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Integration of Artificial Intelligence in Industrial Design: From Generative Models to Intelligent Automation

Abstract

This article examines the role of artificial intelligence in transforming industrial design processes. Special attention is given to generative design, the use of AI in CAD environments, and the concept of digital twins. Practical examples of intelligent systems applied in product development are provided, demonstrating increased efficiency, reduced timeframes, and improved quality of design solutions. The paper also discusses future prospects for AI integration and the associated ethical challenges.

Keywords

artificial intelligence, industrial design, generative design, CAD systems, digital twins, automation, intelligent technologies

Introduction

Modern manufacturing is undergoing a profound transformation driven by the active implementation of digital technologies and automated solutions. As a result, industrial design—a key discipline that defines the appearance, functionality, and ergonomics of products—has found itself at the heart of these technological changes. One of the most significant drivers of such changes is artificial intelligence (AI), which is rapidly penetrating various stages of design: from idea generation to optimization of structural solutions and interaction with production capabilities.

Traditionally, industrial design relied on the experience and intuition of the designer. However, as products become more complex and their lifecycle shortens, the need arises for tools capable of rapidly analyzing multiple parameters and proposing optimal solutions. Artificial intelligence—primarily machine learning algorithms, generative modeling, and big data processing—provides such capabilities, transforming the philosophy of the design activity itself.

Particularly noteworthy is the application of AI in generative design, where systems independently create dozens or even hundreds of design variants based on specified constraints. Moreover, AI integration in CAD systems enables the automation of repetitive tasks, intelligent verification of blueprints, and product behavior forecasting under real operating conditions. Another area involves digital twins, combining AI and simulation to model manufacturing processes and test designs in a virtual environment.

The aim of this article is to explore the key areas of AI integration into industrial design workflows, analyze the benefits and potential limitations of such technologies, and present practical examples of successful AI application in product and system development.

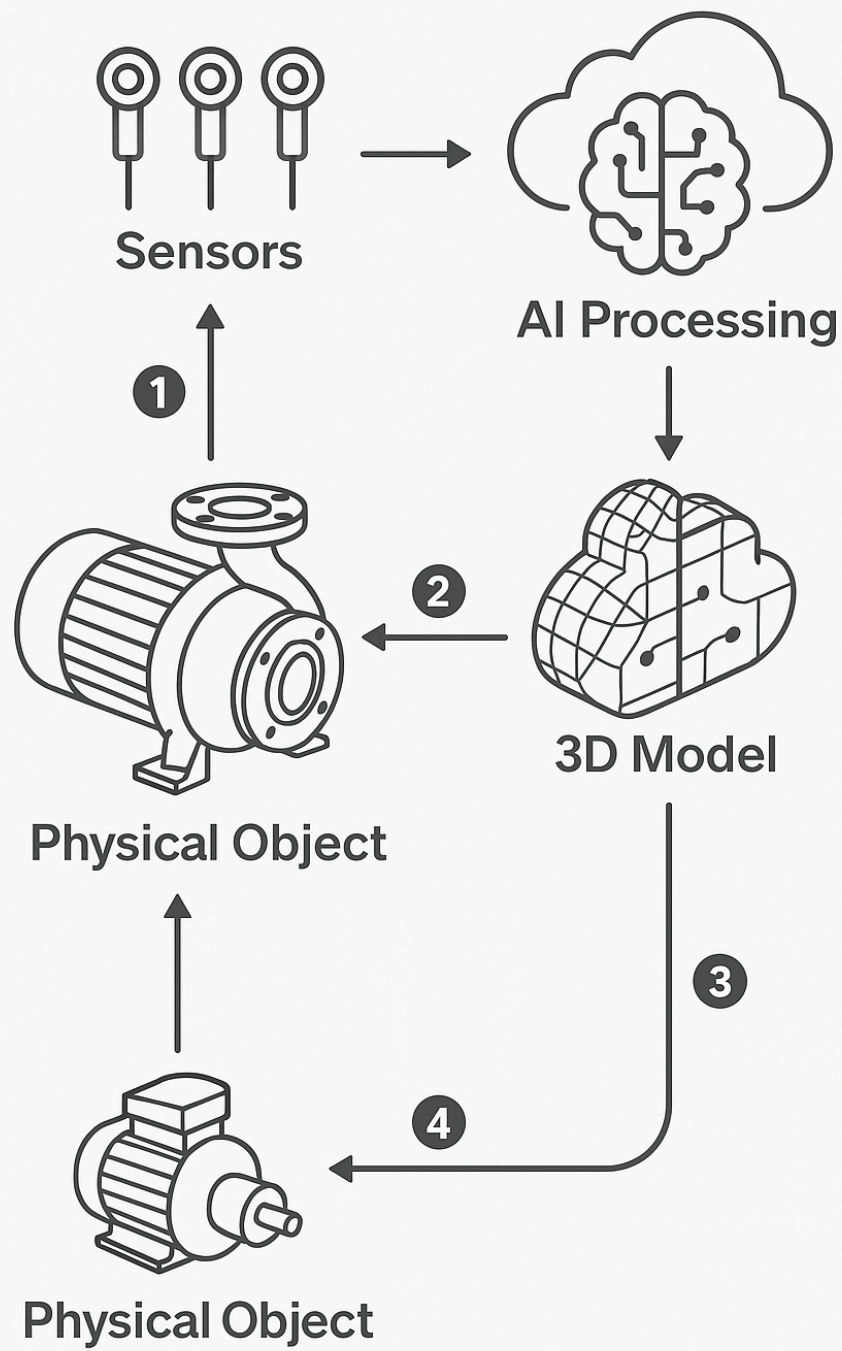
Generative Design: Algorithms and Opportunities

Generative design is one of the most promising areas for the application of artificial intelligence in industrial design. Unlike traditional approaches where the designer manually creates the product structure, generative methods automatically generate design variants based on specified input parameters: strength characteristics, weight, materials, technological constraints, aesthetic requirements, and so on.

The key feature of generative design is AI's ability to create hundreds of design solutions, each meeting the defined criteria, and then automatically select the best ones based on given metrics. These algorithms are based on evolutionary computations, deep learning, and topological optimization. In this process, the designer acts more like a curator, setting boundaries and choosing the most suitable option from those proposed.

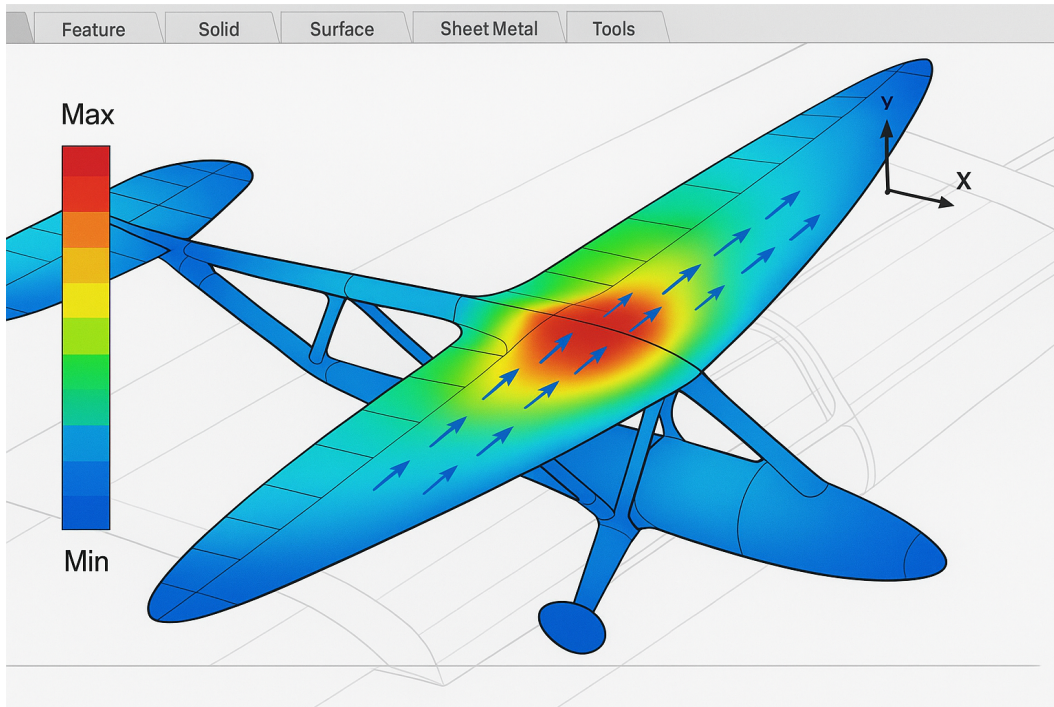
In practice, generative design is widely used in aerospace for designing lightweight but strong structures, in automotive engineering to reduce component weight while maintaining stiffness, and in biomedicine for creating personalized implants. The adoption of generative design significantly reduces development time and material costs.

Figure 1. Design variants generated by AI in Autodesk Fusion 360.



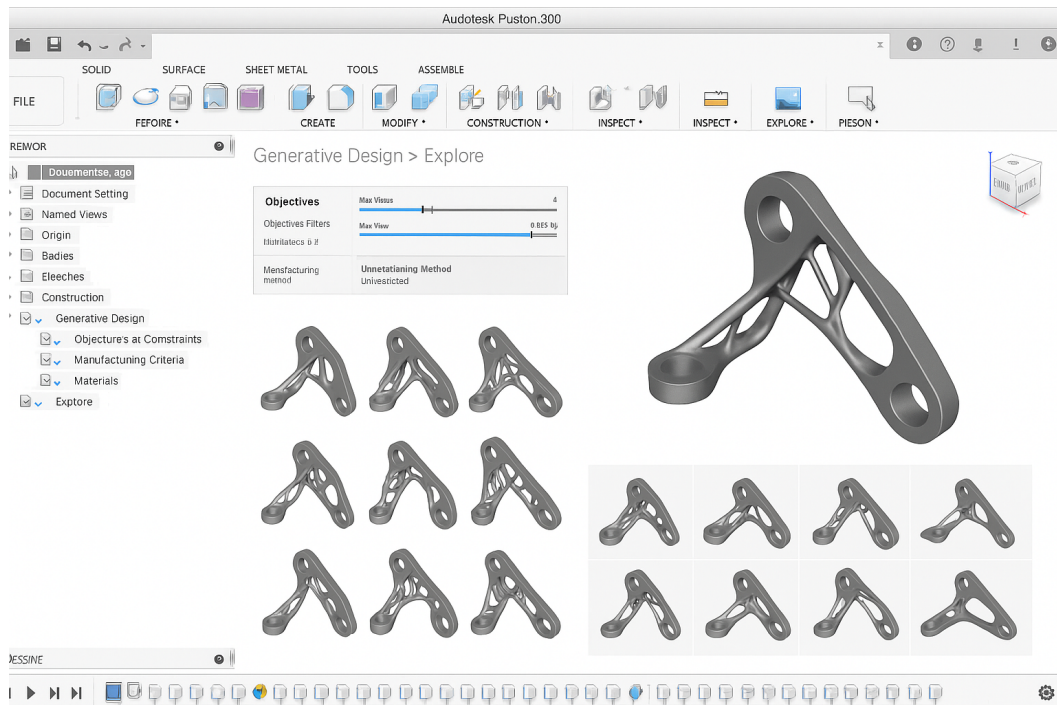
AI in Computer-Aided Design (CAD) Systems

Computer-Aided Design (CAD) systems have traditionally played a key role in engineering modeling, drafting, visualization, and preparing products for manufacturing. With the introduction of artificial intelligence, CAD environments have acquired entirely new functionalities, enabling not only automation of routine tasks but also intelligent analysis and generation of design solutions.



Modern CAD programs such as Autodesk Fusion 360, SolidWorks, PTC Creo, and Siemens NX include AI modules that suggest optimal geometric solutions, detect design conflicts, and propose improvements based on analysis of previously created models. AI algorithms can also predict how a product will behave under load, vibration, or temperature using machine learning methods trained on simulations or real-world tests.

Figure 2. Load distribution prediction in a CAD system using an AI-powered strength analysis module.



Intelligent Automation and Digital Twins

Digital twins have become one of the central areas in the transformation of industrial design and engineering analysis. A digital twin is a virtual representation of a physical object, system, or process that continuously updates using data from physical sensors, production systems, or analytical models. AI integration turns digital twins from static models into self-learning systems capable of predicting object behavior in real-time.

Digital twins are actively used in industries such as automotive, aerospace, energy, and petrochemicals. Companies like Siemens and BMW employ digital twin platforms for virtual testing of production lines, automatic detection of bottlenecks, and adaptive adjustment of equipment operating parameters.

Figure 3. Structure of a digital twin with AI and data streams from a physical object.

Case Studies of AI in Industrial Design

To better understand the potential of AI in industrial design, consider several real-world examples from different industries where intelligent algorithms have already demonstrated their effectiveness.

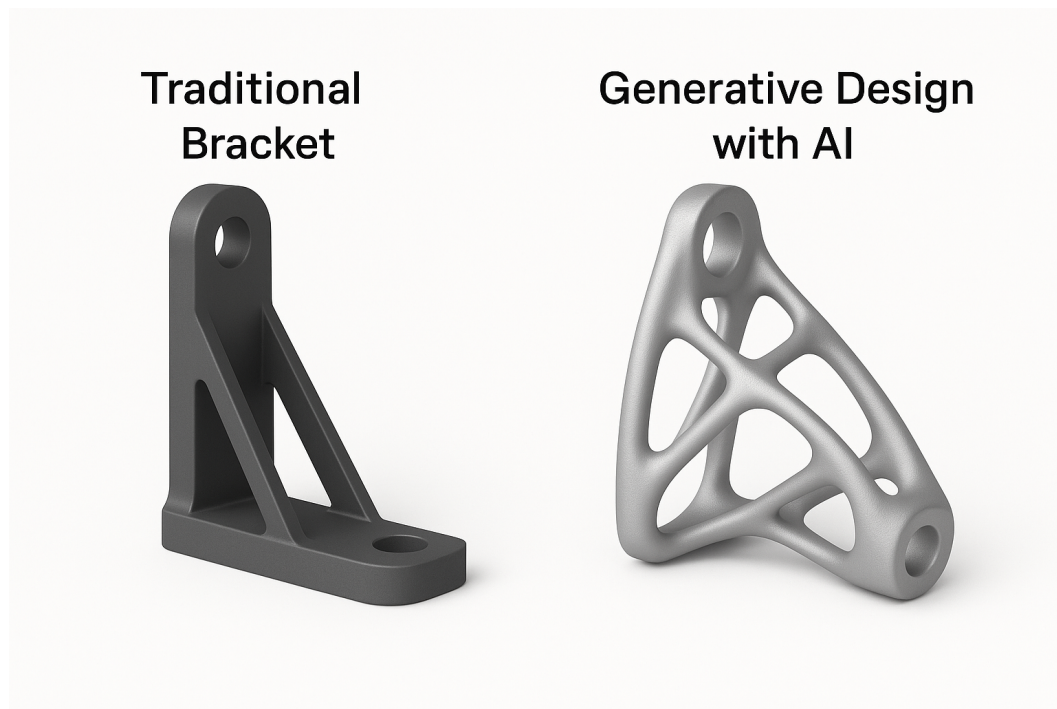
General Motors, in collaboration with Autodesk, developed a car seat bracket using generative design. AI generated over 150 design options. The final version was 40% lighter and 20% stronger than its conventional counterpart.

Airbus uses generative design to create lightweight cabin partitions, reducing the weight of certain components by 45% without sacrificing strength.

In biomedicine, AI is used to create custom prosthetics tailored to a patient's unique anatomy, improving comfort and functionality.

Siemens employs AI-enabled digital twins to optimize production lines in real-time—automatically reconfiguring machinery and reallocating tasks during system overloads.

Figure 4. Comparison of bracket designs before and after applying generative design with AI.



Conclusion

The integration of artificial intelligence into industrial design processes is not merely a technological step forward but a fundamental shift in design paradigms. Through machine learning algorithms, generative models, and digital twins, designers now have tools capable of analyzing vast amounts of data, generating unconventional yet optimal solutions, and adapting to rapidly changing production conditions.

The application of AI significantly reduces product development time, lowers costs, and improves the precision and reliability of constructions. Of particular importance is the ability to predict product behavior before physical prototyping, making the process safer and more economically viable.

Despite certain challenges—model verification, algorithm transparency, and ethical concerns—AI is becoming an indispensable partner for design engineers and is paving the way for next-generation products.

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