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Application of Artificial Intelligence in Mechanical Engineering

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Abstract — Expert systems are computer programs that use artificial intelligence (AI) to simulate the behavior of experts in specific domains. They complement human expertise and can improve over time. Mechanical engineering faces challenges like sustainability and energy efficiency. AI and data analysis can help incorporate advanced technologies into designs, allowing engineers to focus on their expertise while incorporating AI solutions.

Keywords — expert systems; artificial intelligence; simulate; mechanical

I. INTRODUCTION

An expert system is a computer program that uses artificial intelligence (AI) to simulate the reasoning and behavior of a person or organization with expertise in a specific area. Developed in the 1970s by Edward Feigenbaum, a computer scientist at Stanford University, it is designed to complement human experts, not replace them. Feigenbaum explains that computers can now perform more than basic calculations and solve complex problems due to new processing technology and computer architecture. [2]

A. Functioning of an expert system

An expert system is a tool that uses machine learning and artificial intelligence to simulate the actions of experts in specific domains. It consists of three main components: a knowledge base, an inference engine, and a user interface. [2]

- The knowledge base stores information from human experts, often containing a knowledge acquisition module.
- The inference engine uses this information to solve user problems, mapping it to rules and making decisions based on the inputs. It often includes an explanation module to explain the system's conclusion.
- The user interface is the part of the expert system that end users interact with to get an answer to their questions or problems.

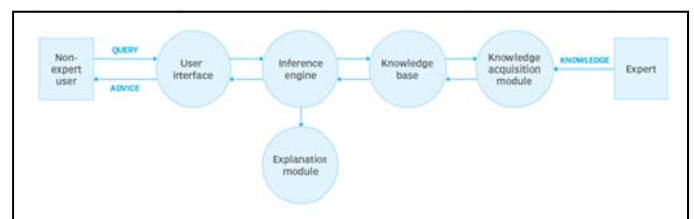


Fig.1 Architecture of an expert system [8]

B. Advantages of expert systems

Expert systems offer several advantages over human experts, including accuracy, durability, logical deduction, cost control, and more experts. They are prone to human error and emotional influence, making decisions based on defined rules and facts. They provide a permanent repository for knowledge and information, drawing conclusions from existing facts using if-then rules. Expert systems are relatively inexpensive compared to human experts, making decisions more efficient and saving time and costs. Additionally, multiple experts contribute to the knowledge base, preventing any expert from skewing decision-making. [1,2]

II. ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) has been around since the 1950s, with researchers initially focusing on knowledge-based "expert systems" that required explicit programming. In the 80s and 90s, AI research evolved into machine learning, allowing machines to learn from data rather than being explicitly programmed. This led to more advanced AI that could recognize images and voices. [4] AI has gained more attention in recent years as technology has improved and a wider range of data becomes available. It is currently the most prevalent technology in computer science, aiming to understand the nature of intelligence and create intelligent robots. Virtual reality, emulation, and speech recognition are some of the technologies being explored. The most common process to obtain usable AI is using algorithms and statistical models to allow machines to learn from data. [3,4]

A. AI in Mechanical engineering

Mechanical engineering faces numerous challenges, including creating innovative products and processes, ensuring sustainable and cost-effective designs, reducing waste, delivering energy-efficient systems using renewable energy sources, competing with companies for shareholder profitability, and maintaining product quality. Engineers must focus on creating environmentally friendly products, reducing waste, and increasing efficiency while maintaining product quality. Additionally, they must stay updated with new technologies and incorporate them into their designs to maintain or improve product quality.

Artificial intelligence (AI) has gained interest due to its ability to process large amounts of data. Mechanical engineering faces challenges in designing systems and components for the future while respecting sustainability and energy efficiency. AI solutions can be incorporated into designs by data scientists and other professionals with AI programming languages and algorithms. Mechanical engineers, who specialize in factory automation, materials synthesis, and product design, aim to leverage AI solutions while focusing on their own skills. Artificial intelligence (AI) encompasses various sub-disciplines, including machine learning and deep learning.

- Machine learning uses algorithms to learn from data and past performance without human intervention, with applications like image recognition.
- Deep learning, based on artificial neural networks, uses mathematical models inspired by the human brain for structure and function. Python is the leading programming language, essential for data scientists and software developers.

Both AI and machine learning have their applications in various fields.

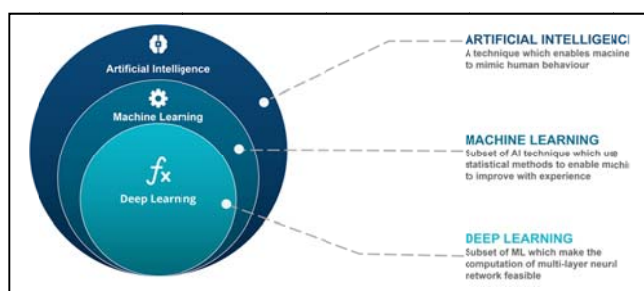


Fig.2 Positioning of Deep Learning, Machine Learning and AI [7]

III. RESULTS AND DISCUSSION

Artificial intelligence can be utilized in mechanical engineering for automated design and optimization of machine systems and parts like motors, gears, bearings, heat exchangers, and HVAC systems. It can also simulate and analyze system performance to predict behavior, identify future issues, and suggest improvements. The design process involves analyzing component function and performance requirements, determining materials and manufacturing methods, and creating detailed drawings and specifications for component manufacturing.

Conceptual design is the initial stage in designing a machine component, defining its basic requirements and constraints.

Conceptual design is followed by **detailed design**, which involves designing a component to meet requirements and constraints, considering factors like materials, manufacturing methods, and cost.

Analysis and Optimisation (CAE) The design undergoes an analysis and optimization phase using CAD and CAE simulation tools to ensure it performs as intended and meets performance requirements. (Fig.3)

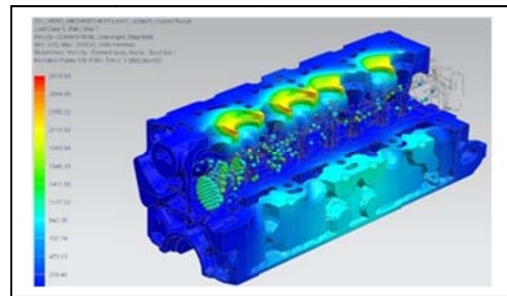


Fig.3 CAE simulation software [10]

Multi-Objective Optimization. The design undergoes an analysis and optimization phase using CAD and CAE simulation tools to ensure it performs as intended and meets performance requirements.

CFD: Computational Fluid Dynamics. Fluids, like air and water, are crucial in our daily lives and have a profound impact on the world. [6] Computational Fluid Dynamics (CFD) is a powerful tool that studies simulates and predicts fluid flow patterns in various applications. With the increasing power of computers and numerical algorithms, CFD has become essential in engineering, meteorology, and medicine. (Fig.4) [5]

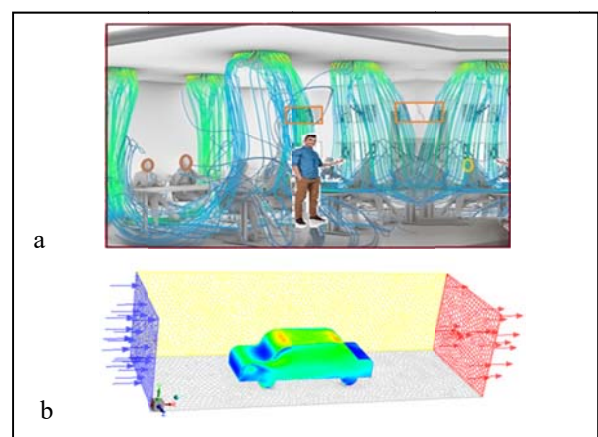


Fig.4 CFD simulation and optimization:
a) of heating, ventilation, and air conditioning (HVAC) systems in order to provide results for temperature and air quality in the very large building;
b) for the flow behavior around vehicles in order to reduce fuel consumption with less resistance. [9]

IV. CONCLUSION

Artificial intelligence (AI) is a rapidly growing field in the manufacturing industry, focusing on simulating human intelligence on devices designed to learn and think like humans. AI is a branch of computer engineering that focuses on building machines for tasks that typically require human intelligence, such as speech recognition and natural language understanding. Cognitive computing refers to intelligent systems that learn through interactions with people and the environment, rather than explicit programming. The development of AI has significantly changed the manufacturing sector, enabling automation, intelligent development, and better meeting demands in the new era of the Industrial Revolution. The application of AI in mechanical engineering can enhance the efficiency, reliability, and performance of mechanical systems, while also promoting the development of new and innovative technologies.

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