The Role of Artificial Intelligence in Mechanical Engineering: Optimizing Design Processes, Manufacturing Industry and Robotics

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Abstract: Artificial intelligence (AI) technology, as one of the most sophisticated science and technology in today's world, is increasingly being used to production and life, particularly in the manufacturing business. it demonstrates how artificial intelligence technology is used in mechanical manufacturing, namely in defect detection, quality inspection, enhancing workplace safety, and other areas. Artificial intelligence technology is becoming increasingly important in people's lives as it becomes more widely used in people's daily lives, such as the widespread use of smart dishwashers and smart sweepers, which are the products of the fusion of artificial intelligence and the mechanical manufacturing industry. Indeed, artificial intelligence technology has been widely utilized in the mechanical manufacturing business, which not only ensures production precision, but also enhances job productivity and workplace safety. The rise of artificial intelligence has caused significant changes in the manufacturing industry as a whole. Without exception, the manufacturing industry must rely on AI technology to accomplish automation and intelligent development, as well as to improve productivity. Using artificial intelligence to categorize mechanical components, we may propose parts from a based solely on an image or CAD model. To find a necessary component in machines we must currently browse through a catalogue and be able to discern which part you want based on the available possibilities and your understanding of the catalogue. There are serial numbers to memorize since a single digit or character change might indicate a different sort of part. The algorithm will choose which sections are the best and will significantly facilitate our search.

Keywords: Intelligence (AI), Machine Learning, Deep Learning, Manufacturing Technologies, Robotics, Mnufacturing Industry, Mechanical Engineering.

INTRODUCTION

Artificial intelligence is now the most represented technology in this discipline as a subfield of computer science. By imitating, extending, and increasing human intellect, it seeks to comprehend the nature of intelligence and create equivalent Intelligent robots. Virtual reality technology, emulation technology, and speech recognition technology are just a few of the many ways that artificial intelligence, in general, examines. Artificial intelligence (AI) technology, as one of the most advanced science and technology in the current society, has been applied more and more widely to production and life, and especially in manufacture industry.

There are several ways artificial intelligence (AI) may be used in mechanical engineering. The design and optimization of mechanical systems and parts, such as engines, gears, and bearings, may be automated using AI, for instance. The performance of mechanical systems may also be simulated and analyzed using AI in order to forecast behavior, spot future issues, and suggest changes. AI may also be used to track and manage mechanical systems in real-time, improving their dependability and efficiency. Overall, applying AI to mechanical engineering may assist to increase the effectiveness,

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dependability, and performance of mechanical systems as well as promote the creation of novel and cutting-edge technologies. Different ideas have arisen as a result of the advancement of technology, and terms like robots, machines, and learning machines are now often used. Even if these ideas appear to be at odds with one another, they are connected. Humans and even animals possess an inherent intelligence that is now starting to be incorporated into computers and robots. Numerous corporate sectors now employ artificial intelligence extensively, and new applications are being discovered all the time. Artificial intelligence is not being developed to eliminate jobs for people. Its primary goal is to expand already-existing company sectors and perhaps start new business lines. Artificial intelligence conjures up the idea of a human-like electromechanical robot taking the place of people. It is clear that computers will never be able to transmit human creativity, passion, and character in the same way that they can with modern technology. Additionally, it appears that computers may be able to control devices like robots that mimic some physical human actions. They may also be able to serve as the brains of systems that replicate human thought processes in domains like data analysis and medical diagnosis. In smart applications, the terms artificial intelligence, machine learning, and deep learning are frequently used interchangeably. However, there are distinctions between them. A part of machine learning is called deep learning. All machine learning applications are considered to be examples of artificial intelligence since machine learning is a subset of artificial intelligence that may operate intelligent applications. A broad field, artificial intelligence encompasses sophisticated and complicated operations. This is why there are several ideas, techniques, and technologies in his field of study. Cognitive computing is the term for intelligent systems that communicate with one another and with humans. These systems learn via interactions with people and the environment around them rather than from explicit programming.

One may argue that the development of artificial intelligence has significantly altered the manufacturing sector as a whole. Without exception, the manufacture sector must rely on AI technology in order to achieve automation, intelligent development, and to better satisfy its demands in the new era of the 4.0 industrial revolution.

Material and Method

Learning in human intelligence is comparable to learning in artificial intelligence and learning made possible by neurons. In order to develop digital neurons and artificial neural networks, computer programs were used to replicate how neurons in human intellect function. Artificial intelligence now has the ability to learn by digesting many data and information inputs and to build abilities like issue solving in accordance with the analyses that arise from these data thanks to these newly generated digital neurons and artificial neural networks. Artificial intelligence-enabled machines and robots are not confined to carrying out the duties that are given to them. They are simultaneously capable of making a variety of choices depending on the knowledge they have received from the material accumulating in their memories (Andrew Ng, 2022).

The manner that their algorithms learn is where deep learning and machine learning diverge from one another. Larger datasets may be used since deep learning considerably automates the feature extraction phase of the process and eliminates some of the need for manual human interaction (Khan M.A., 2014).

Although a labeled dataset is not always required for this sort of learning, deep machine learning can benefit from supervised learning, commonly known as labeled datasets. Unstructured data (such text and photos) may be incorporated by deep machine learning, which can also automatically recognize feature sets that separate various data types. We can grow machine learning more interestingly since it doesn't require human interaction to interpret data, unlike machine learning. The acceleration of advancement in fields like computer vision, natural language processing, and speech recognition is mostly attributed to deep learning and neural networks.

Artificial neural networks (ANNs), often known as neural networks, are made up of node layers with an input layer, one or more hidden layers, and an output layer. Each artificial neuron or node is linked to others and has a threshold and weight that go with it. Any top individual node whose output exceeds

the predetermined threshold becomes active and transmits information to the following network tier. If not, no data is sent to the following network layer.

The depth of layers in a neural network is all that is meant by the "deep" aspect of deep learning. A deep learning algorithm or deep neural network may be thought of as a neural network with more than three layers inputs and outputs. A simple neural network is one that has just two or three layers (Yang J.R., 2019).

Machine learning is the process of developing software that can learn from experience without explicit programming. For example, a program may learn how to interpret a handwritten message from an image or diagnose breast cancer from medical data without being expressly programmed to do so. This also includes programs that can play computer games, stack things, walk, play chess, play go, etc.

Applications of AI in mechanical engineering

There are various areas where AI finds applications in mechanical engineering. It comprises of data handling and automation, to perform the work with minimum of human intervention. Fields such as machine design, manufacturing, crash simulation, predictive maintenance, robotics, industry 4.0 applications etc come under Mechanical engineering. AI is being used in areas where large data is generated, and models are available to predict performance and diagnostic for failure and preventive maintenance.

A. MACHINE DESIGN

Mechanical design is the first step in the process of conceptualising a component, a product or a process. Dixon reviewed the use of AI in mechanical engineering design and concluded that unlike electrical engineering domain, it involves material selection, analysis, and geometry. It cannot be done just by analysis alone as it is iterative and is intellectually important. It has weak and strong solution approaches. Geometry is important as it has features for manufacturing and functioning. Application of AI will require comprehensive models at each stage of design process. AI finds application during design analysis.

B. VIBRATION ANALYSIS

Thorsten used AI for vibration analysis of a cracked beam. Initially analytical data obtained from FE analysis on Ansys, was used for learning of AI/ ANN and then it was used for predicting the natural frequencies of cracked beam without using computer modelling and simulation.

C. CRASH SIMULATION

Constantin used machine learning to analyse crash simulation data. They had data of 1000 simulations of full frontal crash with variations in design of car and impact conditions. Understanding of large amount of simulation data would have required lot of time and human effort. Such is also the situation in Robustness Analysis or Design Space Exploration data.

D. MANUFACTURING

Development of machine learning, advanced sensors has helped in the generation of autonomous robots. Voice recognition and other features have given rise to human and robot collaboration. Thorsten have identified that large data is being generated in Industry 4.0. This data pertains to quality, environmental data, data from sensors of production line, machine tools and semantic data in different formats. This big data with the help of AI is used for process improvement and product quality sustainability. Development of machine learning, advanced sensors has helped in the generation of autonomous robots. Voice recognition and other features have given rise to human and robot collaboration. Thorsten have identified that large data is being generated in Industry 4.0. This data pertains to quality, environmental data, data from sensors of production line, machine tools and semantic data in different formats. This big data with the help of AI is used for process improvement and product quality sustainability.

Artificial intelligence and mechanical manufacture industry

Mechanical manufacture industry has experienced four stages of development. The first stage is machine manufacturing age. In the late 18th century, Industrial Revolution characterized by the invention of steam engine and machine tool brought manufacture industry into the age in which machines replaced manual manufacture. From the beginning of 1900s to 1960s, the second industrial revolution happened, and manufacture industry stepped into the stage of electrification and automation. Streamline and volume-produce emerged in this stage. Based on the upgrading of industry 2.0, electric information technology was applied in mechanical manufacture industry and electric information era has come. At this stage, machines have gradually replaced human being and micro-electric technology, computer science, automation technology have been widely applied in mechanical manufacture industry. Mechanical manufacture was developing into integration. Now mechanical manufacture has stepped into the age of intelligence. From the beginning of 21st century, the fourth industrial revolution is integrating internet, big data, cloud computing, internet of things, artificial intelligence into mechanical manufacture industry.

The application of artificial intelligence technology in mechanical manufacture industry is mainly reflected in the following aspects:

1. Fault diagnosis

The process of mechanical design, manufacturing and automation is relatively complex, and a large amount of data calculation is required in this process. For example, a large number of formulas are needed in the process of modeling and demonstration to calculate and deduce, and if the process is completely dependent on manual calculation, on the one hand, it is easy to calculate wrongly, on the

other hand, it also takes a lot of time and effort, which is not conducive to the entire production process. Luckily, artificial intelligence can automatically classify and categorize information to improve the accuracy of calculation, and therefore, the subsequent errors or failures can be effectively avoided. In addition, artificial intelligence can also diagnose mechanical failure. In the method of fault diagnosis based on Expert System Theory, firstly, the data being monitored by machines are input into the system through the human-machine interface. Then the reasoning machine obtains the corresponding diagnostic results through forward inference engine and puts forward expert opinions. Finally, the most similar cases in history are obtained by intelligent searching, and the similarity is calculated based on the historical cases to diagnose mechanical faults. This advantage of artificial intelligence technology can also be reflected in the maintenance of equipment. Artificial intelligence in equipment maintenance is mainly predictive maintenance, which is done by collecting the actual operation data of parts of the equipment and then comparing them with that of the intelligent training model, timely warning and reminding related personnel to maintain. This technology not only improves the safety of the production system, but also effectively reduces the downtime, and improves production efficiency as well.

2. Quality inspection

The traditional manual detection, on the one hand, due to the differences between different people, makes the inspection standard difficult to be completely the same. On the other hand, even the same person may have inconsistent test standard at different time and with different physical or mental state. Moreover, especially when faced with product inspection of rapid mass production, it is almost impossible for manual detection to do the full inspection. However, based on deep learning machine vision technology, artificial intelligence detection makes quality inspection standards more unified, stable, and faster detection.

3. Improving the safety of working places

Safety has always been a hot issue in traditional manufacture industry due to its frequent occurrence of unsafe problems in manufacturing process. Thanks to AI, there problems can be avoided to the greatest degree. AI can recognize the safety status of working places with its unique cognitive function, it will warn the workers to leave the spot or take other necessary actions in case of emergency.

Moreover, AI system can also set up visiting limitations of workers to identify the entry of the unpermitted people, and with its image recognition technology, AI can assess whether the workers on the spot are conforming to the safety regulations, for example, if they are wearing necessary safety equipment, such as safety helmet, safety goggles. Thus, the safety situation in manufacture industry will be much improved with the help of AI system In addition to the above aspects, artificial intelligence is also greatly helpful in product development, manufacturing and rear services. Relying on its powerful data storage and effective information processing, artificial intelligence can help its clients find their desirable products and thus shorten the time for products design. Also, in products manufacturing procedure, artificial intelligence can help bring about most accurate products. Similarly, in products rear service, artificial intelligence can help provide far-distance equipment maintenance when in need, such as spare parts management, routine or predictive equipment maintenance, fault warning and diagnosis, products upgrading, and etc.

Advantages of artificial intelligence in manufacture industry

1. Effective and accurate information processing

Effective and accurate information processing guarantees the security and stability of mechanical manufacture and automation. Mechanical automation relies greatly on electronic information transmission system to transmit information, and it is very easy to have problems in the process of information transmitting, especially when you input or output a lot of information, some unpredictable errors may occur and result in serious adverse effects.

The main reason for this problem is the instability in the mechanical electronic system itself, so, it is necessary to apply artificial intelligence technology when the information is being processed. Artificial intelligence technology can monitor the stability of electronic information system in the process of information transmission very accurately to ensure the security and accuracy of information input or output. Therefore, artificial intelligence can better information processing, and plays a significant role in mechanical manufacture and automation.

2. Powerful data storage and calculation

Artificial intelligence technology improves the precision of mechanical manufacturing and automation. The most representative application of artificial intelligence technology in mechanical manufacture and automation is the neural network system. In fact, the system is an electronic information system built by imitating the human nervous system, and its main feature is its large amount of storage and the absolute accuracy of the data. Specifically, the neural network system analyzes some data by simulating the structure of neurons, and then uses the results of the analysis to obtain the participating values. From the structural point of view, the structure of neurons is very close and stable, thus making the whole neural network system more intelligent. Therefore, even if it is necessary to process huge amounts of information data, neuronal systems can be accurate and precise, and the relevant data in the process of mechanical manufacture and automation can rely on neural network systems for effective calculation and storage. Furthermore, the application of deep learning algorithm in artificial intelligence has promoted mechanical manufacturing and automation to a new level, bringing more diversified innovation and practice to the manufacturing industry.

The role of robotics and the Industry 4.0

It is the era by which organizations are automating many processes, making them more efficient and resulting in collaboration of people and machine. Competitiveness in today's business environment is increasing day by day. It is important to take smarter decisions at right time which gives the requirement of more intelligent systems to take smart decisions. Machines in the form of robots from decades are used to perform dedicated tasks in manufacturing processes whereas human in collaboration are assigned predefined tasks such as Inspecting the quality of product and to discard the one with some defects. Robots play an important role in modern industry that can complete their tasks intelligently, with their focus on safety, flexibility and collaborative. In the next few years our society will be different from today. The main technologies are Artificial Intelligence and Robotics Industry.

Robotics and industrial automation has completely changed the production and manufacturing phase. Both are working in implementing automation to increase production and hence the economy.

Human-robot collaboration plays an important role in Industry 4.0. In human-robot collaboration, the robot assists the human operator and work hand in hand. It is not easy to replace humans in this also machines do not replace humans but relives him of tedious tasks like the lifting of heavy loads, putting heavy parts from one place to another. The aim behind collaboration is to combine the skills of humans and machines together so achieve more, precise and accurate output. Human robot collaboration is a future for industries in manufacturing and production. Main advantage of Human robot collaboration is flexibility in production, less risks and high-quality performance.

Robots can do wonder in product design too. It is a challenge for many companies to use AI and big data to design the product that meet the exact need of targeted customer. For example, Nike was having a challenge to design the spike shoes; where, a stiff spike plate was better to give the runner support to push off against. But the spike plates were heavy resulting in sprinter down. With, the help of robotics software, the task is accomplished with both stiffness and lightness shoe design. Human designer can accomplish the same task after number of iterations even though it would not be so optimized as after the use of robotics software.

Pros of Robotics Automation

1. Decreased Production Costs: with use of Robotics speed increases which impact production.

2. No time waste: Robots will work in speed without break, sleep and will give better output than human worker

3. Reliability and Quality improves: In industry precision and accuracy plays an important role. Some products are manufactured with same process and same specification every time. So robotics will improve precision and accuracy.

4. Reduced waste: Robots work with accuracy and it will reduce the cost on waste.

5. Increased Safety: Some parts are dangerous to work or pick upon. Safety will be increased using this

6. Savings: Quality and customer satisfaction plays a significant role. Increase in both will return more customer and more business.

7. Multiple Application: robots can perform multiple operation simultaneously which will affect business.

Conclusions and Recommendations

As it allows us to glean a great deal of knowledge from unstructured data, the branch of research known as deep learning (artificial intelligence) offers a vast array of potential applications. It is fundamentally just data analysis. Data is available everywhere in the internet era, and if we can effectively extract it, we can do a lot. There are several potential uses for this area in the realm of mechanical engineering as well. Even though they didn't specialize in computer sciences, it would be beneficial for all engineers interested in data analytics to learn about data science, machine learning, and consider its prospects because practically all studies in deep learning require a domain expert. We will genuinely succeed in our areas if we have domain knowledge and data analysis skills.

The theoretical strategy could be more appropriate if you have a solid understanding of mathematics. Before beginning to study AI, it is important to be familiar with the following areas in mathematics: All the fundamental math, including matrices, vectors, and functions Statistics, probability, and linear algebra Calculus should decide on a technique based on your prior experience (math/coding) and your future research goals.

Designing intelligent tools, gadgets, and systems to improve society's standard of living is the exclusive emphasis of the emerging engineering profession known as artificial intelligence. AI now encompasses a wide spectrum of computer power and massive datasets thanks to the incorporation of

machine learning techniques. Designing, managing, and evaluating AI features properly requires an engineering background. Artificial intelligence offers a complete framework and tools for creating machine learning algorithms in a dynamic environment throughout the enterprise-to-edge spectrum. The three pillars of artificial intelligence are human-centric AI, scalable AI, and robust AI.

Machine learning techniques that enable Artificial Intelligence models to operate similarly to human minds and bodies must be developed, programmed, and trained by AI engineers. They don't need to write expert code in a number of programming languages, but they do need to find vast volumes of real-time organized and unstructured data from multiple sources. AI Engineering supports the infrastructure of smart goods and services as well as the development of artificial intelligence. To achieve understandable AI, they must be able to fully communicate the functioning of AI models to collaborators, teams, and stakeholders.

Additionally, Now the most important question is whether the Robotics will replace human or take all job away from humans. Humans have great knowledge they can do precision handling and have sense of touch. Robots can do repeated task with efficiency, speed and reliability. Industry 4.0 and robotic technology both are our future and together results in customer satisfaction, efficiency and reliability of product. Then the answer is that it is not possible because for robotics to be fully functional it requires installation of navigation devices, elevators, trained people, automatic doors etc. Further, it is not possible for everyone to afford this. Whole process is too much costly. So, robotics will not replace human contact 100%.

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