International Journal of Research Publication and Reviews

AI and Machine Learning Uses in CAD/CAM

Dr. A.K. Madan[1], Prateek Kharbanda[2], Prateek Yadav[3], Roshan Kumar[4]

[1]Professor, Mechanical Engineering department, Delhi Technological University, New Delhi
[2, 3, 4]Student, Mechanical Engineering, Delhi Technological University, New Delhi

ABSTRACT

Computer-aided design (CAD) is the use of computer-based software to aid in design modeling, design analysis, design review, and design documentation. By combining CAD with AI and machine learning, designers can create more intelligent and efficient design processes that can automatically optimise designs based on specific requirements, constraints, and preferences. For example, machine learning algorithms can learn from previous designs to suggest improvements, generate new designs, or automate repetitive design tasks.Moreover, integrating CAD with manufacturing and production processes through AI and machine learning can improve the quality and accuracy of the final product. AI can analyse manufacturing data and identify patterns and issues that humans may miss, helping to optimise production processes, minimise errors, and reduce waste.The primary aim of this review is to present an overview of current state-of-the-art CAD and its applications

Keywords: CAD, CAM, Artificial intelligence, Machine Learning

Introduction

Computer-aided design and manufacturing (CAD/CAM) is a field that has greatly benefited from advancements in artificial intelligence (AI) and machine learning (ML) technologies. The integration of AI and ML in CAD/CAM systems has resulted in increased automation, improved design optimization, and reduced design time. With the increasing demand for efficient and effective CAD/CAM solutions, researchers and engineers are exploring new ways to leverage AI and ML in this field. This paper provides a comprehensive review of the latest trends in AI and ML applications in CAD/CAM, highlighting the recent advancements, challenges, and opportunities for future research. The review covers a wide range of topics, including but not limited to, AI-based optimization techniques, intelligent design exploration, deep learning-based feature extraction, and generative design. Through this review, we hope to provide a detailed understanding of the current state-of-the-art in AI and ML in CAD/CAM, as well as provide insights into future directions of research in this field.

Artificial Intelligence in CAD/CAM and integration

The use of CAD/CAM software has become essential in many industries, including aerospace, automotive, and electronics, among others. The ability to design, simulate, and test products before they are actually manufactured has helped companies save time and money, while improving the quality of their products. As mentioned earlier, the integration of AI in CAD/CAM has brought significant improvements in the design and manufacturing process. AI algorithms can analyze vast amounts of data and suggest design modifications that can optimize the product's performance, reduce its weight, or improve its durability. This not only leads to better products, but it also reduces the time and cost of product development.Moreover, the ability to simulate manufacturing processes using CAM software has allowed companies to optimize their manufacturing operations, reduce waste, and improve efficiency. For example, CAM software can generate tool paths that minimize the amount of material waste, reduce machining time, and improve surface finish quality.

The CAD/CAM software products mentioned in the article, such as Pro/E, Unigraphics, Catia, IDEAS, and SolidWorks, are some of the most widely used in the industry. They offer a wide range of design and simulation capabilities, including 3D modeling, assembly design, finite element analysis, and computer-aided inspection, among others.However, as the article mentions, these software products come with high costs, which may limit their accessibility to small and medium-sized businesses. Nevertheless, the benefits of using CAD/CAM software are clear, and companies that invest in these tools are likely to see improvements in their product quality, manufacturing efficiency, and overall competitiveness in the market.
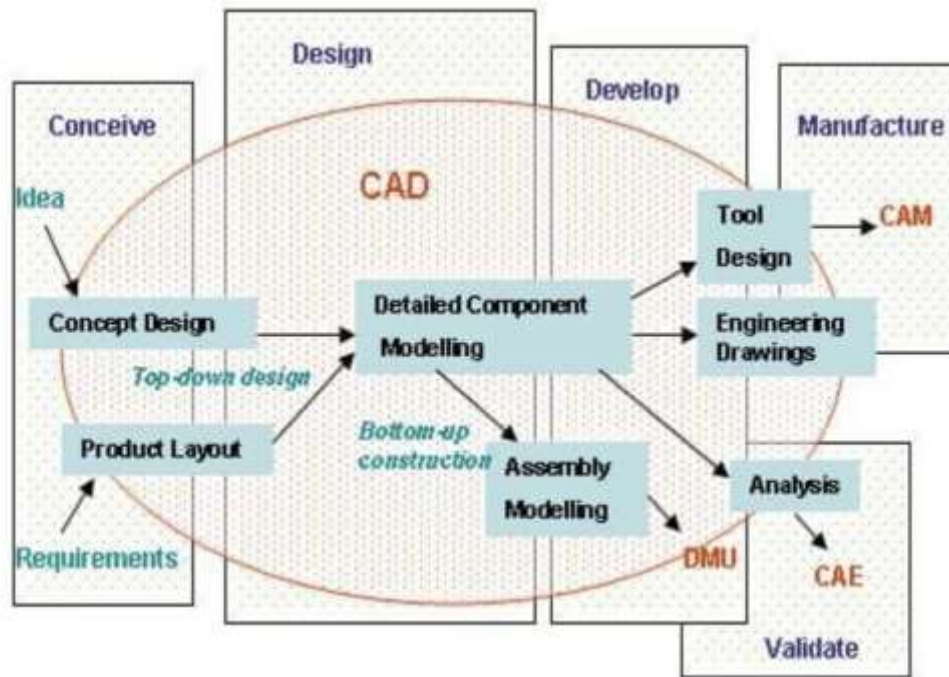
Figure-1: Process of CAD/CAM integration

SOLIDWORKS xDesign

That's correct! Dassault Systemes is a leading company in the CAD/CAM software industry and has been integrating AI into its products for some time now. SOLIDWORKS xDesign is one of their newer products that uses AI as a tool to help with engineering design work. The software allows designers to deploy different solutions to their design challenges instantaneously through cloud collaboration that is generated by the AI tool. With SOLIDWORKS xDesign, designers can define the constraints of their model and the software will use AI to generate the part instantaneously based on the constraints that have been defined. This makes the design process faster and more efficient, while also reducing the risk of human error.

Generative design

Generative design is another AI user developed by AUTODESK. Generative design will lift AI to change tedious design processes into sophisticated ones . The method is done by changing the parameters randomly with-in already defined boundary to generate a set of distinctive designs based on a built-in parametric CAD system. Khan and Awan (2018), proposed a space filling generative design technique (GDT) which integrates a computer program (Jaya Program) and CAD for the creation of innovative designs. According to their design, a CAD model m can be represented by n number of design parameters $x_{(m,1)}$, $x_{(m,2)}$, $x_{(m,3)}$ … $x_{(m,n)}$. Fig. 2 shows different alternatives of 3D CAD model for ceiling lamp using generative design by considering space filling and non-collapsing criteria.
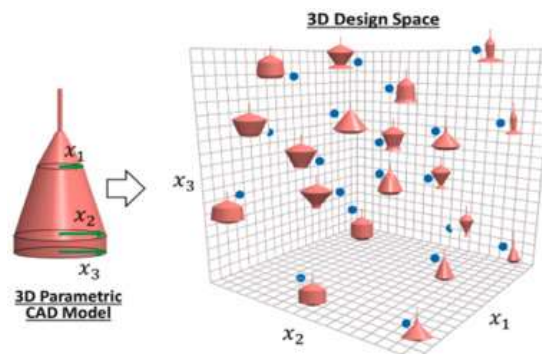

Figure-2: Design alternatives for a 3D ceiling lamp CAD model

Altria with SimSolid

AI-driven analysis and simulation solutions have become increasingly prevalent in recent years, and Altria SimSolid is just one example of such a solution. By utilizing AI and machine learning algorithms, SimSolid can quickly analyze the geometry of a 3D model without the need for meshing or other time-consuming preparation. This can significantly reduce the time and effort required to perform structural analysis and simulation, which can be especially beneficial in industries such as aerospace, automotive, and manufacturing, where design iterations and simulations are frequent.

SimSolid's meshless approach to calculating stresses and deflections is a key advantage, as it eliminates the need for time-consuming meshing operations, which can be a significant bottleneck in the analysis process. Instead, SimSolid uses machine learning algorithms that have been trained on large sets of simulation data to accurately predict deflections and stresses for a given 3D model. This approach can significantly reduce the time required for simulation and analysis, making it an attractive option for engineers and designers looking to optimize their design processes.

Autodesk with Fusion 360

Autodesk's Fusion 360 uses AI to accelerate the entire design to manufacture pipeline through what the developer refers to as generative design in Fusion 360. This tool generates multiple CAD-ready solutions based on manufacturing constraints (such as manufacturing method used), costs, and product performance requirements. For the software to generate a design, it requires you, as the user, to stipulate the essential geometrical aspects of a problem. For instance, you can select regions that must remain, the load that the part must withstand, and the areas that should be avoided. You should also enter your preferred material options and objectives (e.g., a prompt to achieve a specific factor of safety and maximize stiffness). Once the software generates the designs, it allows you to compare them based on properties that are important to you.
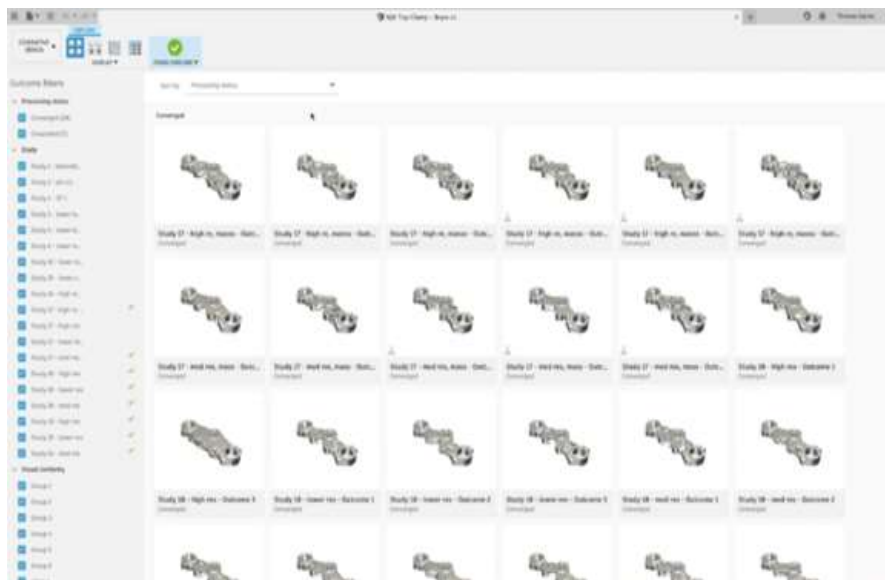

Figure-3: Generative design in fusion360

PTC with ThingWorx

PTC Inc.'s ThingWorx platform is an AI-powered IIoT solution that offers several tools, including a predictive maintenance tool that uses AI to detect potential failures in equipment. The platform can identify parameters that could cause equipment failure and predict when and why parts will fail, allowing manufacturers to perform maintenance proactively and prevent downtime.

ThingWorx also uses AI to optimize overall manufacturing efficiency and equipment effectiveness. The platform can analyze data from sensors and other sources to identify areas where processes can be improved, allowing manufacturers to optimize their production processes and reduce waste.

Additionally, ThingWorx enables remote asset monitoring, which can help manufacturers track equipment and predict potential issues before they cause downtime or other problems. By leveraging AI and machine learning algorithms, the platform can analyze data from sensors and other sources to identify patterns and anomalies, allowing manufacturers to take action proactively.

Overall, PTC Inc.'s ThingWorx platform is an example of how AI and IIoT can be used to improve manufacturing efficiency and prevent equipment failure. By leveraging data from sensors and other sources, the platform can identify potential issues before they cause problems, allowing manufacturers to optimize their production processes and improve their bottom line.

How AI is improving CAD and CAM processes in modern manufacturing

Figure-4: AI used in manufacturing

Increased Productivity: Higher Productivity AI first and primary enhances 3-D modeling by increasing the effectiveness of the method. As many as 15 million CAD designs are used as the fundamental dataset by means of certain AI layout assistants, which influences their forecasts. With that tons know-how, they are able to make forecasts which are remarkably accurate. By disposing of the need for customers to manually sketch numerous elements, this increases performance throughout the layout procedure. These AI assistants also are capable of automating design selections. For instance, AI can routinely apply geometry to new initiatives by aligning them primarily based on how pieces were carried out in previous designs. To assure that everything traces up nicely, this technique would often want slow, careful tweaks, but AI can do it in a matter of seconds. Manufacturers can then accelerate the time to market for new products whilst they can also focus on different sports or produce more.

CAD-CAM Engineering Software Integrated with AI In Dentistry

CAD/CAM software can provide accurate and precise results in manufacturing surgical guides for dental implant placement. The software can generate a three-dimensional virtual model of the patient's mouth, allowing the dentist or surgeon to plan the implant placement and determine the size and specifications of the implant and abutment. This helps to ensure a more accurate fit and reduces the risk of complications during the implant surgery.

Resins are commonly used to make surgical guides because they are strong, durable, and can be easily fabricated using CAD/CAM technology. Intraoral scans are also an advanced technology that allows dentists to easily capture all the information needed from the patient's mouth, making the process more comfortable and convenient for the patient.

Advantages over Conventional Method

The software helps in saving time and effort by creating surgical guides that assist the doctors in accurately placing the implants. The use of surgical guides also ensures a higher success rate in the implant placement surgeries.The software is especially useful in complex cases where there is significant bone loss, and the doctors might otherwise avoid implanting. With the help of the software, the doctors can confidently perform the surgery by accurately placing the implants.Moreover, using CAD/CAM software for a long time can also help in saving money as it eliminates the need for other types of treatment or additional surgeries. It can also solve cases where there is only one implant already present or where two implants need to be placed on the side, which the doctors might otherwise refuse to treat.Overall, the use of CAD/CAM software in dental implant placement surgeries is beneficial for both the doctors and the patients. It helps in increasing the accuracy and success rate of the surgeries while saving time, effort, and money.

Conclusion

The most effective boundaries presently AI have are inadequate records and high-priced installation. Therefore dentists, clinicians, CAD-CAM engineers and Computer technology engineers have to carry out obligations together for imparting first-rate remedy to society. AI can offer many blessings for CAD/CAM workflows and consequences, consisting of saving time and resources, improving accuracy and reliability, growing productivity and profitability, and improving quality and customer delight. AI minimises human mistakes, inconsistencies, and deviations whilst maximising the utilisation of machines, materials, and power to deliver merchandise that meet or exceed the specs, expectations, and wishes of the marketplace.AI based tools like Hyperganic and others (locate examples), can assist transform the design technique past the capabilities of human beings today. Generative designing makes use of a couple of iterations primarily based on preferred results and supplied inputs and allows designers to optimise designs faster and beyond the optimizations from ordinary layout good judgment which has traditionally been based on design for manufacturability or layout for production and meeting.The destiny of AI in the CAD enterprise appears brilliant, with organizations hinting at new AI-pushed merchandise. For example, Ansys, a software organisation that has created the Ansys engineering simulation software program, is currently exploring how it can use AI to improve the accuracy and velocity of simulations even as making the associated workflow both sturdy and clean to apply. For instance, the up to date platform will

boast higher generative designs. It will routinely regenerate the specs of designs created using CAD software and recreate the fine viable layout, permitting customers to reassess and increase the best of a layout. It can even regenerate designs from scans, with the regenerated layout featuring specs which are as near the scans' as possible. In end, we can say that AI is the future of dentistry. The software of AI is developing every day in dentistry. The dentist can't get replaced by means of AI but AI can assist the dentist to look new requirements in health care. The correlation between dentists and AI is wanted to establish speedy to get accuracy in treatment. In this regard, it's going to store time because it will no longer require users to manually create the designs. More information will, of direction, be made available as the launch nears. Indeed, those answers are bound to make AI more available, with the related impacts being undeniably great in the future. For example, greater designers and engineers will get to experience greater productivity and performance, reduced costs and mistakes, higher and extra green designs, and more optimised manufacturing strategies.