Computer Generative Design (Arificial Intelegent) in Architectural Design and Construction

By : Architect / Roshna Muhammad Ezzadin

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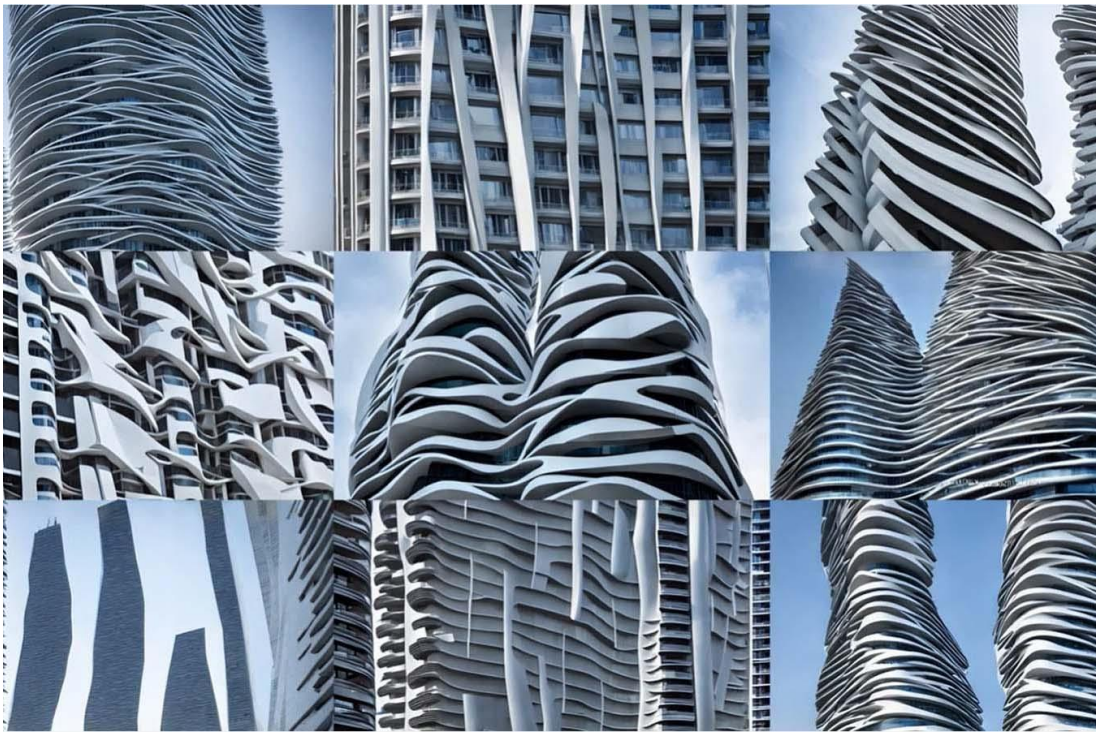
Abstract

Architects often face a significant amount of data in the early stages of projects. Artificial Intelligence (AI) is a new science that efficiently utilizes and manipulates data to achieve goals. AI has been spread across various disciplines and sub-fields, including modeling, anomaly detection, association, and clustering. This work aims to clarify the benefits of AI adoption in architectural design and encourage architects to use it. It uses a two-fold methodology: highlighting related literature and presenting published case studies of applied and intended projects. AI is expected to play a significant role in architecture practice in future projects.

Introduction

Artificial intelligence (AI) is a term that describes machines that mimic human cognitive functions, such as problem-solving, pattern recognition, and learning. Machine learning is a subset of AI that uses statistical techniques to enable computer systems to learn from data without being programmed. As the machine is exposed to more data, it becomes better at understanding and providing insights. AI goes beyond understanding to building intelligent entities. Initially associated with microbiology, AI has expanded to include general-purpose areas like learning and perception, as well as specific tasks like diagnosing diseases, marketing, engineering, and the economy, AI is defined as systems' ability to interpret external data correctly, learn from it, and use these learnings to achieve specific goals and tasks through flexible adaptation. Data is the cornerstone of AI activity, and it goes parallel to developments in computing facilities and the amount and quality of data stored in global resources. AI is a tool for any discipline to redefine itself, enabling tasks such as self-driving cars, remote operation, and smart homes through relevant algorithms.



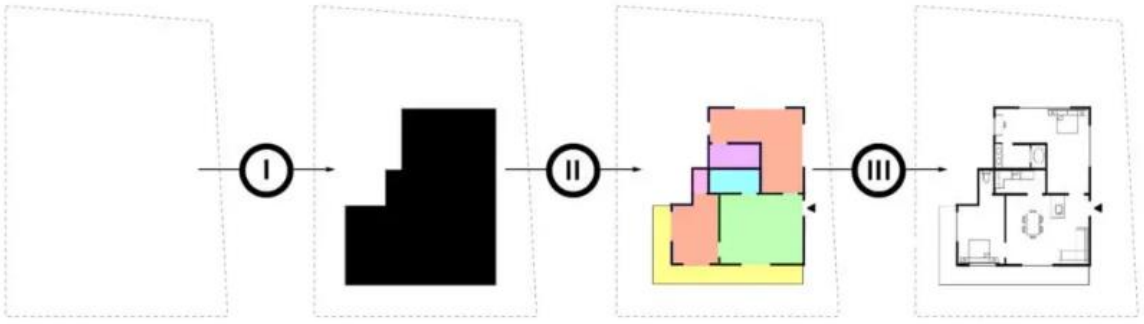
Complex Facade Generated by Ai (midjourney)

AI in Design Options

Computational technologies and AI are crucial in architecture due to the vast amount of data produced globally. They help create analytical information that influences decisions in design phases. AI helps process large amounts of data, reducing design time. Commercial software like CATIA and Grasshopper demonstrate the applicability of new technologies and materials. Researchers are also studying AI applications in floor plan analysis, generative design, and Generative Adversarial Networks.

AI in design options

In the sample below use of deep learning and GANs in generating floor plans demonstrates the potential of AI in architectural organization. This tool allows for multiple iterations of projects and generates appropriate floor plans, fostering a more analytical process and generating creative ideas. This experience underscores the potential of AI in providing informed decisions during the design phase. In Copenhagen, a research project identified three main areas where AI could contribute positively: research (organizing information), design (a better iterative process), and knowledge management (developing an internal database of experience). The research division is planning for a paradigm shift and preparing for the onset of AI into architecture practice for five years.

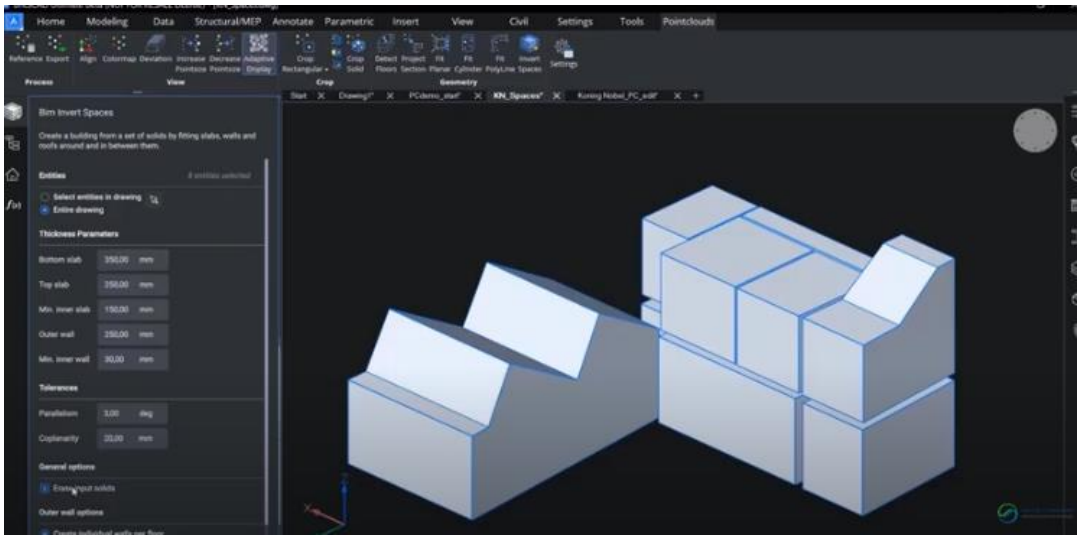


Stages of floor plan design by AI

AI as a style guide

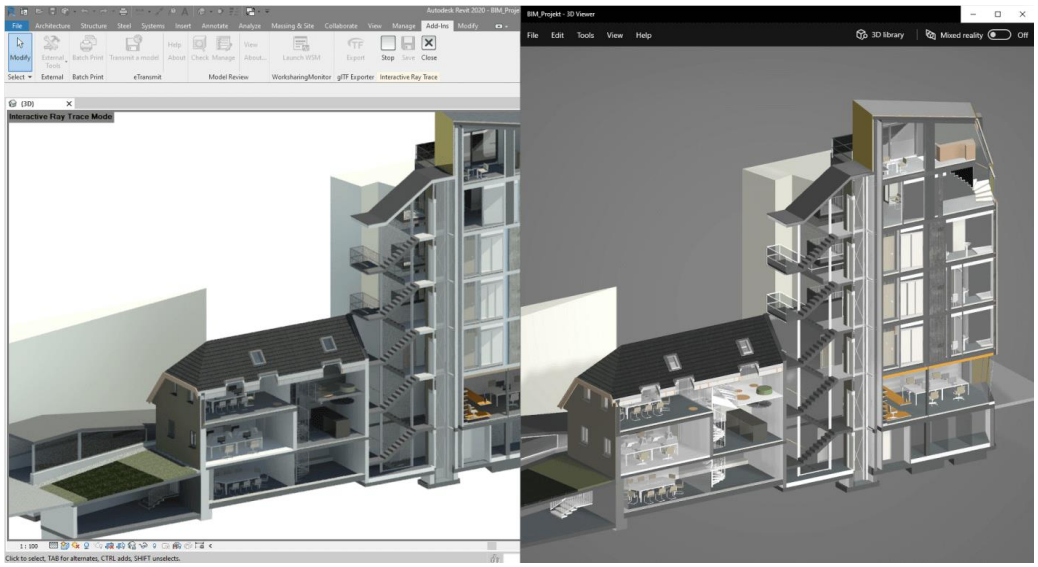
BricsCAD is an AI-based CAD design solution that aids architects in 2D drafting, 3D modelling, and BIM. It helps in finding and duplicating construction elements, reducing manual labor and ensuring accurate design decisions by examining sample models.

BricsCAD, AI style after analyze.



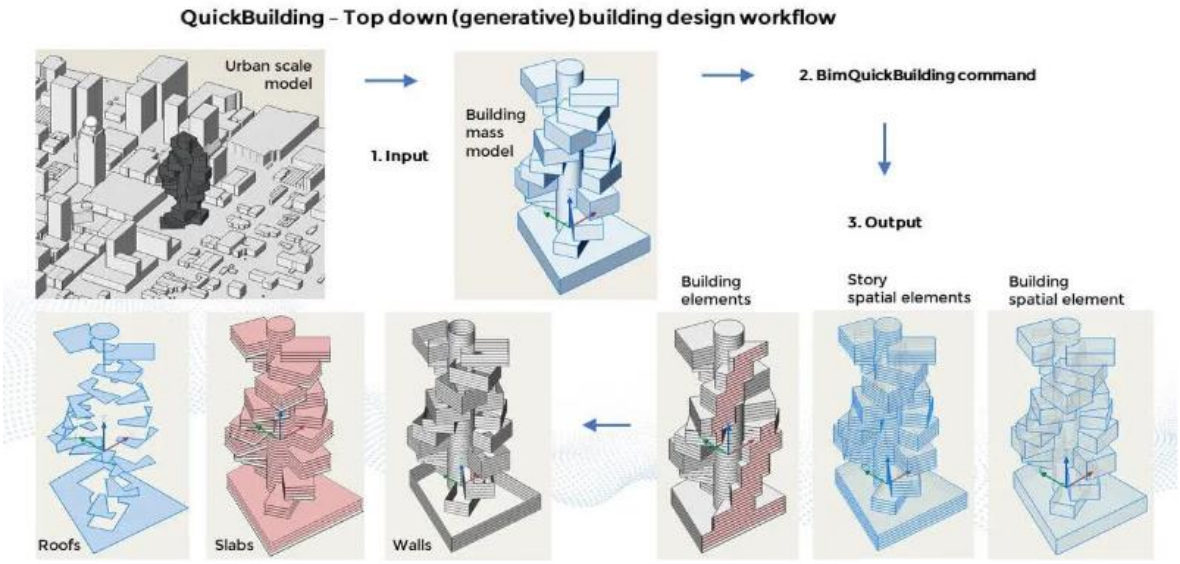
AI to Add Detail

Artificial intelligence enhances detail in design by automating intricate connections between walls and floor slabs, saving architects time and enhancing the overall model quality.

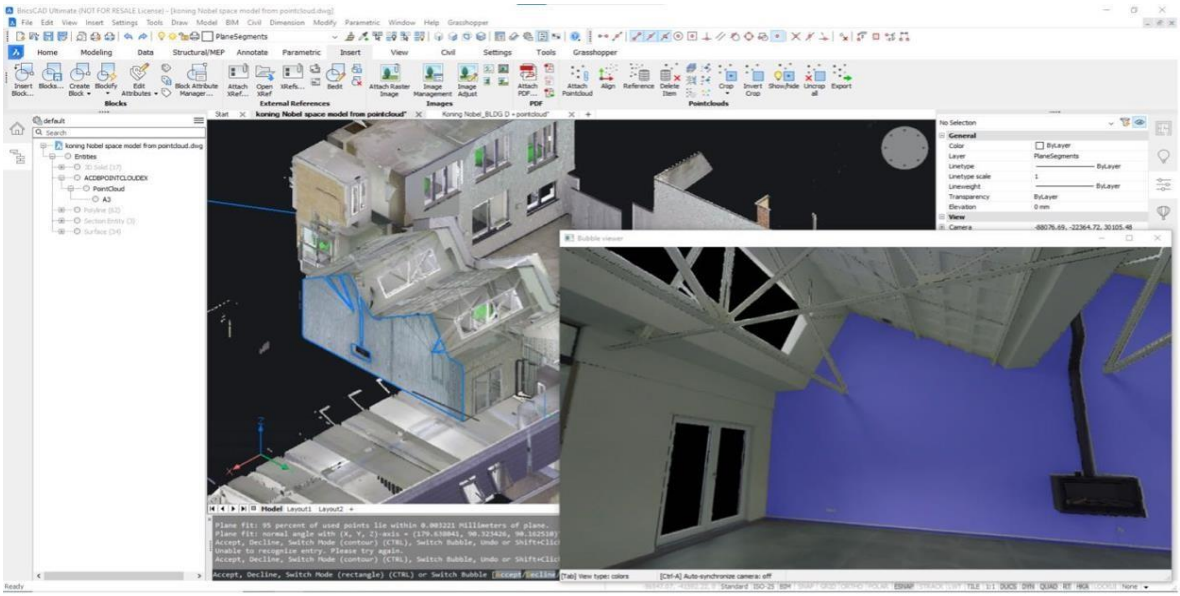


AI in (BIM)

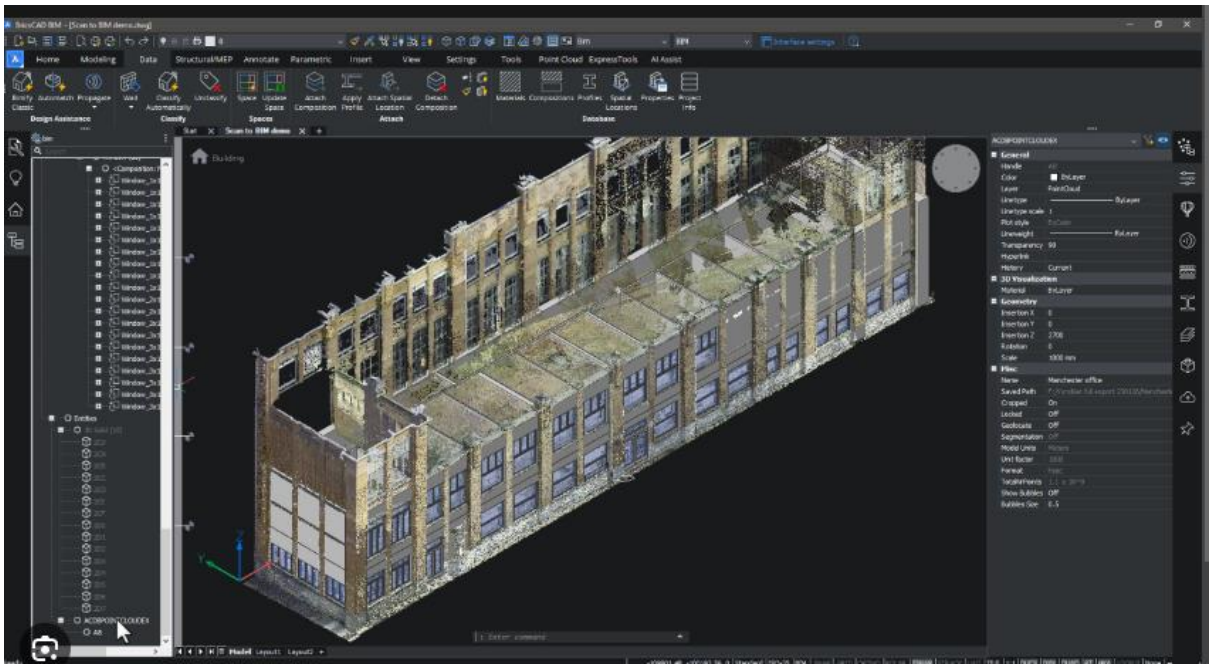
Building Information Modelling (BIM) is a collaborative approach in the construction industry that simulates building design in a virtual environment. It provides a data-rich, intelligent, and parametric digital representation of facilities. AI supports the complexity of BIM software, ensuring efficient planning, design, and construction.



AI and machine learning algorithms are transforming the design process, with AI emerging as a top trend in Building Information Modeling (BIM). BricsCAD BIM automates repetitive tasks, eliminating design bottlenecks. Geometry is a key principle, with the 3D modelling tool allowing architects to create shapes quickly. Correct BIM classification is introduced later, eliminating the need for creative design. The "Bimify" tool uses AI to assign BIM classifications to geometry, but architects can manually change classifications.



Bricsys is developing semi-automatic techniques to acquire 3D solids for building remodeling. They use BricsCAD to find planar surfaces and fit them to coplanar points. AI optimizes geometry, and BricsCAD applies an algorithm to build walls, floor slabs, roofs, and internal walls based on room volume planes.



AI in Analysis of Building Performance

Integrating AI and Building Information Modeling (BIM) can improve building performance analysis. EPA software evaluates energy and structural performance, while automated BPA uses machine learning to generate optimal options. Cove.tool is an intelligent platform for sustainable data-driven design, integrating machine learning to optimize high-performance design options. Structural performance analysis is crucial to prevent disasters.

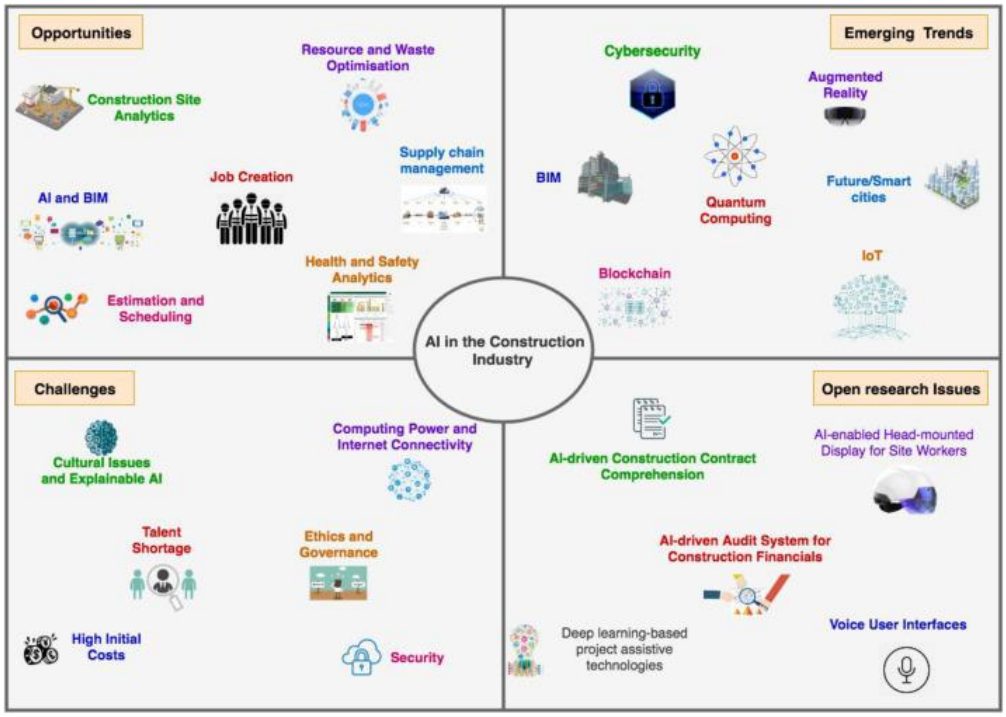
AI in Architectural Representation

Architectural representation is crucial, and computational technologies and AI have advanced this process. Virtual technology in architectural animation, such as Vray, Lumian, Twinmotion, and Cinema 4D, provides high-quality visual products. Virtual reality and augmented reality have emerged as interactive techniques in architecture, offering a view of current and future building stances.

AI for Construction

The construction industry is transforming with the integration of AI, robotics, BIM, and AR technologies. Additive manufacturing and automation are becoming key innovations, particularly in site work tasks. Machine learning and AI can manage change orders, information requests, and vulnerabilities, acting as smart assistants and alerting project managers.

An algorithm is developed to analyze job site photos, identify safety hazards, and correlate them with accident records. This allows for the computation of risk ratings for projects and the holding of safety briefings when an elevated threat is detected.



Artificial intelligence in the construction industry

Conclusion

The study explores the potential benefits of electronic computation software and AI in the architecture profession, highlighting their efficiency in achieving designs and saving time. While AI and software are not substitutes for architects, they can help them generate alternative designs using vast amounts of data. Future advancements in construction may involve cost reductions of up to 20% through robotics, AI, and the internet of things. Engineers can send robots into newly constructed structures using virtual reality goggles, while AI can route plumbing and electrical systems in modern structures. AI is also being used to create workplace safety solutions, monitoring interactions between employees, equipment, and objects in real-time to alert managers of potential hazards and productivity issues. Despite job losses, AI is not expected to completely replace the labor force, but rather to change business strategies, reduce costly mistakes, and improve building operations. Construction industry executives should invest in areas where AI has the greatest potential to meet their specific needs, as early adopters will determine the industry's future course and profit.