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Artificial Intelligence in Engineering

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ABSTRACT

Artificial intelligence (AI) has moved past its primitive stages and is now poised to revolutionize various fields, making it a disruptive technology. This technology is expected to completely transform traditional engineering in design, electrical, communication, and renewable energy approaches that have been human-centred. Despite being in its early stages, AI-powered engineering applications can work with vague design parameters and resolve intricate engineering problems that cannot be tackled using traditional design, electrical, communication, and renewable energy methods. This article aims to shed light on the current progress and future research trends in AI applications in engineering concepts, focusing on the ramp-up period of the last 5 years. Various methods such as machine learning, genetic algorithm, and fuzzy logic have been carefully evaluated from an engineering standpoint. AI-powered design studies have been reviewed and categorized for different design stages such as inspiration, idea and concept generation, evaluation, optimization, decision-making, and modeling. The review shows that there has been an increased interest in data-based design methods and explainable artificial intelligence in recent years. The use of AI methods in engineering applications has proven to be efficient, fast, accurate, and comprehensive, particularly with the use of deep learning methods and combinations that address situations where human capacity is inadequate. However, it is crucial to choose the appropriate AI method for an engineering problem to achieve successful results.

INTRODUCTION

The conventional approach to product and engineering design processes is centred around human expertise, utilizing scientific, intuitive, experiential, and creative methods [1]. However, recent years have seen a shift in this approach with the incorporation of Artificial Intelligence (AI) in product and engineering design, similar to other engineering disciplines. AI refers to computer algorithms that mimic cognitive processes or activities observed in living organisms. AI can be utilized in tasks such as learning, understanding, estimating, problem-solving, suggestion, and decision-making in various disciplines, including the engineering design process [2]. The integration of AI-supported design techniques can effectively manage complex design operations, such as comparison, evaluation, and estimation, thereby allowing the designer to focus on tasks that require innovation and creativity. In this regard, AI methods facilitate shortened design processes, precise results, and reduced overall design costs. Moreover, its exceptional computational ability provides Artificial Intelligence (AI) with a competitive edge in performing such tasks, surpassing human capabilities.

Among the plethora of Artificial Intelligence (AI) techniques, expert systems, fuzzy logic, artificial neural networks, and genetic algorithms have been the most frequently employed classical methods in the design evaluation and optimization processes over an extensive period [3]. Nevertheless, the application of contemporary data-driven methods, including machine learning and deep learning, in the design process has seen a significant rise in recent times. Several other Artificial Intelligence (AI) techniques can be employed in one or more phases of the design process, encompassing the likes of idea inspiration, concept generation, evaluation, optimization, and decision-making. In the realm of engineering design, the use of classical AI techniques, specifically fuzzy logic, genetic algorithm, and the artificial neural network has been thoroughly studied. The research findings have yielded favourable outcomes in utilizing these methods for addressing design problems. Similarly, the application of such conventional AI techniques has been scrutinized concerning the design and development of photovoltaic, wind, and fuel cells [4].

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LITERATURE REVIEW

The present investigation focuses on the utilization of Artificial Intelligence (AI) in engineering design processes. As AI exhibits diverse applications in design, a systematic and rational literature review approach incorporating a search method is imperative. The review process entails a sequence of steps, namely, searching, selecting, and obtaining information, to ensure the comprehensiveness, reliability, and replicability of the study. Scientific databases are scanned for articles, which are subsequently evaluated based on their relevance and scope, with irrelevant materials being excluded. The compiled literature is then categorized according to its content. Artificial Intelligence (AI) refers to the use of computational techniques to simulate human cognitive activities such as interpretation, inference, decision-making, estimation, and classification. This interdisciplinary field integrates knowledge from various scientific domains such as mathematics, biology, genetics, engineering, and computer science. The primary objective of AI research is to enable computers to perform human-specific cognitive tasks rapidly, effectively, accurately, and efficiently. Unlike conventional software, AI techniques can handle incomplete and uncertain data by creating semantic relationships between data, allowing for inferences about past events and predictions about future outcomes. In addition to the design and engineering disciplines, AI is now widely applied in various domains including engineering education, healthcare, transportation, economics, law, and manufacturing [5.6].

Despite the widespread adoption of increasingly sophisticated AI technology, the opaque decision-making processes of such algorithms have raised concerns over their reliability. In particular, sectors where decision-making is of critical importance, such as defence, healthcare, and banking, have emphasized the need for transparent and explainable AI applications. High-performance intelligent systems incorporating AI methods must be transparent and explainable to inspire trust in these applications. Only by understanding how decisions are reached can confidence in AI technology be established. In the field of artificial intelligence (AI), problem-solving methods can be classified into two categories: strong and weak AI [7,8]. Strong AI techniques attempt to replicate the mental and heuristic processes utilized by humans when solving a problem, to endow computers with the ability to think, perceive, and reason. In contrast, weak AI generally refers to computational software that performs specific tasks successfully, without involving heuristic processes. Despite the term "weak," these methods often outperform humans in a given task. However, they lack the flexibility and adaptability of strong AI and cannot generalize their success to other tasks. It should be noted that most AI methods used today fall under the category of weak AI [9]. Nevertheless, the concept of super AI, which describes software with higher processing and thinking capabilities than humans, has emerged in recent years, although it is still in the preliminary research phase.

AI applications have become increasingly popular in the design industry, particularly in recent years. AI technology can provide designers with various tools and techniques to automate design tasks, speed up the design process, and create more accurate and efficient design outcomes. Some of the key AI applications in design include inspiration and concept generation: AI tools can be used to generate and suggest new design ideas based on a set of input parameters, such as style, color, and shape. These tools use machine learning algorithms to analyze vast amounts of data and generate ideas that match the criteria provided by the designer. AI can assist designers in evaluating and optimizing design concepts based on specific criteria, such as cost, performance, and manufacturability [10,11]. AI algorithms can analyze design concepts and suggest changes or improvements optimize the design for the desired outcome. AI can assist designers in making informed decisions about design choices by analyzing data and providing insights into the design process. AI algorithms can analyze design data and provide recommendations based on previous design outcomes. Modelling: AI can automate the 3D modelling process, allowing designers to create more accurate and efficient 3D models of their designs. AI algorithms can generate 3D models based on input parameters and data, reducing the time and effort required by designers. Overall, AI applications are transforming the design industry by providing designers with new tools and techniques to create more efficient, accurate, and effective design outcomes.

To sum up, the contribution of AI applications in design has been significant and continues to grow as technology advances. By enabling faster, more accurate, and more innovative design, AI has the potential to revolutionize the way we create products and solve problems. The article is structured into multiple sections that address different aspects related to the applications of artificial intelligence in engineering. In Section 3, the AI method is discussed, while Section 4 delves into the various AI applications in engineering, such as design engineering, electrical engineering, communication engineering, and renewable energy. The findings of the research are presented in Sections 5 and 6, followed by a result and discussion of the key takeaways. Section 7 serves as a conclusion, summarizing the main findings and exploring the implications of the research.

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AI METHOD

Expert systems, fuzzy logic, artificial neural networks, and genetic algorithms have been the most commonly employed classical techniques in the design evaluation and optimization processes for a considerable period. However, in recent years, there has been an increase in the use of modern data-driven methods, such as machine learning and its sub-field deep learning, in the design process [12]. Various other AI techniques can be utilized in one or more stages of the design process, including idea inspiration, concept creation or generation, evaluation, optimization, and decision-making. In some design applications, hybrid AI, which combines methods such as neural networks, fuzzy logic, and swarm intelligence, may be used simultaneously. The interrelationships among many of the commonly used AI techniques are depicted in Figure 1. Evolutionary algorithms, big data/mining, swarm intelligence, and knowledge-based systems may also be applicable in other fields, such as classical computer programming and statistical computing, and were not classified solely as a sub-branch of AI.

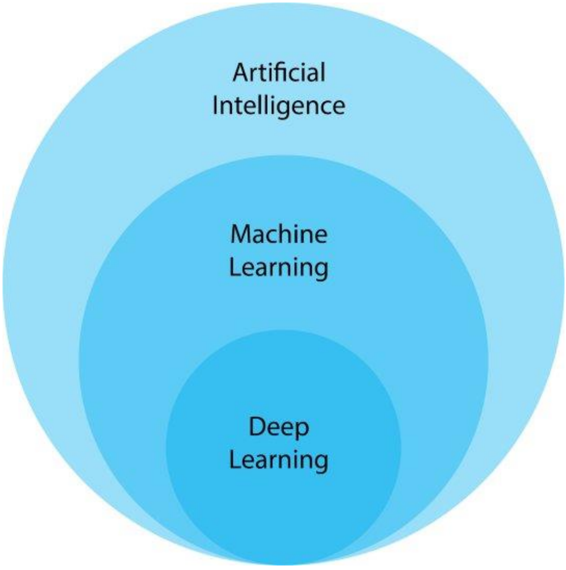

Figure 1. the most widely utilized AI methods

1. Machine learning

Machine learning is a class of statistical AI methods that uses available data sets to make predictions and inferences without requiring a specific algorithm like traditional programming. Instead, it detects patterns and similarities within the data set to interpret future data, making it useful for complex tasks like natural language processing, sound and image recognition, and pattern recognition [13]. Modern machine learning algorithms rely on statistical learning to understand and interpret data, with some overlap between the two concepts but also differences in interpretability. Statistical learning is best suited for problems with linear relationships between input data (independent variables) and output (dependent variables), such as linear and logistic regression. Its high explain ability feature stems from the ability to determine how changes in independent variables affect the dependent variable. On the other hand, the interpretability of results in machine learning is more challenging due to the absence of a linear relationship between input and output variables. While interpretability can be disregarded in some cases due to the ease of machine learning applications and their success with large datasets, the lack of interpretability remains a concern. Nonetheless, with increasing data, machine learning algorithms can enhance interpretability similar to the mechanism of human learning. Furthermore, topology optimization can be executed using machine learning models as an alternative to the computationally demanding finite element analysis [14]. Nonetheless, machine learning is frequently characterized as a black box as it is not entirely clear how these algorithms generate their outcomes. The concept of machine learning encompasses three primary learning models: supervised, unsupervised, and reinforcement, as demonstrated in Figure 2.

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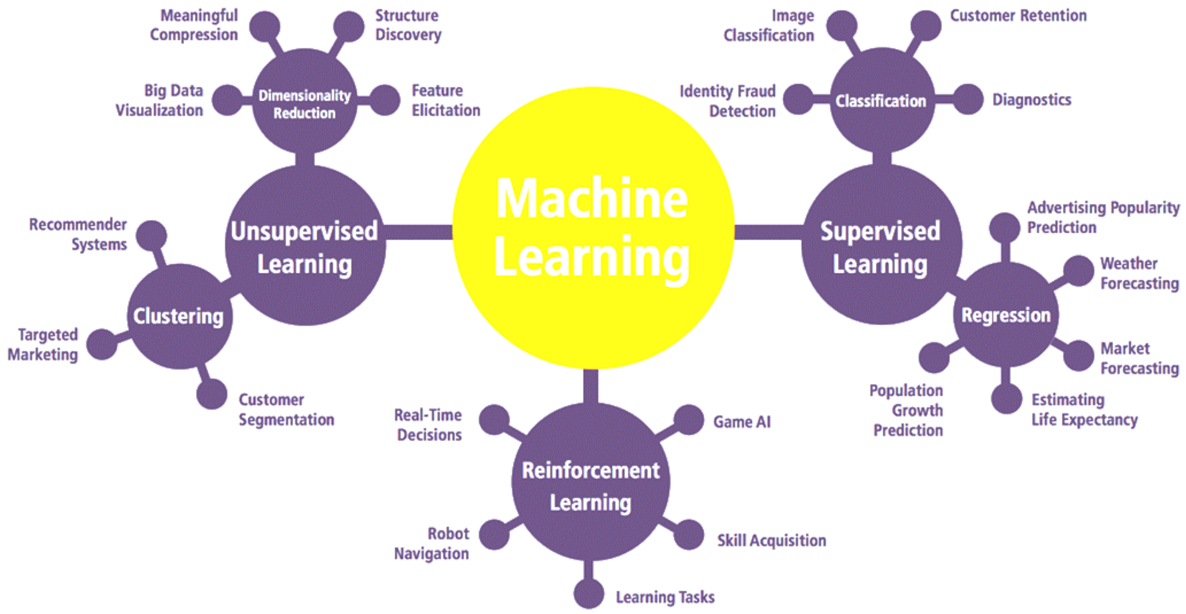

Figure 2. Machine learning.

Supervised learning refers to the process of obtaining the optimal function, or model, that characterizes the relationship between input variables and labelled output variables. This learning method involves identifying the correlation between input and label values, thereby enabling the classification of outputs with multiple categories or regression tasks involving continuous numbers. The dataset used in supervised learning is typically divided into two subsets: train and test data. While the former is used for model feature selection and network weight adjustment, the latter is utilized to measure the success of the machine learning model. It is worth noting that creating labelled datasets can be time-consuming and the input-output relationship between the data should be unambiguous. Nevertheless, supervised learning techniques have high success rates with minimal error margins. Artificial neural networks, logistic regression, linear regression, K-nearest neighbour, decision trees, and support vector machines are some commonly employed supervised machine learning algorithms.

2. *Artificial Neural Network*

The Artificial Neural Network (ANN) emulates the structure and relationships of living nervous systems, such as neurons, dendrites, and axons. By creating a mathematical model of this system, ANN is capable of solving complex and ill-defined problems through the optimization of network weights between interconnected neurons. This process, known as network training, forms the basis of deep learning methods. Although ANN is often classified as supervised learning, it can also be trained by unsupervised learning methods [15]. Various neural networks exist, with Back Propagation Neural Network (BPNN) being one of the more commonly used ones. BPNN is trained using feed-forward and back-propagation algorithms, where information flows forward to the output layer and backward to the previous layers, respectively. Figure 3, illustrates an artificial neural network.

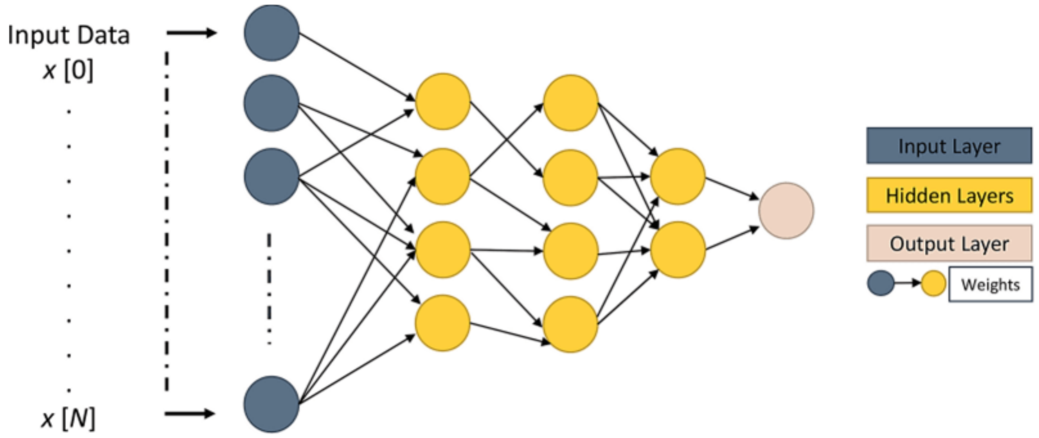

Figure 3. Artificial neural network.

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In the feed-forward algorithm, the previous layer's information is multiplied by the network weights in the current layer, and a bias is added to create a transfer function. The net input from this function is then evaluated in the next stage's activation function, and the information that exceeds a given threshold value is transferred to the next layer. Finally, the difference between the value obtained in the output layer and the data label is referred to as loss or error.

3. Genetic Algorithm

Genetic Algorithm (GA), invented by John Holland in the 1970s, is a heuristic search algorithm that imitates the evolutionary process of natural selection, where strong individuals survive while weak ones die. GA uses many terms adapted from natural systems, such as gene, chromosome, population, crossover, and mutation. The candidate solutions, referred to as chromosomes, are composed of gene sequences that display solution properties [16,17]. Genetic operators such as selection, crossover, and mutation are used to find the best solution in the solution space through iterative steps. The initial solution space, also called population, may consist of tens of thousands of randomly selected homogeneous chromosomes, depending on the problem's complexity. Figure 4, demonstrates the genetic algorithm.

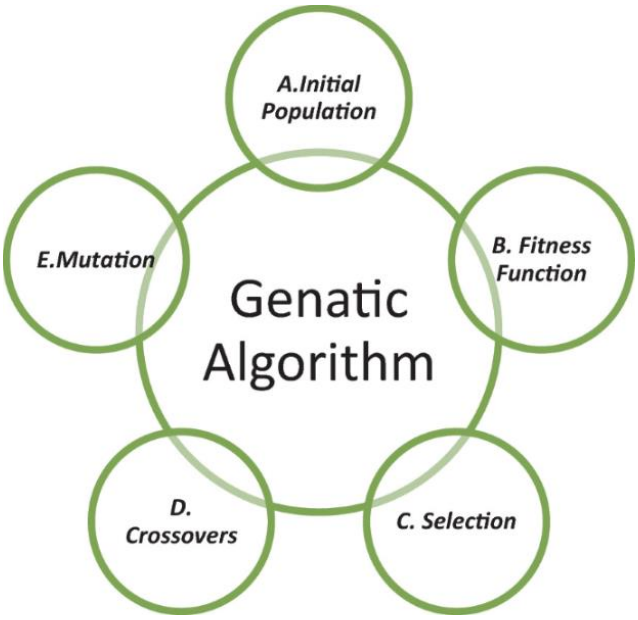

Figure 4. Genetic algorithm.

The fitness function calculates the solution value of each chromosome, which is then compared to the objective function. The pairing of high-fitness chromosomes ensures the reproduction of new (offspring) chromosomes, removing weak chromosomes from the population to keep the population number constant and improve solution quality. To increase genetic diversity, a limited number of crossover or mutation operations are applied between chromosome pairs. The mutation process involves modifying one or more genes on the chromosome within certain rules. The crossover and mutation processes are repeated continuously until satisfactory results are obtained.

4. Fuzzy logic

Fuzzy logic is a theory that extends classical/binary logic to deal with ambiguous expressions such as "short," "long," "very long," etc., which are similar to human thinking systems and real-life complex problems that classical/binary logic cannot handle. Lotfi Zadeh developed the fuzzy logic system in the mid-1960s. In contrast to the categorical sets of 'one' and 'zero,' the degree of membership in fuzzy sets determines the belonging of an element to a categorical set. In fuzzy logic, an element can belong to two different sets to a certain degree simultaneously. The degree of membership is expressed using values between 0 and 1. The fuzzy logic system comprises four primary units: rule base, fuzzifier, inference mechanism, and defuzzifier. The rule base is an information repository in "If-Then" format that enables the system to reason.

Fuzzification transforms numerical values into membership functions such as "very few," "few," "fast," "slow," etc. Fuzzy input values are interpreted through the rule base, and fuzzy results are obtained in the inference mechanism. The fuzzy results are converted into meaningful numerical values through the defuzzification process. Figure 5, presents fuzzy logic architecture [18,19]. The system's success depends on several parameters such as the number of input and output variables, the number of membership functions, the inference method (e.g., Mamdani, Sugeno, etc.), and the defuzzification method (e.g., weight averages, centre of the area, etc.). An increase in the number of input and output

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variables necessitates an increase in the number of rules. Creating membership functions and building a rule base may require a significant user experience.

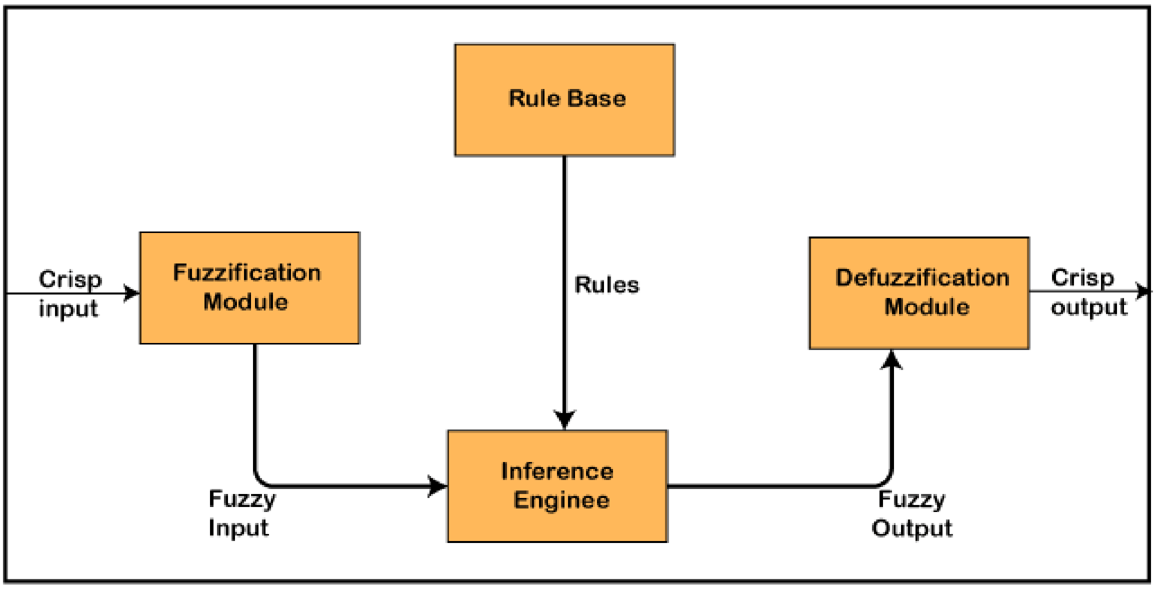

Figure 5. Fuzzy logic architecture.

AI APPLICATIONS IN ENGINEERING

This section categorizes AI applications based on their intended use in various design stages. Specifically, it explores AI applications that are utilized for design tasks, including but not limited to inspiration, idea and concept generation, concept evaluation, optimization, decision-making, and modeling. These stages include things like generating ideas and concepts, evaluating those ideas, optimizing designs, making decisions, and creating models [20,21]. AI applications have made significant contributions in the fields of electrical engineering, renewable energy, and communication engineering. In electrical engineering, AI methods have been used to improve the performance and efficiency of power systems, including power generation, transmission, and distribution. For example, AI-based predictive maintenance techniques can be used to identify potential faults in electrical equipment, reducing the risk of unexpected failures and improving the reliability of power systems. AI-based optimization algorithms can also be used to improve the efficiency of power generation and transmission systems, reducing costs and improving overall performance. In the field of renewable energy, AI applications have been used to improve the efficiency and reliability of renewable energy systems such as solar, wind, and hydroelectric power systems. AI-based control systems can be used to optimize the performance of renewable energy systems, increasing the amount of power generated while reducing costs. AI methods can also be used to predict weather patterns, which can be used to optimize the operation of renewable energy systems. In communication engineering, AI applications have been used to improve the performance of communication systems, including wireless networks and optical communication systems. For example, AI-based algorithms can be used to optimize the allocation of radio frequency (RF) channels in wireless networks, improving network performance and reducing interference. AI-based optical signal processing techniques can also be used to improve the performance of optical communication systems, increasing data rates and reducing error rates.

1. Engineering Design

By categorizing AI applications based on their intended use in design tasks, researchers and practitioners can better understand the capabilities of different AI tools and techniques, and how they can be best utilized to achieve specific design goals. For example, AI applications used for the idea and concept generation may use natural language processing (NLP) techniques to analyze written descriptions of design requirements and generate multiple potential design ideas [22,23]. On the other hand, AI applications used for decision-making may use machine learning algorithms to analyze large datasets and provide recommendations for design choices based on previous successful designs. Thus, by understanding how AI can be applied to different design stages, designers and engineers can work more efficiently and effectively, ultimately leading to better designs and products.

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Inspiration

Idea generation is one of the most important stages of product design. However, due to psychological inertia, it is not always possible to generate creative and innovative ideas (design fixation). During the conceptual design process, human designers can easily become stuck on some design ideas, impeding their ability to think about developing novel ones. This is a significant impediment to achieving the ideal/perfect design. The process of inspiration is complex, requiring thorough market investigation as well as domain expertise, intuition, a sharp mind, and creative abilities. Prolonging this process may result in higher costs of production and a loss of market share. AI has been used to overcome this barrier through verbal, written, and visual inspiration. Patents are excellent examples of the latter two sources of inspiration. Technical documents containing technology and design information such as technical features and functionality, materials, operating principles, and concepts in patent content may be utilized as an essential source of motivation for design and product development [24,25].

Idea and concept generation

In the early design phase, the concept generation process begins with the identification of the problem. Many criteria, including user demand, cost, aesthetics, ergonomics, functionality, production method, and recycling, should be considered during this process. The main challenge of conceptual design is to generate concepts that meet these criteria. Creating unique, creative, and effective concepts is a time-consuming process that necessitates a creative mind as well as knowledge and experience [26,27]. AI may be employed for direct concept generation in addition to idea generation via inspiration, as discussed in the previous section. Machine and deep learning methods, in particular, aid designers in the generation of creative concepts.

2. Evaluation of ideas and concepts

Evaluation of ideas and concepts A large number of design ideas and concepts generated in the early design stages should be evaluated to find the ideal design. Features of design concepts such as creativity, innovation, applicability, diversity, aesthetics, and functionality can be evaluated by various methods. Evaluation based on these features often requires users and domain experts. However, user demands often contain uncertainties that need to be clarified. Furthermore, this conventional evaluation process becomes extremely difficult and time-consuming, especially for a large number of design options which is usually the case [28,29]. With AI methods, an objective and rapid evaluation can be made, and thus significant time and cost savings can be achieved.

Design optimization

Design optimization is utilized to determine the best product configuration, improve product features, increase functionality, cut costs, make lighter parts, and so on. The goal here is to create/determine the best design under various constraints. To determine the optimal design variables, a mathematical description of the issue is created using advanced engineering knowledge in the conventional optimization process [30-34]. Designers are increasingly using artificial intelligence methods such as evolutionary algorithms, swarm intelligence, artificial neural networks, and machine learning to solve design optimization problems with minimal engineering knowledge.

Modeling

Creating 3D images of a design concept and its geometric representation in a computer environment is known as modelling. It involves expressing the volume occupied by the object in space using mathematical equations. Modelling is highly beneficial for both designers and product stakeholders as it provides a general idea of the product's structure. Traditionally, designers can create a limited number of 3D models that can take weeks or months after the conceptual design phase [35,36]. AI algorithms and methods can aid designers in automating the modelling process in MATLAB environments. The development of 2D and 3D model repositories has made 3D model generation via AI more accessible. The contributions of AI applications in design are numerous and significant. AI has revolutionized the design process by enabling designers to automate many tasks and create more efficient and effective designs. Some of the specific contributions of AI applications in design include:

- Automation of repetitive tasks: AI applications can automate many repetitive design tasks, such as creating and modifying 3D models, testing different design options, and generating detailed design reports. This allows designers to focus on more creative and high-level tasks, such as concept development and problem-solving.
- Faster design iterations: With AI applications, designers can quickly test and iterate through different design options, allowing them to find the best solution faster. This can lead to faster product development and ultimately reduce time to market.
- Improved accuracy and precision: AI applications can generate more accurate and precise designs by analyzing large amounts of data and using advanced algorithms to optimize design parameters. This can lead to better-performing products and increased customer satisfaction.

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- Increased creativity and innovation: By automating repetitive tasks and freeing up designers' time, AI applications can enable designers to be more creative and innovative in their work. This can lead to the development of new and unique design solutions that would not have been possible without AI.
- Better collaboration and communication: AI applications can facilitate collaboration between designers, engineers, and other stakeholders by providing a shared platform for design development and feedback. This can help to improve communication and ensure that everyone is working towards a common goal.

2. Electrical Engineering

AI applications have made significant contributions to electrical engineering in recent years. AI-based algorithms have been used to develop smart grids that can monitor and manage energy usage more efficiently. These systems can predict energy demands and adjust supply accordingly, reducing wastage and improving overall energy efficiency. AI-based condition monitoring systems can analyse data from sensors and detect anomalies in equipment behaviour, allowing for early detection and prevention of equipment failure. This can improve maintenance scheduling and reduce downtime, saving time and money. AI algorithms can be used to optimize the design and operation of power systems, resulting in improved efficiency and reliability. For example, AI-based models can help to predict electricity prices and optimize power generation to reduce costs. AI techniques can be used for fault diagnosis in electrical systems. By analyzing sensor data, AI algorithms can identify the root cause of faults and suggest corrective actions, reducing downtime and maintenance costs. Robotics is an important field in electrical engineering, and AI has made significant contributions in this area. AI algorithms can be used to control robotic systems and optimize their performance in a range of applications, from manufacturing to medical devices.

3. Renewable Energy

AI can make significant contributions to renewable energy in various ways. AI algorithms can analyze large amounts of historical weather data to forecast energy generation from renewable sources like wind and solar. These forecasts help grid operators to plan for energy demand and supply in advance, ensuring a stable and reliable supply of renewable energy. AI algorithms can optimize renewable energy systems by automatically adjusting parameters such as turbine speed, blade angle, and solar panel orientation to maximize energy generation efficiency. This helps to reduce energy costs and improve system performance. AI algorithms can optimize the use of energy storage systems, such as batteries and flywheels, by predicting energy demand and supply fluctuations. This helps to ensure that energy storage systems are used efficiently and effectively.

AI algorithms can help to manage the smart grid by monitoring energy usage and predicting energy demand. This helps to ensure that renewable energy sources are integrated into the grid effectively and that energy supply and demand are balanced. AI algorithms can monitor energy consumption patterns in homes, buildings, and industrial settings to identify areas where energy usage can be reduced. This helps to promote energy conservation and reduce carbon emissions. Thus, AI is helping to make renewable energy systems more efficient, reliable, and cost-effective, which is essential for achieving a sustainable energy future.

4. Communication Engineering

AI applications have made important contributions to communication engineering in recent years. AI algorithms are used for signal processing in various communication systems such as radar, sonar, and wireless communication. AI algorithms can detect patterns and analyze signals, which are used to improve the quality of communication signals and reduce noise. In communication systems, it is essential to allocate resources such as power, bandwidth, and time to maximize the system's performance. AI algorithms are used to optimize the allocation of resources in communication networks to achieve efficient communication. AI algorithms are used to manage communication networks. They can analyze network traffic, detect anomalies, and optimize network performance. AI algorithms can also predict future network traffic and proactively take measures to prevent network congestion. AI algorithms are used in speech and image recognition technologies, which are widely used in communication systems. Speech recognition technology is used in voice-controlled devices, virtual assistants, and automated customer service systems. Image recognition technology is used in video conferencing, surveillance systems, and augmented reality applications.

RESULT

The use of AI applications in design has brought about significant benefits, including increased efficiency, reduced design time, and improved design quality. With AI algorithms and methods, designers can automate repetitive design, analysis, and redesign processes, thereby saving time and effort. This automation also reduces the likelihood of errors, which improves the overall quality of the design.AI has also simplified the tasks of creating and evaluating 2D and 3D design concepts, which were previously time-consuming and costly. Thanks to the development of computer vision technology, it is now possible to achieve more precise results in a shorter amount of time. This, in turn, has made the design process more cost-effective compared to traditional design methods. Moreover, AI methods have helped to avoid

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bias and over-commitment to an idea when generating and evaluating design options. This has enabled designers to reach the global optimum in a wide range of solution areas, leading to more innovative and effective designs. The objectivity of AI methods also ensures that they achieve similar results under the same conditions. Despite the increasing use of AI in design, human designers will always be involved in the decision-making process, leveraging their knowledge, experience, sensory, and intuitive abilities. This is because AI is not yet self-sufficient for any given creative design task, and there is always an error margin in AI-produced results. However, as AI technology continues to evolve, designers will likely rely more heavily on AI applications in the future to achieve better designs in less time.

DISCUSSION

AI has made significant contributions to the design process by improving efficiency, accuracy, and innovation. By automating routine and repetitive tasks, such as generating design options, evaluating alternatives, and optimizing solutions, AI frees up designers' time and creativity to focus on more strategic and high-level tasks. One of the key benefits of AI in design is the ability to process large amounts of data, which can help to identify patterns, generate insights, and discover new design possibilities that would be difficult or impossible for humans to find on their own. AI can also learn from past design decisions and use that knowledge to inform future designs, leading to continuous improvement and refinement of the design process. AI has also enabled the use of advanced visualization technologies such as virtual and augmented reality to create immersive and interactive design experiences. This can help designers to better understand and communicate their designs to stakeholders, and to identify potential issues or improvements before physical prototypes are created. Thus, AI has the potential to transform the design process by making it more efficient, accurate, and innovative, and by enabling designers to focus on higher-level tasks that require human creativity and intuition. As AI technologies continue to evolve, we can expect to see even more advanced applications in design, including the ability to create entirely new design possibilities and solutions that were previously unthinkable.

CONCLUSION

AI methods have simplified the design process by allowing for repetitive tasks such as design, analysis, and redesign to be performed independently. The advancements in computer vision technology have made it easier to create and evaluate 2D and 3D design concepts, which is not only cost-effective but also results in more precise outcomes in a shorter time. Additionally, AI methods eliminate bias and over-commitment to an idea during the design process, enabling designers to achieve the global optimum in various solution areas. AI is objective and generates similar results under the same conditions. Unlike human-centred design, which relies on the designers' limited knowledge that fades over time, the knowledge and skills learned by AI never vanish and can be retrieved at any time. While AI is gradually taking over the tasks of human designers, the authors believe that human designers will always be involved in the decision-making process with their knowledge, experience, sensory, and intuitive abilities, as there is always an error margin in the AI-generated results. Moreover, the selection of AI techniques for design problems is dependent on the nature of the problem and the volume of data available. Traditional AI methods, including artificial neural networks, fuzzy logic, expert systems, and genetic algorithms, have been traditionally utilized in the assessment, optimization, and decision-making of design concepts that require specialist knowledge and experience. Conversely, data-driven methods have become more popular in recent years due to advancements in computer processor speed and storage capacity, the availability of labelled and unlabeled data sets, and the ease of access to enormous data. The development of modern data-driven techniques has resulted in a significant surge in design research, including inspiration, concept creation, and 3D model generation. AI applications have made significant contributions in the fields of electrical engineering, renewable energy, and communication engineering. In electrical engineering, AI methods have been used to improve the performance and efficiency of power systems, including power generation, transmission, and distribution. AI-based predictive maintenance techniques can be used to identify potential faults in electrical equipment, reducing the risk of unexpected failures and improving the reliability of power systems. AI-based optimization algorithms can also be used to improve the efficiency of power generation and transmission systems, reducing costs and improving overall performance. In the field of renewable energy, AI applications have been used to improve the efficiency and reliability of renewable energy systems such as solar, wind, and hydroelectric power systems. The recent increase in design inspiration and concept creation is closely related to the availability of large quantities of data. These techniques have ushered in a new age of design processes by processing massive data sets beyond human capability. In other words, knowledge and experience-centric approaches are being replaced by data-based methods. A potential direction for future research is to focus on AI systems that aim to enhance designs by improving their form, function, and behaviour. To achieve this goal, rapid prototyping techniques that alleviate production constraints and simplify design iterations can be integrated into AI processes. As a result, the initial design concepts can be transformed into functional products in a shorter amount of time. Additionally, incorporating Virtual Reality (VR) and Augmented Reality (AR) technologies into the design process can enhance the efficiency and performance of generative design models.

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REFERENCES

[1] H. Benradi, A. Chater, and A. Lasfar, "A hybrid approach for face recognition using a convolutional neural network combined with feature extraction techniques," *IAES Int. J. Artif. Intell. (IJ-AI)*, vol. 12, no. 2, p. 627, 2023.

[2] I. Aattouri, H. Mouncif, and M. Rida, "Modeling of an artificial intelligence based enterprise callbot with natural language processing and machine learning algorithms," *IAES Int. J. Artif. Intell. (IJ-AI)*, vol. 12, no. 2, p. 943, 2023.

[3] M. M. Khaleel, Faculty of Electrical Engineering Technology, University Malaysia Perlis, 02600, Arau, Malaysia, M. R. Adzman, S. M. Zali, M. M. Graisa, and A. A. Ahmed, "A review of fuel cell to distribution network interface using D-FACTS: Technical challenges and interconnection trends," *Int. J. Electr. Electron. Eng. Telecommun.*, pp. 319–332, 2021.

[4] M. M. Khaleel, M. R. Adzman, and S. M. Zali, "An integrated of hydrogen fuel cell to distribution network system: Challenging and opportunity for D-STATCOM," *Energies*, vol. 14, no. 21, p. 7073, 2021.

[5] A. Darko, A. P. C. Chan, M. A. Adabre, D. J. Edwards, M. R. Hosseini, and E. E. Ameyaw, "Artificial intelligence in the AEC industry: Scientometric analysis and visualization of research activities," *Autom. Constr.*, vol. 112, no. 103081, p. 103081, 2020.

[6] R. Jiménez-Moreno and R. A. Castillo, "Deep learning speech recognition for residential assistant robot," *IAES Int. J. Artif. Intell. (IJ-AI)*, vol. 12, no. 2, p. 585, 2023.

[7] B. Hdioud and M. El Haj Tirari, "Facial expression recognition of masked faces using deep learning," *IAES Int. J. Artif. Intell. (IJ-AI)*, vol. 12, no. 2, p. 921, 2023.

[8] O. Barki, Z. Guennoun, and A. Addaim, "New approach for selecting multi-point relays in the optimized link state routing protocol using self-organizing map artificial neural network: OLSR-SOM," *IAES Int. J. Artif. Intell. (IJ-AI)*, vol. 12, no. 2, p. 648, 2023.

[9] N. George, A. B. Kadan, and V. P. Vijayan, "Multi-objective load balancing in cloud infrastructure through fuzzy based decision making and genetic algorithm based optimization," *IAES Int. J. Artif. Intell. (IJ-AI)*, vol. 12, no. 2, p. 678, 2023.

[10] A. Darko, A. P. C. Chan, M. A. Adabre, D. J. Edwards, M. R. Hosseini, and E. E. Ameyaw, "Artificial intelligence in the AEC industry: Scientometric analysis and visualization of research activities," *Autom. Constr.*, vol. 112, no. 103081, p. 103081, 2020.

[11] M. M. Khaleel, T. Mohamed Ghandoori, A. Ali Ahmed, A. Alsharif, A. J. Ahmed Alnagrat, and A. Ali Abulifa, "Impact of mechanical storage system technologies: A powerful combination to empowered the electrical grids application," in 2022 IEEE 2nd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering (MI-STA), 2022.

[12] H. H. Elmousalami, "Artificial intelligence and parametric construction cost estimate modeling: State-of-the-art review," *J. Constr. Eng. Manag.*, vol. 146, no. 1, p. 03119008, 2020.

[13] H. Salehi and R. Burgueño, "Emerging artificial intelligence methods in structural engineering," *Eng. Struct.*, vol. 171, pp. 170–189, 2018.

[14] I. K. Nti, A. F. Adekoya, B. A. Weyori, and O. Nyarko-Boateng, "Applications of artificial intelligence in engineering and manufacturing: a systematic review," *J. Intell. Manuf.*, vol. 33, no. 6, pp. 1581–1601, 2022.

[15] W. Sha *et al.*, "Artificial intelligence to power the future of materials science and engineering," *Adv. Intell. Syst.*, vol. 2, no. 4, p. 1900143, 2020.

[16] Y. Pan and L. Zhang, "Roles of artificial intelligence in construction engineering and management: A critical review and future trends," *Autom. Constr.*, vol. 122, no. 103517, p. 103517, 2021.

[17] T. Ertekin and Q. Sun, "Artificial intelligence applications in reservoir engineering: A status check," *Energies*, vol. 12, no. 15, p. 2897, 2019.

[18] D. M. Dimiduk, E. A. Holm, and S. R. Niezgoda, "Perspectives on the impact of machine learning, deep learning, and artificial intelligence on materials, processes, and structures engineering," *Integr. Mater. Manuf. Innov.*, vol. 7, no. 3, pp. 157–172, 2018.

[19] X. Wang, H. Lu, X. Wei, G. Wei, S. S. Behbahani, and T. Iseley, "Application of artificial neural network in tunnel engineering: A systematic review," *IEEE Access*, vol. 8, pp. 119527–119543, 2020.

[20] Y. Wang and S. H. Chung, "Artificial intelligence in safety-critical systems: a systematic review," *Ind. Manag. Data Syst.*, vol. 122, no. 2, pp. 442–470, 2022.

[21] H. Moayedi, M. Mosallanezhad, A. S. A. Rashid, W. A. W. Jusoh, and M. A. Muazu, "A systematic review and meta-analysis of artificial neural network application in geotechnical engineering: theory and applications," *Neural Comput. Appl.*, vol. 32, no. 2, pp. 495–518, 2020.

[22] X. Wang, A. Liu, and S. Kara, "Machine learning for engineering design toward smart customization: A systematic review," *J. Manuf. Syst.*, vol. 65, pp. 391–405, 2022.

[23] M. M. Khaleel, K. Abduesslam, and M. Nizam, "DVR with artificial intelligent controller for voltage sag mitigation," in International Conference on Advances in Engineering and Technology (ICAET'2014) March 29-30, 2014 Singapore, 2014.

[24] A. Alsharif, C. W. Tan, R. Ayop, A. A. Ahmed M. M. Khaleel., "Impact of electric Vehicle on residential power distribution considering energy management strategy and stochastic Monte Carlo algorithm," Energies, vol. 16, no. 3, p. 1358, 2023.

[25] A. Alsharif, C. W. Tan, R. Ayop, A. A. Ahmed, and M. M. Khaleel, "Electric vehicle integration with energy sources: Problem and solution review," AJAPAS, pp. 17–20, 2022.

[26] A. Peramunugamage, U. W. Ratnayake, and S. P. Karunanayaka, "Systematic review on mobile collaborative learning for engineering education," *J. Comput. Educ.*, vol. 10, no. 1, pp. 83–106, 2023.

[27] E. Nwoye, W. L. Woo, B. Gao, and T. Anyanwu, "Artificial intelligence for emerging technology in surgery: Systematic review and validation," *IEEE Rev. Biomed. Eng.*, vol. PP, pp. 241–259, 2023.

[28] S. Verma, R. Sharma, S. Deb, and D. Maitra, "Artificial intelligence in marketing: Systematic review and future research direction," *International Journal of Information Management Data Insights*, vol. 1, no. 1, p. 100002, 2021.

[29] M. M. Khaleel, S. A. Abulifa, I. M. Abdaldeam, A. A. Abulifa, M. Amer, and T. M. Ghandoori, "A current assessment of the renewable energy industry," AJAPAS, pp. 122–127, 2023.

[30] M. M. Khaleel, A. Alsharif, and I. I. K. Imbayah, "Renewable energy technologies: Recent advances and future predictions," AJAPAS, pp. 58–64, 2022.

[31] A. Alsharif, C. W. Tan, R. Ayop, A. Ali Ahmed, M. M. Khaleel, and A. K. Abobaker, "Power management and sizing optimization for hybrid grid-dependent system considering photovoltaic wind battery electric vehicle," in 2022 IEEE 2nd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering (MI-STA), 2022.

[32] A. Alsharif, C. W. Tan, R. Ayop, A. A. A. Ahmed, A. Alanssari, and M. M. Khaleel, "Energy management strategy for Vehicle-to-grid technology integration with energy sources: Mini review," AJAPAS, pp. 12–16, 2022.

[33] I. Antonopoulos *et al.*, "Artificial intelligence and machine learning approaches to energy demand-side response: A systematic review," *Renew. Sustain. Energy Rev.*, vol. 130, no. 109899, p. 109899, 2020.

[34] M. R. Islam, M. U. Ahmed, S. Barua, and S. Begum, "A systematic review of explainable artificial intelligence in terms of different application domains and tasks," *Appl. Sci. (Basel)*, vol. 12, no. 3, p. 1353, 2022.

[35] G.-J. Hwang and Y.-F. Tu, "Roles and research trends of artificial intelligence in mathematics education: A bibliometric mapping analysis and systematic review," *Mathematics*, vol. 9, no. 6, p. 584, 2021.

[36] M. Nazar, M. M. Alam, E. Yafi, and M. M. Su'ud, "A systematic review of human–computer interaction and explainable artificial intelligence in healthcare with artificial intelligence techniques," *IEEE Access*, vol. 9, pp. 153316–153348, 2021.