primarily based on transformer architectures, which are a type of deep neural network architecture that computes a numerical representation of training data.

V. METHODS AND TECHNOLOGIES INVOLVED IN GENERATIVE AI DESIGN MANUFACTURING

Generative design is a term used to describe a set of processes and tools that utilize physics-based simulation and various analytical methods to determine the form and composition of a product while considering its performance requirements. By applying these techniques, generative design software can explore a wide range of potential design options and identify the most suitable solutions for a given product, often resulting in highly optimized and innovative designs.

Generative AI design in manufacturing is a multidisciplinary field that utilizes a range of technologies and methods. Here's a breakdown of some of the most noteworthy ones:

1. 3D printing: This technology is used to quickly prototype and test new designs without committing to costly custom manufacturing runs. 3D printers can produce complex structures that traditional methods cannot manufacture.
2. Computer-Aided Design (CAD) software: This software is used to create 3D models of designs and simulate their behavior in various conditions. This helps engineers optimize designs before they are manufactured.
3. Machine learning algorithms: These algorithms are used to analyze large data sets of designs and identify patterns that can be used to generate new designs. They can also be used to optimize designs for specific objectives.
4. Topology optimization: This method is used to optimize the structure of a design to meet specific performance requirements. It involves iteratively removing material from a design while maintaining its structural integrity.
5. Finite element analysis (FEA): This method is used to simulate the behavior of a design under various conditions, such as stress, heat, and vibration. FEA helps engineers optimize designs for specific operating conditions.
6. Natural language processing (NLP): This technology is used to generate designs based on textual input, such as a description of a product's requirements or a user's preferences.

7. Reinforcement learning: This technique involves training an AI agent to optimize a design by rewarding it for achieving certain objectives, such as minimizing weight or maximizing strength.

Overall, generative AI design in manufacturing is a rapidly evolving field that is advancing the way products are designed, optimized, and manufactured.

By using generative design, manufacturers can deliver higher quality products in a more efficient, cost-effective, and sustainable way. The benefits of generative AI design include cost efficiency, increased performance, faster design cycles, increased design variety, an ability to learn and improve, and more sustainable design solutions. Generative design allows manufacturers to quickly generate thousands of design options for a single product, making it a powerful tool for innovation and growth in the manufacturing industry.

Generative design is a powerful tool that can help manufacturers create better, more efficient products with less time and cost. By automating certain steps in the design process and using machine learning algorithms, generative design can create a vast number of design options based on the input parameters, allowing designers to choose the best possible solution for their needs. As technology continues to evolve, we can expect even more exciting developments in the world of generative design and its applications in manufacturing.

Generative design is an artificial intelligence-based approach that harnesses the power of cloud computing and machine learning to accelerate the design-to-make process.

Generative design provides significant benefits for manufacturing, including light weighting, performance improvement, parts consolidation, and sustainability. By leveraging the power of cloud computing and machine learning, generative design accelerates the design-to-make process, leading to more efficient and sustainable manufacturing practices.

VI. TOOLS FOR SUPPORT

A number of popular engineering design applications already offer generative design capabilities powered by artificial intelligence. They have successfully integrated generative design into its products, bringing it out of the lab and into mainstream use. Furthermore, there is a growing number of open source standalone projects that provide generative design capabilities as well.

Fusion 360 Generative Design Extension from Autodesk: Autodesk's generative design technology offers designers and engineers the ability to rapidly explore multiple design solutions based on manufacturing constraints, cost, and product performance requirements. The Generative Design Extension in Fusion 360 enables users to compare manufacturing methods and constraints, prioritize attributes such as light weighting and material exploration, and even evaluate cost considerations. With this technology, designers and engineers can quickly identify the most efficient and cost-effective manufacturing method for their product, as well as identify opportunities for sustainability and part consolidation. By streamlining the design process and automating certain steps, generative design can help manufacturers create higher quality products at a lower cost and in less time.

Ansys Discovery: Ansys Discovery's approach to simulation-driven design and topology optimization is another example of how generative design can aid engineers in creating innovative and optimized products. By utilizing physics simulation and interactive modeling, engineers can quickly explore different design options and optimize their designs for functional requirements, such as air flow, fluid flow, and heat management, while also taking into account manufacturing constraints. This allows for a more efficient design process, with the ability to quickly evaluate and refine design concepts without the need for physical prototyping.

Dassault Systèmes CATIA Generative Design Engineering: CATIA is a versatile software suite that encompasses computer-aided design, engineering, manufacturing, 3D modeling, and product lifecycle management, created by the French company Dassault Systèmes. One of the notable features of this powerful platform is its Generative Design Engineering (GDE) function. GDE takes a multi-step, multi-departmental approach to setting parameters. It is particularly beneficial for organizations such as large automakers, where engineering and design are multi-disciplinary processes, and designers may not have the expertise in materials or manufacturing methods required to optimize a component.

GDE allows non-specialist designers to automatically generate optimized conceptual parts from functional specifications. Starting with a basic shape model, designers can validate its general functionality and then provide the functional specifications, such as material, space, load, weight

reduction targets, and manufacturing process. GDE then generates an optimized part that can be loaded into the variant manager, which has another set of criteria for generating alternative designs. The best option can then be compared and assessed, and delivered to engineers for further enhancement and validation using the same CATIA 3Dexperience Platform.

The primary goal of GDE is to facilitate a collaborative workflow between designers and engineers for both conventional and additive manufacturing.

VII.   CONCLUSIONS

Artificial Intelligence (AI) and Machine Learning (ML) are prominent topics in Industry 4.0. These evolving techniques have the potential to provide numerous benefits to production systems, including resilience and sustainable growth. Despite their potential advantages, the implementation of AI/ML in manufacturing Micro, Small, and Medium Enterprises (MSMEs) requires significant effort in terms of data quality and employee skills. Therefore, the full potential of AI/ML has not yet been realized in the context of MSMEs, which could otherwise use these technologies to improve their core processes or innovate their product offerings to remain competitive.

AI/ML-based solutions are mainly applied to maintenance and quality in MSMEs, with other application domains receiving less attention. However, the implementation and proper use of these solutions face several limitations in MSMEs, including data problems related to availability, quality, and quantity, lack of knowledge and skills in the field, financial resource constraints for investment, complexity of the proposed solutions, and inadequate management involvement and strategy.

Data availability continues to expand, encompassing various forms of data such as text, images, videos, audio (speech), and even 3D signals (such as those produced by LIDAR for self-assisted driving - an industry that is expected to experience significant growth in the upcoming years, with millions of cars on the roads gathering terabytes of data on a daily basis).Massive amounts of processing power are required to process these data and create the Foundation Model. Once the data has been processed, it becomes synthetic data that can serve as a blueprint for various applications. It can be further processed to extract meaning in a specific context, and transformers are used to accomplish this task. The open approach taken in offering Generative AI through APIs is

leading to a self-sustaining evolution in both the development of increasingly powerful tools and the expansion of fields of application. This presents an excellent opportunity for small-scale newcomers to leverage Generative AI tools and support customized applications.

The majority of modern CAD solutions only allows for precise geometry and cannot alter the faceted model geometry produced by generative design. However, the most effective generative design software employs convergent modeling technology to enable a combination of precise geometry and faceted geometry, allowing engineers to use a blend of traditional and generative design techniques. This innovative approach to design can be particularly advantageous for industrial machinery companies seeking to reduce the weight and enhance the energy efficiency of their machines. Although presently most applications are limited to prototype testing or producing one-off components, there is no doubt that these design methods will become more widespread in the future.

Although it is impossible to predict which specific examples and use cases of generative AI will show the most promise for the future, some have made tremendous progress in recent years, such as image generation and speech synthesis. Other areas, such as medicine and manufacturing, have also shown enormous potential. However, progress in physical use cases appears to be somewhat slower due to the inherent limitations imposed by manipulating matter as opposed to data.

In the next few years, generative AI will be used even more, increasing effectiveness and enabling new services. It is also bound to raise ethical and societal issues. Expect strong impact on business (short term), on education (long term) and on society (medium to long term). The application of AI to Robotic Process Automation (RPA) has the potential to enhance the effectiveness of shop-floor operations, enable more flexible manufacturing, and create a more reliable supply chain. It is also poised to become a new tool for augmenting human creativity. By significantly reducing time-to-market, AI can empower designers and illustrators to produce a greater variety of creative designs.

REFERENCES
[1].   https://generativeai.net/
[2].   Regenwetter, L., Nobari, A. H., &Ahmed, F. Deep Generative Models in Engineering Design: A Review.

https://decode.mit.edu/assets/papers/2022_regenwetter_review.pdf

[3]. Kumar, S., & et al. (2023). Machine learning techniques in additive manufacturing: a state of the art review on design, processes and production control. Journal of Intelligent Manufacturingvolume34, 21–55 (2023)

[4]. Ribeiro, J., Lima, R., Eckhardt, T.,&Paiva, S. (2021). Robotic Process Automation and Artificial Intelligence in Industry4.0 – A Literature review. CENTERIS-International Conference on ENTERprise Information Systems- Procedia Computer Science 181 (2021) 51-58

[5]. Collins,C., Dennehy, D., Conboy, K., &Mikalef, P. (2021). Artificial intelligence in information systems research: A systematic literature review and research agenda. International Journal of Information Management 60 (2021) 102383

[6]. Badue, et. Al. (2021). Self-driving cars:A survey. (2021). Expert Systems With Applications 165 (2021) 113816

[7]. Kehayov, M., Holde, L.,& Koch, V. (2022).Application of artificial intelligence technology in the manufacturing process and purchasing and supply management. Procedia Computer Science 200 (2022) 1209-1217

[8]. Tercan, H., & Meisen, T. (2022). Machine learning and deep learning based predictive quality in manufacturing: a systematic review. Journal of Intelligent Manufacturing (2022) 33:1879–1905

[9]. Charmet, et al. (2022). Explainable artificial intelligence for cybersecurity: a literature survey. Annals of Telecommunications (2022) 77:789–812

[10]. Kritzinger, W., & et al. (2022). Digital Twin in manufacturing: A categorical literature review and classification. IFAC PapersOnLine 51-11 (2018) 1016–1022

[11]. Tsang, Y.P., & Lee, C. K. M. (2022). Artificial intelligence in industrial design: A semi-automated literature survey. Engineering Applications of Artificial Intelligence 112 (2022) 104884

[12]. Liu, C., Tian, W., & Kan, C. (2022). When AI meets additive manufacturing: Challenges and emerging opportunities for human-centered products development. Journal of Manufacturing Systems 64 (2022) 648–656

[13]. Pilagatti, A. N., & et al. (2022). Generative Design and new designers' role in the manufacturing industry. Procedia CIRP 112 (2022) 364–369

[14]. Buonamici, F., & et al.(2021). Generative Design: An Explorative Study.Computer-Aided Design and Applications. 18(1), 2021, 144-155. http://www.cad-journal.net

[15]. Simone, V. D., Pasquale, V. D., & Miranda, S. (2023). An overview on the use of AI/ML in Manufacturing MSMEs: solved issues, limits, and challenges.4th International Conference on Industry 4.0 and Smart Manufacturing.Procedia Computer Science 217 (2023) 1820-1829

[16]. https://www.autodesk.in/products/fusion-360/generative-design-extension

[17]. https://www.ansys.com/en-in/products/3d-design/ansys-discovery

[18]. https://discover.3ds.com/performance-driven-generative-design-cloud

[19]. https://www.accenture.com/us-en/blogs/industry-digitization/how-ai-driven-generative-design-disrupts-traditional-value-chains

[20]. https://www.autodesk.com/solutions/generative-design/manufacturing

[21]. https://ieeecs-media.computer.org/media/tech-news/tech-predictions-report-2023.pdf