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Using Artificial Intelligence to Transform Sketches into Realistic Visualizations of Iconic Buildings

Fatmanur Atalay
Necmettin Erbakan University, Faculty of Fine Arts and Architecture, Department of Architecture, Konya , Turkey
Corresponding author email: fnuratalay@gmail.com
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Abstract

The sketch phase in architectural design is a process where design requirements are not fully defined, but decisions regarding the architectural product largely become clear. The integration of artificial intelligence (AI) into this process can be considered an exploration of potential design products that address early-stage design decisions. This paper examines how AI technologies can be utilized in the field of architecture, starting from the sketch phase and continuing through 3D visualization and rendering processes. Inspired by the sketches of pioneering modernist architects, the aim is to demonstrate how "sketch-to-sketch rendering" and "sketch-to-3D rendering" can be produced using AI-based tools. Based on the selected sketches by well-known architects and actual visuals of the buildings as references, prompts obtained from ChatGPT were used to generate sketch-to-sketch and sketch-to-3D render visuals in the artificial intelligence tools Air for SketchUp and Leonardo AI, and the results are compared. The applications demonstrate that Air for SketchUp provides more realistic and visually successful results, especially in the 3D rendering phase. Leonardo AI was notable for its capacity to generate quick alternatives that are more experimental and artistic in nature. However, these outputs tend to show weaker ties to architectural context. The findings suggest that human-machine collaboration can offer new potential in architectural design processes and that artificial intelligence tools can transform the traditional sketch process, taking on a supportive role for designers. It was determined that AI tools can contribute to architectural design processes in terms of creativity, reflecting environmental context in design, and developing design ideas.

Keywords

AI tools; Artificial intelligence in architecture; Realistic visualization; Sketch-to-Sketch; Sketch-to-3D Render

1. Introduction

Architecture, an interdisciplinary field that merges engineering and art, requires long design cycles and detailed thinking. Traditionally, architects begin the first phase of the design process—whose main activity is determining the form of a building-with a sketch. In this process, an abstract concept or an uncertain shape becomes tangible, laying the foundation for a series of design problems that need to be solved. To facilitate the progress of the design and to concretize their thoughts, architects use various lines, symbols, shapes, and notes. Although these layers collectively result in a complex sketch that is time-consuming, repetitive, and intensive, this stage is where many decisions concerning the architectural product are clarified. In this context, the form emerging in the initial sketches evolves in later stages of design, providing inputs that are utilized during the construction phase and throughout the building's life cycle (Pena et al., 2021). Emerging and continuously developing computer-aided design tools offer new possibilities for the architectural profession. New technologies also offer an opportunity to reshape the traditional sketch process, which is at the core of conventional design approaches.

In the age of information technology, designers often develop traditional 2D drawings and 3D models using CAD-based software. Alongside this, many designers also have adopted and utilized both parametric designs grounded in digital design (Aksamija, 2018) and Building Information Modeling (BIM), which incorporate numerical data such as materials, cost, and environmental controls to enable the use of 3D models throughout a building's life cycle (Holzer, 2015). After creating 3D models and renderings with architectural design tools, designers frequently employ software dedicated to post-production (e.g., adjustments to lighting, color, contrast, and preparing presentations) to create more impactful visuals (Zhang, 2025). In recent years, one emerging technique in computer-aided architectural design is text-to-image (GAI-Generative Artificial Intelligence) or AI-based image generators Enjellina et al., 2023), which demonstrate important potential in application to architectural design. In parallel with technological advances, AI-used to solve countless problems in all areas of life—also is rapidly being integrated into the field of architecture. By adjusting based on visual requirements, AI provides the opportunity to produce more effective and optimized visuals in architecture.

In this study, the potential use of AI technology in the early stages of architectural design is explored. The research focuses on two main possibilities: generating "sketch-to-sketch" outputs with stronger expressive capabilities based on initial sketches and directly providing "sketch-to-3D visual" previews at the final stage of the design process. In this way, the study aims to develop a vision for human-machine collaboration in the sketch phase of the design process.

The main objective of the research is to explore how the architectural sketching process can be shaped by integrating AI-based tools into the early stages of architectural design. Tools such as ChatGPT, which is based on natural language processing and transformer architecture, Air for SketchUp, which employs generative AI focused on visual data and 3D design, and Leonardo AI, which utilizes image processing and deep learning algorithms, were used to generate and edit architectural visualization images. These AI tools were used to develop sketch-to-sketch and sketch-to-3D renderings based on the initial sketches and structures of architects who, by interpreting modernist principles through their own unique approaches, have made innovative contributions to architectural practice and whose designs have evolved into architectural icons. The AI designs were assessed against the original sketches and iconic structures done by internationally-recognized architects.

2. Literature Review

In the literature review of this paper, the use of artificial intelligence in the field of architecture is addressed, focusing on text-to-image, image-to-image, and image-to-text generation. In this context, the functions of artificial intelligence tools such as Air for SketchUp, Leonardo AI, and ChatGPT are thoroughly evaluated. Additionally, for the applied investigations, research was conducted on the architectural representatives and iconic structures of modernism.

2.1 Artificial Intelligence in Architecture

In 1958, Frank Rosenblatt's discussion of machines with the potential to perceive and recognize their environments laid the foundation for the role of artificial intelligence (AI) in creative disciplines such as architecture (Chaillou, 2020). This early vision suggested that AI could be developed not only to harness computational power but also to emulate human-like cognitive processes. However, the effective adoption of AI as a tool in architecture only became feasible over time through increased computational power and the development of advanced algorithms.

Architectural design is an inherently complex process that draws on experience and creativity to generate new solutions (Pena et al., 2021). AI approaches in architecture offer the ability to produce numerous viable solutions within a reasonable timeframe by addressing various design requirements (Bölek et al., 2023). One of the earliest research projects applying AI to architectural form design was introduced in Soddu's 1989 work Città Aleatorie. In this study, Soddu defined a generative design approach for architecture and urban planning by constructing an artificial DNA of Italian medieval towns (Soddu, 2020). Notably, this work emphasized not only form generation but also the algorithmic representation of architectural identity. Later, Yeh (2006) extended this approach to functionality by employing neural networks in generating hospital layout plans. Thus, AI's role in architectural design has evolved from aesthetic production to encompass complex programming and performance optimization.

AI contributes to solving architectural design problems in various domains such as performance-based design, form finding, spatial programming, multi-objective optimization, restoration, and the development of design tools (Bölek et al., 2023). For example, Wen et al. (2010) and Rian and Asayama (2016) used fractal algorithms for architectural form generation, while Tamke et al. (2018) explored the effects of machine learning on architectural applications through two case studies focused on performance-based design and production. Chaillou (2020) examined data science and architecture as a unified research domain, investigating the potential of Generative Adversarial Networks (GANs) in architectural design, highlighting their interactive capabilities from floor plan creation to building design. Pena et al. (2021) noted that much of the research in this field centers on evolutionary computation and cellular automata, offering a comprehensive literature review on AI in architecture. These approaches support not only form generation but also broader objectives such as spatial programming, optimization, restoration, and tool development. Collectively, the literature reflects a shift in AI's role from being merely a technological tool to becoming a design partner.

AI integration also facilitates solutions to problems such as predicting energy savings in buildings (Banihashemi et al., 2017), energy efficiency and life-cycle analysis (Sartori et al., 2021), and climate-responsive facade adaptation (Kim & Clayton, 2020). The application of AI-based methods has enabled the analysis and optimization of complex design problems that previously were difficult to address, thereby advancing interdisciplinary collaborations (Bölek et al., 2023).

Although AI has been present in architecture for over 40 years, application has become increasingly widespread in recent years due to advances in computational power, big data analytics, and new algorithmic developments. Today, many studies employing AI tools based on evolutionary computation (EC) and genetic algorithms (GA) focus on improving existing designs through form optimization (Pena et al., 2021). From a critical perspective, this trend points to a certain methodological homogeneity. Given the multidisciplinary nature of architecture, there is a clear need to integrate more diverse AI models—such as natural language processing or predictive analytics.

Leach and Yuan (2020) interpret this transformation through the concept of “Architectural Intelligence,” describing it as a new approach to design and production shaped by AI integration. While these methods aim to support human activity, they may eventually lose their distinctiveness as they become more widespread and evolve into standard architectural practice (Leach & Yuan, 2020). In other words, AI applications that were once seen as novel and innovative increasingly are becoming a natural component of the design process. AI is reshaping not only how we design but also how we think about architecture itself.

Although the literature demonstrates that AI has become a versatile tool in architecture, there is still a need to establish more critical connections between studies, explore greater methodological diversity, and conduct deeper analyses of application domains. The evolving relationship between AI and architecture not only accelerates the design process but also redefines its very nature.

2.2 Generating Text-To-Image, Image-To-Image, Image-To-Text

Text-to-image generation models, which create new digital images from input prompts written in everyday language, increasingly have gained traction in both academia and industry (Avinç, 2024). Through the applications of transformer-based architectures in the field of natural language processing (NLP), text-to-image systems built on deep generative models are being utilized for computer vision tasks (Lyu et al., 2022). These tools have the capacity to generate vivid and visually rich images based on specific textual inputs-or prompts-provided by users (Miao & Yang, 2023). In order to enhance image quality and modify its aesthetics, constructing these prompts typically requires practice and skill in interacting with the system (Liu & Chilton, 2022). Crafting an effective prompt often involves carefully arranging words, and even a minor change in wording can lead to significant performance differences (You et al., 2022).

With high-resolution image synthesis capabilities, the latest models-such as Midjourney, Inc (2024); CompVis, Stability AI & Runway, 2024; Disco Diffusion (2024); OpenAI, (2024b); Imagen (2024); Magnific (2024); Air for SketchUp (2024); Leonardo Interactive Pty Ltd (2024)-have advanced text-to-image generation. These tools not only generate images from text but also possess the ability to extract features from a given image and combine that information with textual commands to produce new images (text and image-to-image). First, the AI model analyzes the provided image by identifying its elements (shapes, colors, textures). It performs a detailed pixel-level inspection to understand the structure of the image and stores this information in “feature maps” (Castiglioni et al., 2021). The features extracted from the image are then combined with the user’s textual prompts. At this point, AI models use techniques such as Contrastive Language–Image Pretraining (CLIP) to determine the semantic relationship between the text and the image (You et al., 2022). Once the visual and textual data are merged, the AI uses techniques like Generative Adversarial Networks (GAN) to create a new image (Chaillou, 2020).

AI analyzes contextual and aesthetic elements to determine how the text commands should modify the image. For instance, a command like “minimalist design” reduces superfluous details in the image and presents a simple, orderly appearance. This outcome is achieved through style transfer and visual modification algorithms (Cai et al., 2023). Thus, AI analyzes and interprets an image, extracts features, and associates them with text to create a new image. This technique allows for the text-guided customization of visuals in various fields-such as architecture, art, design, and media-accelerating processes and yielding more effective results. Although it can create new images, applying this technology to 3D design workflows and enabling designers to build 3D models from AI-generated inspiration have yet to produce advanced results (Liu et al., 2023). However, tools like Architectures AI (Architectures, AI, 2024), which are still in development, are expected to refine this capability and, specifically for architecture and design, to be integrated into BIM (Building Information Modeling) and parametric design tools.

The process of generating text from images (image-to-text) using AI combines computer vision and NLP techniques (Núñez-Morales et al., 2024). First, the AI leverages Convolutional Neural Networks (CNN) to analyze the image and extract features such as color, shape, texture, and spatial relationships. These data are then processed by models like CLIP (Contrastive Language–Image Pretraining) to contextualize and interpret the relationship between the image and text (Belhadi et al., 2024). The extracted features are fed into language models to create meaningful text about the scene or objects in the image. A transformer-based language model generates descriptive or context-relevant text that reflects the content of the image. This approach enables the AI to interpret the content of an image and provide the user with meaningful, goal-oriented text (Kohnke, 2022). Standout AI technologies that can interpret images and extract text include the Google LLC (2025); Open AI (2024c); DeepAI.org (2024); Imagen (2024). When asked to write a prompt based on a given image, GPT-4 does not actually interpret or process the image but instead only infers context to produce text (OpenAI, 2024a). In this study, Air for SketchUp and Leonardo AI were employed to generate visuals from images and text, while ChatGPT was used to produce text based on the context of the images.

2.2.1 Air for SketchUp

As an AI-based tool integrated into SketchUp, it offers solutions for automating and optimizing users' 3D modeling processes. By leveraging AI and deep learning techniques for generative design and visual enhancements, the tool essentially positions AI as both a design guide and a production tool within the 3D modeling process. Advanced algorithms such as Convolutional Neural Networks (CNN) and Generative Adversarial Networks (GAN) enable it to analyze user inputs and provide appropriate visual-spatial solutions (Nandhini Abirami et al., 2021). Within architectural design, it analyzes models created in SketchUp to optimize surface details and material applications. In addition to processing visuals derived from 3D models in SketchUp, it also can handle images in formats like .jpg and .png (Air for SketchUp, 2024). It employs style transfer algorithms to assist in producing outputs that align with a specific design style. This method learns a design's aesthetic language from certain references (Cai et al., 2023) and applies it to the surface details and overall form of the user-provided image. Moreover, it processes the parametric data provided by the user, offers suggestions, and accelerates the design process (Air for SketchUp, 2024). By integrating AI technologies, such as generative design and machine learning, into a widely used design platform like SketchUp, this tool enhances design efficiency at every stage of the architectural design process and streamlines the workflow for designers.

2.2.2 Leonardo AI

Leonardo AI is an artificial intelligence tool with various functions such as reproducing visual aesthetics, performing style transfer, and supporting creative design processes. By using deep learning algorithms based on artificial neural networks (ANN) (Jie et al., 2023), it enables users to imitate certain artistic styles or produce original visuals. Additionally, through methods like Generative Adversarial Networks (GAN) (Chaillou, 2020), it can optimize visual content from both creative and technical perspectives. Leonardo AI analyzes text inputs and uses text–visual matching processes to generate meaningful visual outputs. It integrates the text–visual contextualization capabilities of models like CLIP (Contrastive Language–Image Pretraining) or similar technologies to create images that are both more aesthetic and semantically rich (You et al., 2022). During this process, the AI interprets the textual input provided by the user, comprehends the context, and produces stylized images based on that context. By employing advanced techniques such as style transfer, it can reinterpret specific artistic movements or design languages (Leonardo Interactive Pty Ltd, 2024). Leveraging AI and deep learning techniques, it supports the design process by addressing users' artistic and aesthetic needs. In disciplines such as architecture, art, and media, it merges text-to-image generation with artistic stylization to make processes more efficient and effective (Leonardo Interactive Pty Ltd, 2024).

2.2.3 ChatGPT

Defined as an interactive AI powered by natural language processing and deep learning, ChatGPT is a language model developed by OpenAI that redefines text-based human–machine interactions (Biswas, 2023; Annamalai et al., 2025). This system is built on the Generative Pre-trained Transformer (GPT) model, which utilizes the Transformer architecture to deeply analyze language structure, context, and meaning (Kohnke, 2022). As a novel AI-based technology, ChatGPT draws attention due to its advantages and disadvantages alike, thereby necessitating ongoing discussions, research approaches, and ethical evaluations (Foroughi et al., 2024; Kasneci et al., 2023). ChatGPT can analyze images, detect and extract any text within them, and present this text to users after editing (Annamali et al., 2024). In architecture, ChatGPT can enhance creativity and efficiency across a broad range of tasks, from developing design ideas to technical documentation, project management, sustainability and ergonomic analyses, client communication, and visual production. However, it falls short of fully replacing human expertise in areas requiring aesthetic sensitivity, comprehensive technical analysis, strict adherence to local regulations, on-site experience, and an understanding of human contexts in architectural projects (Bölek et al., 2023; Avinç, 2024; Tian et al., 2024).

Table 1 provides a comparison of the AI-based technologies used in this study—Air for SketchUp, Leonardo AI, and ChatGPT—focusing on their functionalities, usage methods, and solutions offered. In terms of purpose and focus of use, Air for SketchUp and Leonardo AI primarily generate visual/formal outputs, while ChatGPT provides textual and theoretical support in architectural education and idea development processes. The difference in the AI techniques used by these tools stems from the distinction between visual generation and text generation technologies. The core functionalities of the tools directly affect the user experience: Air for SketchUp and Leonardo AI operate mainly through visual content, whereas ChatGPT is based on continuous feedback and interactive, text-based communication.

Table 1. Comparison of AI Tools: Air for SketchUp, Leonardo AI, and ChatGPT.

Feature	Air for SketchUp	Leonardo AI	ChatGPT
Primary Purpose	Optimization of 3D design and generative modeling	Production of artistic and creative visual content	Natural language processing and conversation-based AI
AI Techniques Used	Generative Adversarial Networks (GAN), Convolutional Neural Networks (CNN), Style Transfer	Generative Adversarial Networks (GAN), Style Transfer	Transformer-based architecture (GPT), Attention Mechanism
Core Functionality	Enhancing 3D modeling or reference visuals with automatic design suggestions	Creating and enhancing artistic visuals based on text or reference images	Generating human-like text responses and content
User Interaction	Users provide reference images and text inputs and can continuously adjust the outputs	Users input text or reference images	Interactive; processes text inputs and generates responses
Main Outputs	3D rendered images, optimized geometries, material applications	2D and 3D visuals, artistic content, stylized designs	Text-based responses, creative content, explanations
Integration	Directly integrated with SketchUp software, export options available	Independent tool with export options for different applications	Independent tool or adaptable to various platforms through API integration
Use Cases	Architectural design, urban planning, material optimization	Digital art, graphic design, architectural rendering, media production	Education, customer support, content creation, research assistance

In terms of output, Air for SketchUp rapidly generates material suggestions from 3D models and visuals, enhancing integration with designs for SketchUp users. Leonardo AI provides stylized visual content. ChatGPT produces textual outputs such as content drafts, explanations, and summaries, and can be adapted to various platforms through API integrations. In architectural use cases, Air for SketchUp is utilized in direct design applications such as urban planning, building form optimization, and material simulation. Leonardo AI is effective in presentation-oriented tasks such as concept drawing visualization, posters, animations, and rendering images. ChatGPT is useful for tasks such as preparing project texts, answering user questions, generating research suggestions, and providing theoretical support.

When the design process is considered holistically, the combined use of tools that generate both visual and textual content can form an integrated AI set that supports all phases of an architectural project, including idea development, form creation, visual presentation, and written documentation.

2.3 Architectural Representatives of Modernism and Their Iconic Buildings

Architects who interpret modernist principles in their own unique ways have expanded the boundaries of modern architecture, providing innovative contributions to architectural practice. Elements such as functionality, simplicity, and aesthetics are key features they emphasize in their designs. Renowned architects like Frank Gehry, Santiago Calatrava, Zaha Hadid, and Norman Foster (also known as "starchitects") designed buildings that have greatly influenced the field of architecture, each becoming symbolic of their individual styles (Aatty & Al Slik, 2019). These buildings, designed by architects who have left a profound impact on architectural practice—affecting not only the design understanding of their own era but also inspiring future architectural practice—are referred to as "iconic buildings" (Zamparini et al., 2023; Ulug, 2022). Iconic buildings are structures that either possess intrinsic historical or cultural value or are associated with an important place or person (Elhagla et al., 2020). They often stand out in terms of design, scale, visual appeal, urban context, or architectural style (Davarpanah, 2012), playing an important role in shaping their surroundings (Elhagla et al., 2020).
In the first phase of the design process, most architects traditionally begin with sketches. Comparing the initial sketches of architects who are known for their distinctive architectural lines with the actual built structures, it is evident that the forms often closely match one another. In this study, six architects—considered pioneers of modern architecture—were selected, each with a building for which the architect's own sketches from the design phase are available. Norman Foster, for instance, is recognized for his innovative designs and sustainable approach. Located in London, 30 St Mary Axe—commonly known as The Gherkin—is one of Foster's most iconic projects. Completed in 2004, it stands as a modern landmark with its aerodynamic form and diamond-patterned glass facade (Caliò et al., 2021).

Kengo Kuma's Alberni in Vancouver is a striking architectural landmark. This 43-story, 181-unit curved structure is Kuma's first residential project in North America (Serednicki, 2024). The Hunters Point Library, designed by Steven Holl, is a modern public building situated within a park by the East River in Long Island, leaving extensive green spaces around it due to its compact and vertical design (Lehmann, 2024). Tadao Ando's Modern Art Museum of Fort Worth, Texas, features a minimalist approach that highlights modern art. The museum skillfully integrates concrete, glass, and water, showcasing Ando's characteristic geometric precision and use of light (Sherzad et al., 2022).

Renzo Piano's Centro Botín, an international center for art, culture, and education, is located in Santander, Spain. Built along the coastline, it consists of two structures with a design that seamlessly integrates into its surroundings, appearing to hover in midair (Piano & Vidal, 2015). The Walter Gropius House, designed by

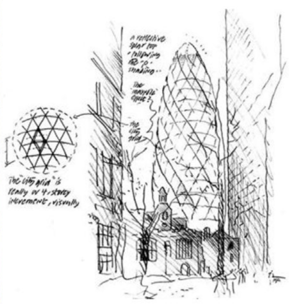
Walter Gropius, The Architects' Collaborative (TAC), and Wils Ebert, combines functionality and minimalist aesthetics (Krohn, 2019), effectively employing modern materials such as concrete and glass in adherence to Bauhaus principles (MacCarthy, 2019). Figure 1 provides online images of these buildings and their original sketches by the respective architects.

30 St Mary Axe Tower

Architect: Norman Foster and Partners

Image of building (Foster and partners, 2025b)

Sketch of building (Foster and Partners, 2025a)

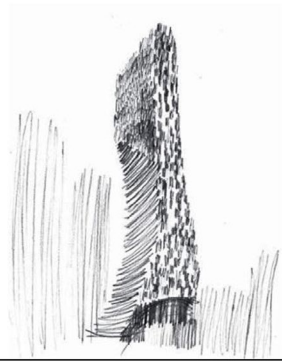


Alberni Tower

Architect: Kengo Kuma and Associates

Image of building (Ikiz, 2023)

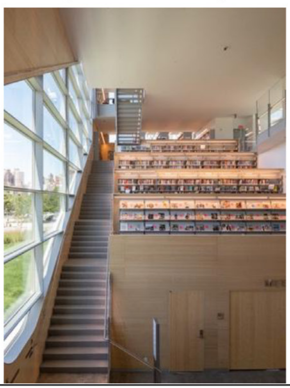
Sketch of building (Aşıkkutlu, 2023)



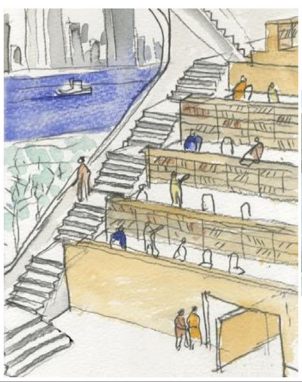
The Hunters Point Library

Architect: Steven Holls Architects

Image of building (Warchol, 2024a)



Sketch of building (Warchol, 2025b)

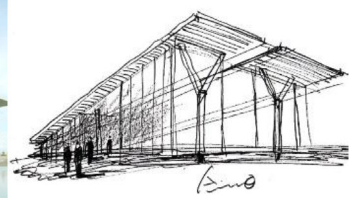


The Modern Art Museum of Fort Worth

Architect: Tadao Ando

Image of building (Yusheng, 2022)

Sketch of building (Architizer, 2022)

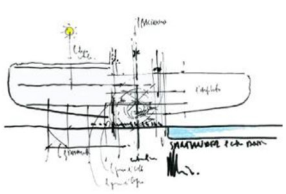


Centro Botín

Architect: Renzo Piano Architecture, Luis Vidal and arquitectos

Image of building (Cano, 2024a)

Sketch of building (Cano, 2024b)



The Walter Gropius House

Architect: Walter Gropius, The Architect's Collaborative(TAC), Wils Ebert

Image of building (Hansaviertel Berlin, 2025)

Sketch of building (Hansaviertel Berlin, 2025)

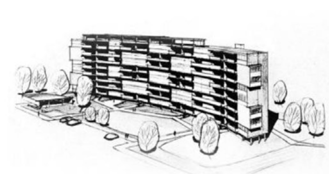


Figure 1. Images of Iconic structures in modern architecture and designers' associated sketches.

The similarity between architects' initial sketches and the forms of their completed buildings underscores how firm and consistent their design visions are throughout the creative process. Norman Foster's aerodynamic form of The Mary Axe Tower, for instance, aligns with the organic and fluid lines in his sketches. Likewise, Tadao Ando's sketches for the Modern Art Museum of Fort Worth clearly reflect the building's minimalist geometry and its treatment of light and shadow. In Renzo Piano's Centro Botín, one can observe that the sketches already highlight the forms that appear to hover and harmonize with the surrounding environment. Kengo Kuma's curved building design for Alberni matches the organic lines found in his sketches. Steven Holl's sketch for the Hunters Point Library clearly demonstrates the building's compact and vertical internal layout. As for Walter Gropius and his collaborators' design of Gropius House, the functional, minimalist structure corresponds with the simplicity seen in its sketches. Figure 1 emphasizes the strength of the vision presented by these architects during the sketch phase and how those initial design ideas are directly translated into the building's form.

2.4 Theoretical Framework

The theoretical framework of this study is shaped at the intersection of architectural design thinking and artificial intelligence (AI)-assisted design processes. Developed based on an extensive body of literature, this framework specifically examines how AI systems contribute to architectural thinking, representation, and conceptual development through technologies such as text-to-image, image-to-image, and image-to-text transformation.

Although the discipline of architecture traditionally has relied on drawing to concretize design ideas, the advancement of AI tools has transformed this process into a more data-driven, iterative, and generative structure. As highlighted by researchers such as Chaillou (2020); Bölek et al. (2023); Leach & Yuan (2020), the concept of Artificial Intelligence in Architecture reveals a shift from drawing as a static act of production toward a new design experience based on human–machine interaction. In this context, generative models such as GANs and CLIP (Contrastive Language–Image Pretraining) offer the capability to transform textual or visual inputs from users into spatially and aesthetically coherent outputs (Miao & Yang, 2023; Castiglioni et al., 2021).

The theoretical framework is further enriched by approaches such as generative design (Soddu, 2020), style transfer (Cai et al., 2023), and evolutionary computation (Pena et al., 2021). These approaches emphasize AI's potential to reproduce design languages, enable rapid prototyping, and generate multiple alternatives.

Within this structural context, the relationship between the conceptual sketches and final buildings of prominent figures in modern architecture is reexamined. The works of these architects serve as a reference point to evaluate the extent to which AI-generated outputs adhere to the designer's original sketches. As discussed by Ulug (2022) and Zamparini et al. (2023), the concept of design authenticity plays a key role in understanding how closely AI can align with a designer's vision.

Accordingly, the theoretical framework not only maps out the technical capabilities of AI tools but also identifies the focal points through which these tools can be evaluated. In the transformation of the architectural design process through the integration of artificial intelligence (AI) tools, the foremost emphasis is placed on AI's capacity to generate realistic design scenarios. These scenarios aim to enhance the level of 'realism' by producing context-sensitive designs that respond to environmental, functional, and structural conditions. This focal point is particularly important in terms of visualizing design decision-making processes. Moreover, the extent to which the designer adheres to their initial conceptual sketches is evaluated through the criterion of 'adherence to the sketch', as it reflects the preservation of original ideas and the avoidance of deviation from design authenticity. Since AI tools tend to generate their own interpretations, the degree of adherence to the original sketch must be consciously regulated by the designer. Despite operating in the early stages of design, the system's ability to generate detailed outputs (or 'detailing') defines the quality of AI's contribution. The refinement of materials, surfaces, and formal details within the design allows for a clearer articulation of design decisions.

AI is expected to enhance 'visualization quality' by producing meaningful and rich visual representations. This facilitates both the evaluation and communication of design ideas. Ensuring 'coherence', or the spatial, functional, and conceptual consistency among all generated outputs, is essential for a successful design process. The closer AI suggestions align with inputs provided by the designer, the higher the overall system coherence. Throughout this entire process, 'AI contribution' to the creative workflow shapes the nature of interaction between the designer and the tool. Within this holistic structure, AI transforms architectural sketching from being merely a linear act of drawing into a data-informed, visually and conceptually enriched design experience. The theoretical framework diagram considered in the analysis of the architectural sketching process shaped by the integration of artificial intelligence tools is presented in Figure 2.

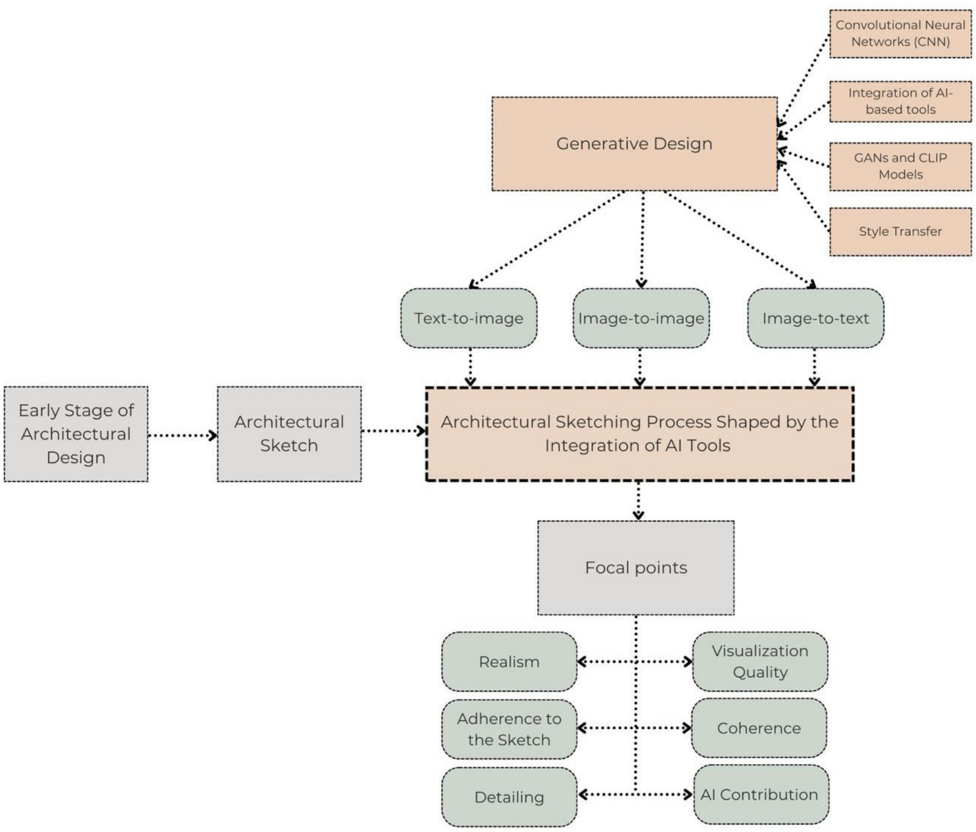


Figure 2. The theoretical framework diagram linking the architectural sketching process and AI tools.

3. Methodology

By leveraging AI, it is possible to program architecture to respond interactively and autonomously to environmental and functional contexts (Özel, 2020). In this way, parametric design tools and BIM or CAD-based systems, which can be restrictive in form generation, can find alternative solutions or produce more varied spatial renderings early in the design phase.

This study examines the outcomes of integrating artificial intelligence as a design tool in the earliest phase of the design process, the sketching stage. The digitization of this phase and its transformation into a different expressive technique through AI-supported visualization tools will bring a new dimension to the design process. The primary aim of this study is to test the ability of artificial intelligence to generate realistic visualizations from architectural sketches using different tools and to evaluate the impact of AI on the design process within the framework of human-machine collaboration. Additionally, the study assesses the role of AI-generated visualizations in architectural design practice. In this context, the sketches of buildings by architects who have made innovative contributions to architectural practice were used as the primary material. Different variations were generated using AI tools, and the direct transition from sketches to architectural products is discussed.

The study was conducted based on the following research questions:

- Can AI tools accurately reflect an architect's personal style? To what extent do the generated visualizations align with the original sketches?
- How do AI-generated visualizations contribute to the architectural design process in terms of creativity?
- Are the AI-generated visualizations detailed and accurate enough for realistic architectural representations? Do the model and style settings offered by these tools produce realistic results?

In this context, during the first phase of the study, architects who have made innovative contributions to modern architectural practice were identified. The selection criteria included buildings where the architect's original sketches were available and clearly reflected their personal style. Subsequently, the necessary prompts for AI tools to generate text-based and image-supported outputs were determined. Using real visuals of each building and a set of keywords, ChatGPT was asked to generate prompts. Architectural and environmental features extracted from photographs of these buildings were used to form these prompts.

In the third phase, the sketches of each building were visualized using Air for SketchUp and Leonardo AI. The building-specific prompts generated by ChatGPT, along with the sketches, were first entered into Air for SketchUp. To produce both a more realistic sketch and a rendered image from the sketch, different material and creativity settings were specified, resulting in two different outputs. The same images were then input into Leonardo AI using various model and style settings, generating two additional outputs.

In the final phase, the AI-generated images were compared and evaluated. Figure 3 presents the methodology flowchart used in the study.

In this study, GPT-4, ChatGPT-4o—an AI tool using language modeling skills to explain the context of an image based on provided details—was employed. For generating images from text or from both image and text, the Air for SketchUp v4.0.0.0 .rbz AI plugin was used with the SketchUp_2019 software, while Leonardo AI was used online via the link https://leonardo.ai/.

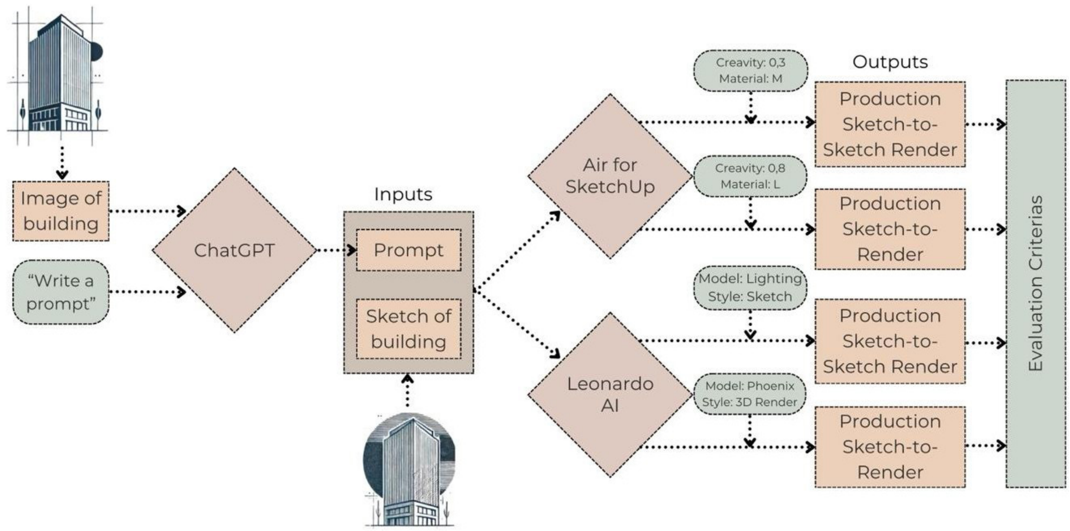


Figure 3. Methodology flowchart used in the study.

4. Realistic Visualization from Sketch

It generally is accepted that during the sketch phase of a building's design process, architects make a series of decisions regarding the building's original form, the materials to be used, and architectural details. To obtain a rendered image (render) of a 3D model, it is necessary to define the architectural details of the building, its relationship with its surroundings, and the atmosphere to be created in the render. Similarly, to transform a sketch into a render image, these components (architectural details, the relationship with the environment, and the atmospheric setting) must be defined. In this context, real images of the buildings were uploaded to ChatGPT and it was asked to generate prompts based on certain keywords. Table 2 presents the inputs given to ChatGPT and the corresponding prompts produced.

When looking at the prompts suggested by ChatGPT in Table 2, they align with the given keywords: they describe the unique form of the buildings and the characteristics of the materials used (glass, concrete, metal, etc.). Additionally, environmental features and atmosphere elements necessary for the render—such as the green spaces around the buildings, walking paths, trees, bodies of water, sky conditions (clear, blue, cloudy, etc.), natural lighting, and human interaction—were defined. The scenes were described from both architectural and contextual perspectives.

Using the architects' sketches compiled from online sources in Figure 1 and the prompts generated by ChatGPT based on real images of the buildings in Table 2, render-style sketches with stronger expressive qualities and direct 3D render images were produced from the initial sketches.

Table 2. Inputs Provided to ChatGPT for Prompt Generation and Prompts Produced by GPT.

Inputs		Outputs
Mary Axe Tower (Foster and partners, 2025b) 	This visual represents Norman Foster's Mary Axe building. Imagine it as a render and write its English prompt.	Create a photorealistic render of a modern skyscraper inspired by Norman Foster's Mary Axe Tower. The building should have a sleek, curved design resembling a bullet or an elongated egg shape, with a facade covered in diamond-patterned glass panels. Surround the skyscraper with a blend of old European-style architecture and contemporary office buildings. Set the scene on a clear, sunny day with a bright blue sky, ensuring detailed reflections on the glass facade to enhance realism and emphasize its unique design.
Alberni Tower (Ikiz, 2023) 	This visual represents Kengo Kuma's Alberni building. Imagine it as a render and write its English prompt.	Create a conceptual 3D render inspired by Kengo Kuma's Alberni building. The design should feature a twisting skyscraper with a shimmering facade composed of staggered panels. Surround it with urban high-rise buildings and incorporate a foreground of greenery under a deep blue sky.
The Hunters Point Library (Warchol, 2024a) 	This visual represents Steven Holl's Hunters Point Library building. Imagine it as a render and write its English prompt.	Create a conceptual 3D render inspired by Steven Holl's Hunters Point Library. The design should feature an open, multi-level interior with wooden bookshelves, large glass walls providing views of an outdoor park, and natural light flooding the space. Include staircases connecting levels and people interacting with the library environment, emphasizing a bright and airy atmosphere.
The Modern Art Museum of Fort Worth (Yusheng, 2022) 	This visual represents Tadao Ando's Modern Art Museum of Fort Worth building. Imagine it as a render and write its English prompt.	Create a conceptual 3D render inspired by Tadao Ando's Modern Art Museum of Fort Worth. The design should feature rectangular pavilions with large glass facades, concrete walls, and Y-shaped columns. The structures should sit above a calm reflecting pool, with a minimalist and serene atmosphere under a clear sky.
Centro Botín (Cano, 2024a) 	This visual represents Renzo Piano's Centro Botin building. Imagine it as a render and write its English prompt.	Create a conceptual 3D render inspired by Renzo Piano's Centro Botin. The design should include two rounded-edge, elevated structures supported by slender columns, with a facade made of large glass panels and textured metallic surfaces. Surround the structures with green open spaces, pedestrian walkways, scattered trees, and a waterfront. Populate the scene with simplified figures to simulate human interaction. Use a partly cloudy sky and ensure natural light highlights key details like glass reflections and metallic textures.
The Walter Gropius House (Hansaviertel Berlin, 2025) 	This visual represents Walter Gropius and other architects' The Walter Gropius House building. Imagine it as a render and write its English prompt.	Create a conceptual 3D render inspired by Walter Gropius's Wills Ebert building. The design should feature a modernist residential structure with curved balconies, clean lines, and large windows. Surround it with a green lawn, trees, and a road in the foreground under a partly cloudy sky.

In Air for SketchUp, the influence of AI was kept more limited for generating sketch-to-render sketches. For all such visualizations, the visualization style was set to Style–Architecture Design–Architecture–Style 01, Keep Material–M (Medium) to maintain the medium level of the given drawing, and Creativity weight=0.3 to limit AI influence. For creating direct 3D renders from the sketches, the AI was allowed to work more freely within the given drawing boundaries. Thus, the visualization style was set to Style–Architecture Design–Architecture–Style 01, Keep Material–L (Low) to maintain a lower level of the original drawing, and Creativity weight=0.8 to allow a higher level of AI influence.

In the Leonardo AI visualizations, Model–Lighting and Style–Sketch settings were used for sketch-to-render sketch generation, while Model–Phoenix and Style–3D Render were chosen for sketch-to-3D render, in order to increase AI influence. Each trial generated four images, and for consistency, the fourth image always was selected. Afterward, the images generated according to the defined prompts were evaluated in terms of realism, coherence, level of detail, visualization quality, and the contribution of AI.

Examining the images produced from Norman Foster's original sketch in Figure 4, the sketch-to-3D render model created by Air for SketchUp with a high creativity value exhibits the greatest realism in terms of lighting, materials, and perspective details.

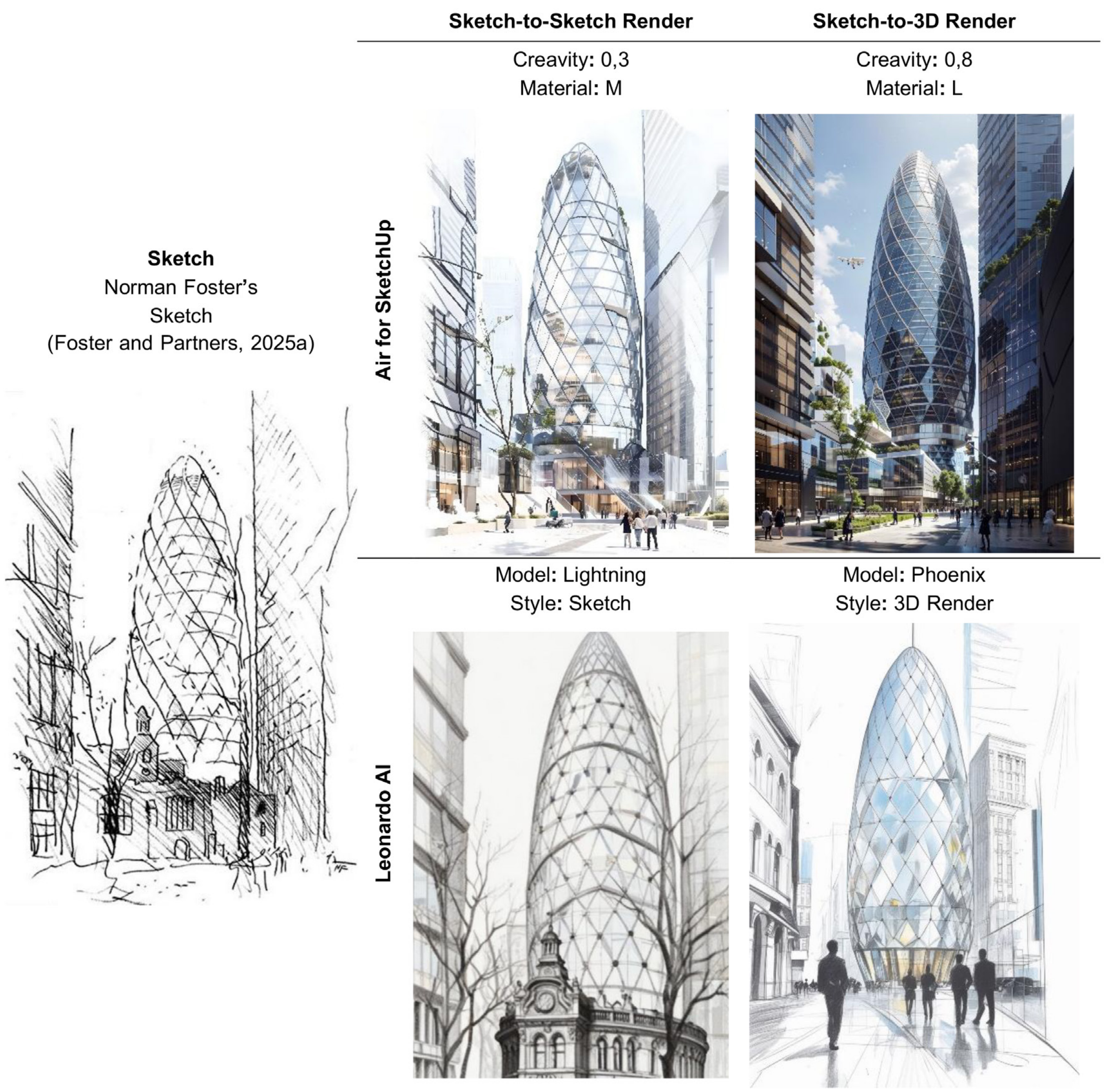


Figure 4. Sketch-to-sketch render and sketch-to-3D render images of 30 St Mary Axe.

In line with the statements in the prompt, the building's texture and its relationship with the surrounding environment were realized, and in terms of visualization quality, this model yielded more successful results compared to Leonardo AI. Regarding detail, all models stood out with different landscape features, material details, and atmospheric effects. In terms of staying faithful to the sketch, Leonardo AI's "Lightning" model preserved the original sketch more than the images created by Air for SketchUp at a 0.3 creativity level, providing a digital sketch-like appearance. As for coherence, while Leonardo AI's models (other than the 3D render) maintained the general form of the building, its 3D render models effectively reflected the contextual and environmental factors. In terms of AI contribution, the sketch-to-render sketch models showed limited AI input aligned with the defined creativity and style data, whereas the sketch-to-3D render images offered more creative and original contributions.

When reviewing the images in Figure 5, generated from Kengo Kuma's Alberni Tower sketch, the sketch-to-3D render images are notable for their high level of detail, realism in lighting and materials, and overall realism.

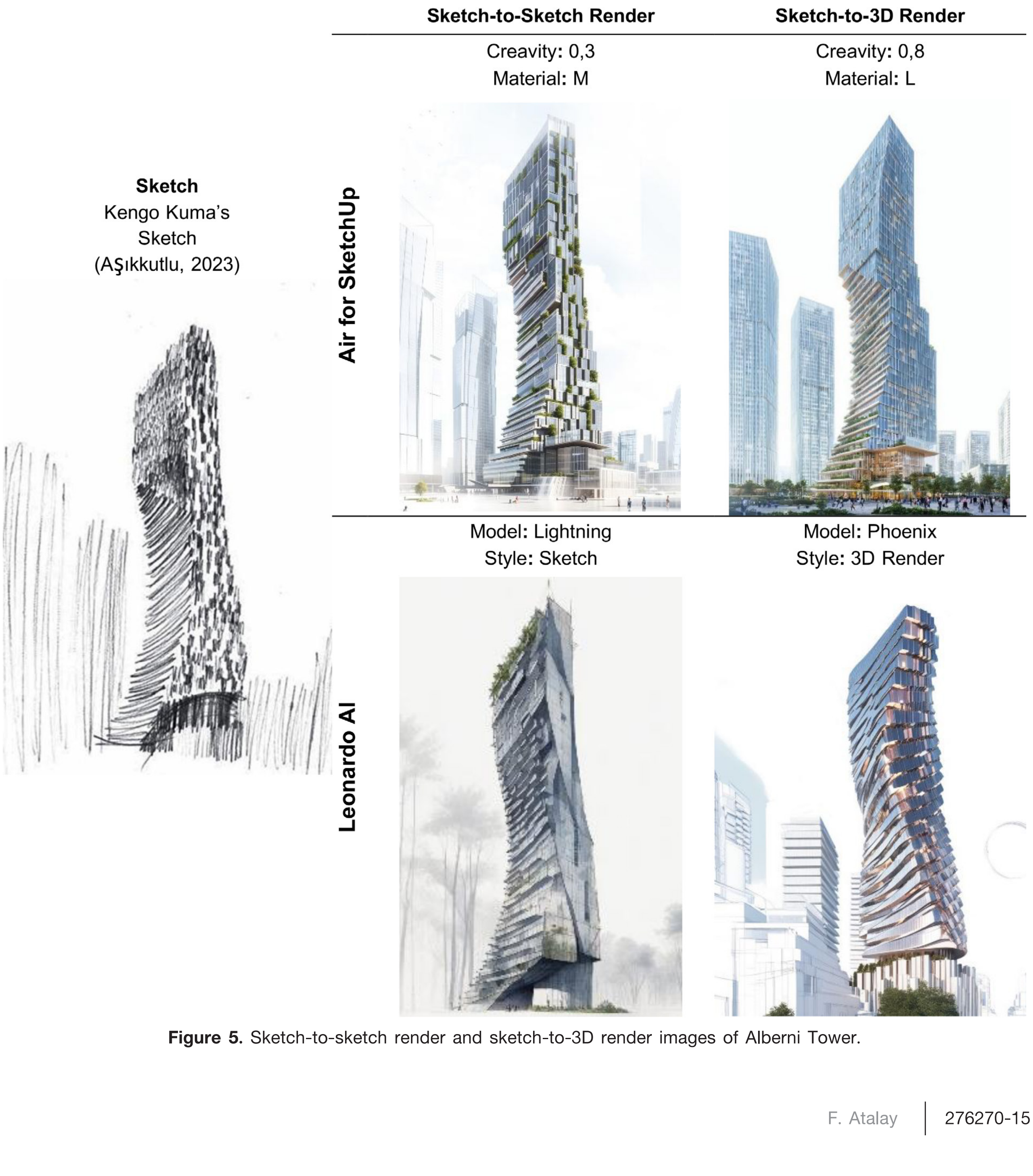


Figure 5. Sketch-to-sketch render and sketch-to-3D render images of Alberni Tower.

Air for SketchUp's 0.8 creativity model more effectively depicts environmental factors and context, making the structure's integration into the urban landscape appear like a genuine render. In terms of detail, this model successfully conveys the building's curved features, textural layers, and landscape integration. As for fidelity to the original sketch, both of Air for SketchUp's models adhere more closely to the abstract linear structure of the original sketch compared to Leonardo AI's models. Regarding visualization quality and coherence, Leonardo AI's "Phoenix" model employs sophisticated processing of material details and lighting effects. Concerning AI contribution, both tools have distinct advantages: Air for SketchUp presents the sketch with more realism and urban integration, while Leonardo AI adopts a more abstract and creative approach.

Examining at the images generated by AI from Steven Holl's sketch in Figure 6, regarding realism, Air for SketchUp's 0.8 creativity model integrates the interior lighting, material textures, user movement, landscape aspects, and architectural elements to merge the environment with a more realistic setting.

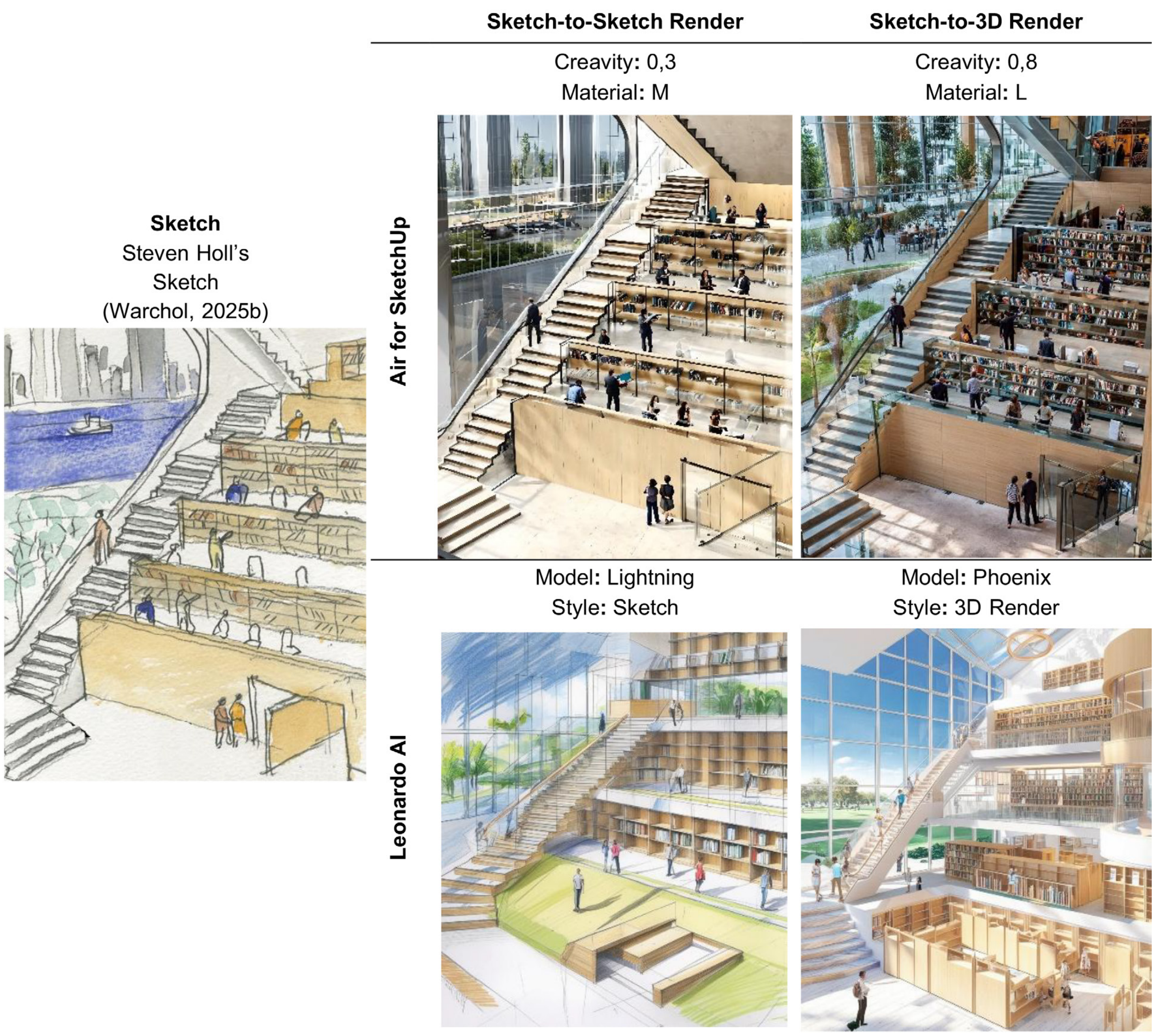


Figure 6. Sketch-to-sketch render and sketch-to-3D render images of The Hunters Point Library

In terms of fidelity to the original sketch, Air for SketchUp's 0.3 creativity model accurately preserves the colored, abstract approach from Steven Holl's original sketch. Leonardo AI's images, however, show a lower performance in preserving the original sketch, exhibiting more changes in visual scenes than expected. In terms of visualization quality and coherence, Air for SketchUp visuals present spatial relationships along with user movement and architectural details to ensure visual consistency. Regarding AI contribution, Leonardo AI goes beyond the details in the sketch to increase the level of creativity, leading to deformation of some architectural elements in the final imagery.

From the images in Figure 7 based on Tadao Ando's original sketch, Air for SketchUp's 3D render with 0.8 creativity value stands out in terms of realism through its use of lighting and materials.

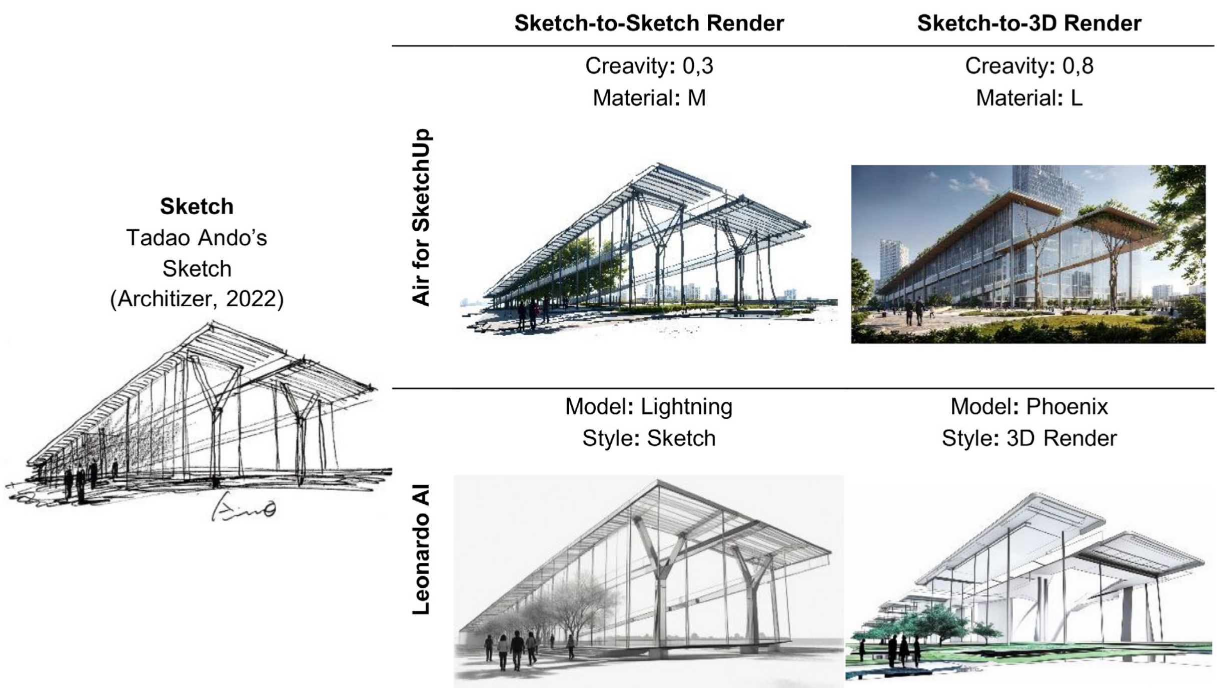


Figure 7. Sketch-to-sketch render and sketch-to-3D render images of The Modern Art Museum of Fort Worth.

In terms of fidelity to the original sketch, Leonardo AI's "Lightning" model better preserves the linear forms and details, reflecting the original design more closely. As for the level of detail, Air for SketchUp's 3D render effectively combines different layers of building materials, shadow effects, and landscape arrangements. It delivers a more coherent image with respect to material and environmental realism. Examining visualization quality, all models demonstrate successful scale and depth perception, though the integration of environmental elements is more prominent with Air for SketchUp. In terms of coherence, both tools' 3D render images reflect the building's relationship with its surroundings to some extent in line with the original sketch, albeit at different levels of sketch preservation. Regarding AI contribution, Air for SketchUp offers a more realistic and integrated approach, whereas Leonardo AI ventures further into experimentation, pushing beyond the boundaries of the original sketch.

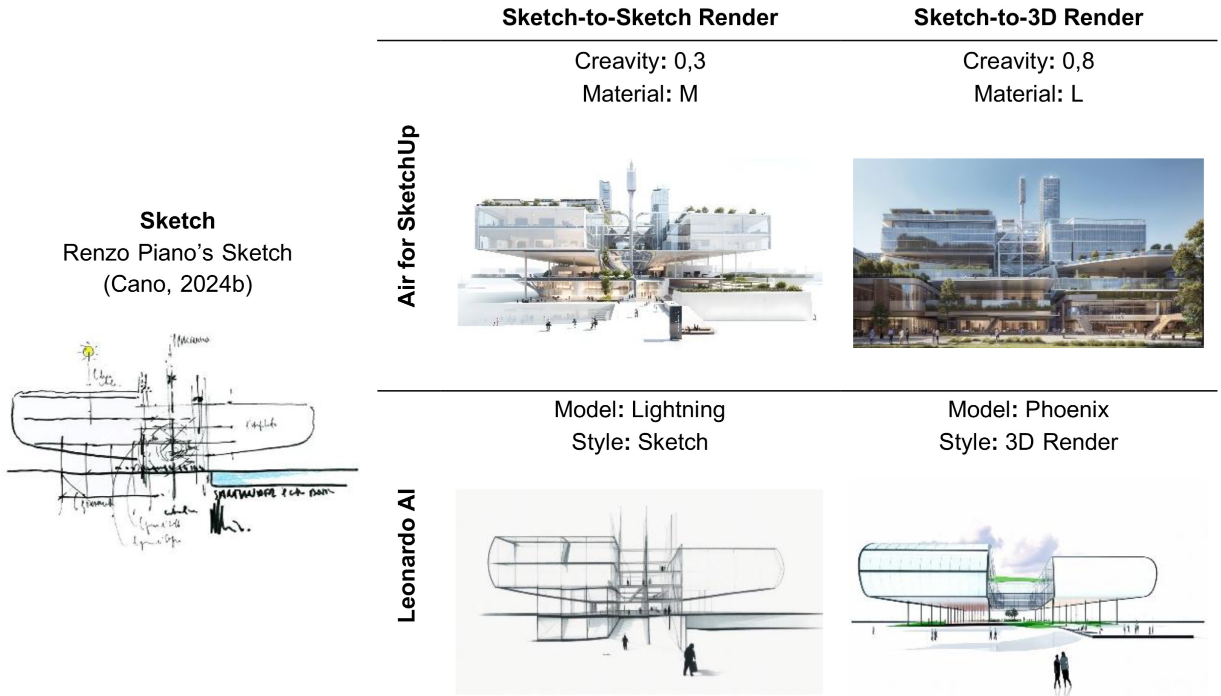


Figure 8. Sketch-to-sketch render and sketch-to-3D render images of Centro Botín.

Evaluating the images in Figure 8, derived from Renzo Piano's original sketch, Air for SketchUp's 3D render adds greater tangibility to the building masses and their surrounding layout, resulting in a scene that harmonizes with the urban fabric. In terms of visualization quality, it strongly conveys spatial depth. In contrast, Leonardo AI's models feature soft transitions and lighter tones, remaining faithful to the conceptual appearance of the building. Regarding fidelity to the sketch, Leonardo AI's adherence to linear and abstract expressions with minimal color and shadow usage preserves the character of the original sketch more effectively. Notably, the 3D render from Air for SketchUp departs more significantly from the lines of the original sketch, reflecting a stronger AI contribution. As for detail, Air for SketchUp models use realistic materials, highlighting the transitions between the building platforms and environmental elements. In terms of coherence, Air for SketchUp models present a more comprehensive approach by linking the building to the surrounding landscape and cityscape, whereas Leonardo AI offers a more minimal backdrop. Regarding AI contribution, Air for SketchUp reinterprets the sketch's abstract forms into a realistic visualization, while Leonardo AI remains closer to the initial linear configuration and retains the sketch's inherent style.

In Figure 9, which shows the images produced by AI from Walter Gropius's sketch, Air for SketchUp's 3D render stands out for its detailed treatment of building facades and site layout, resulting in a higher level of realism.

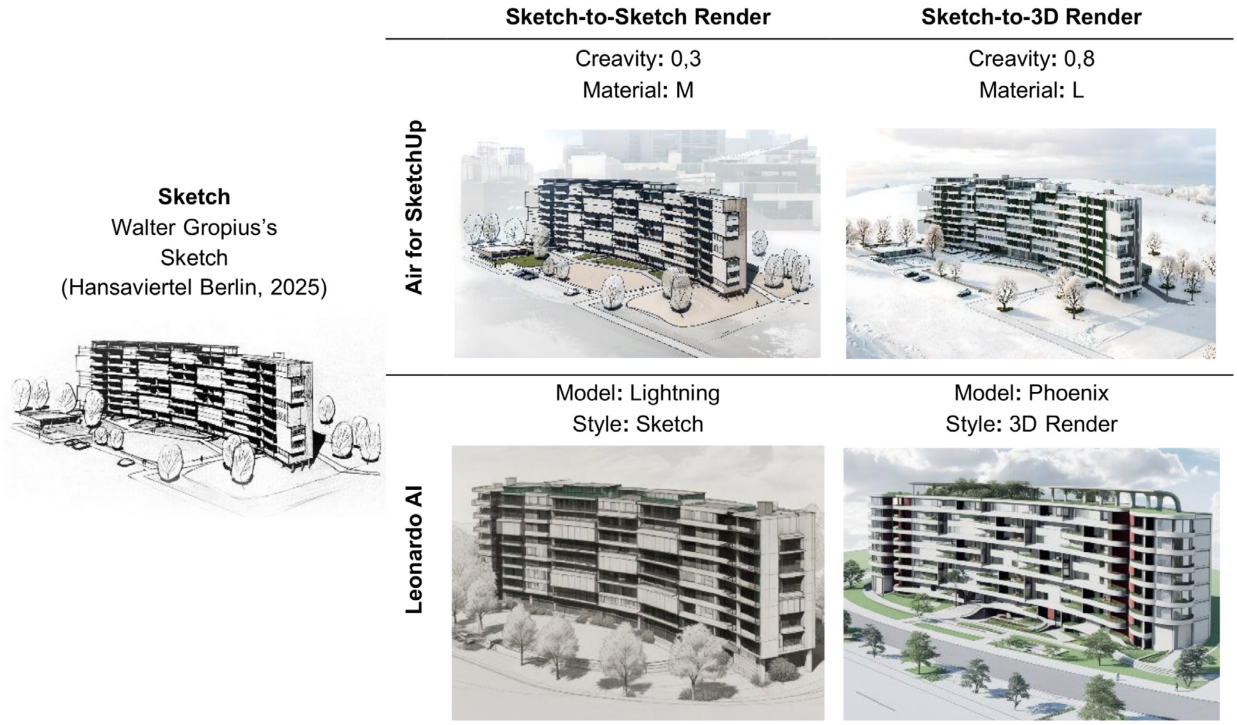


Figure 9. Sketch-to-sketch render and sketch-to-3D render images of The Walter Gropius House.

Regarding the level of detail, this model conveys material and scale elements more convincingly, while Leonardo AI's "Phoenix" model maintains a more minimal use of color and texture. Nevertheless, in terms of fidelity to the sketch, Leonardo AI's "Lightning" model better preserves the layered and modular qualities in the original lines, thus retaining the character of the sketch. Concerning visualization quality, both tools' 3D scenes illustrate the suitability of the building environment to the urban context. However, Air for SketchUp offers more intense use of light and shadow along with perspective work, framing the spatial composition. In terms of AI contribution, while Air for SketchUp transforms the sketch into a more photorealistic image, Leonardo AI focuses on preserving the linear quality of the original sketch.

5. Results and Discussion

In this study, two artificial intelligence tools focused on visual production in architectural design processes—Air for SketchUp and Leonardo AI—were comparatively evaluated. The analyses were conducted based on specific evaluation criteria through the examination of visual outputs. Additionally, the natural language processing-based AI tool ChatGPT was assessed within a complementary framework, in consideration of its text-based outputs.

The evaluations were made according to a visual assessment scale developed by the researcher. The examined criteria were as follows:

- Realism: The extent to which material textures, light-shadow effects, and environmental context in the visual resemble physical reality.
- Adherence to Sketch: The degree to which the image generated by AI remains faithful to the original drawing.
- Detailing: The presence of small-scale architectural elements, surface features, and precision in architectural lines.

- Visualization Quality: The level of technical quality such as resolution, contrast, and sharpness.
- Coherence: The overall structural consistency and internal logical harmony of the visual.
- AI Contribution: The perceived level of creative intervention or depth of automatic generation in the output.

These criteria were rated on a scale of 1 (low) to 5 (high) for each visual, and the results are presented in Table 3, based on the average scores.

Table 3. Comparison of AI Tools According to the Evaluation Criteria.

	Realism	Adherence to the Sketch	Detailing	Visualization Quality	Coherence	AI Contribution
Sketch-to-Sketch Render **Air for SketchUp**	Medium	High	Low	Low	Medium	Medium
Sketch-to-3D Render **Air for SketchUp**	High	Medium	High	High	High	High
Sketch-to-Sketch Render **Leonardo AI**	Low	High	Low	Low	Medium	Low
Sketch-to-3D Render **Leonardo AI**	Medium	Low	Medium	Medium	Medium	High

In the "Sketch-to-Sketch Render" stage, both tools demonstrated success in preserving fidelity to the original sketch. Air for SketchUp achieved a realism score of 3/5 and a fidelity score of 4/5, while Leonardo AI scored 2/5 for realism and also 4/5 for fidelity. This indicates that both tools were able to maintain adherence to the sketch, although Air for SketchUp produced more balanced results in terms of visual quality.

In the "Sketch-to-3D Render" stage, the differences between the tools became more evident. Air for SketchUp stood out with higher scores in detailing (4/5), visualization quality (4/5), and coherence (4/5). However, its fidelity score dropped from 4 to 3 in this stage, suggesting that increased realism partially transformed the original design intent. Leonardo AI, on the other hand, received scores of 3/5 for realism and detailing, and 4/5 for AI contribution, reflecting a more creative yet visually abstract approach.

These findings allow for the following interpretations:

- Air for SketchUp is more successful in producing detailed and realistic 3D outputs in the context of architectural visualization. This can be attributed to its integration with the SketchUp platform (Air for SketchUp, 2024) and its use of GAN and Style Transfer techniques (Cai et al., 2023).
- Leonardo AI stands out for its capacity to generate quick alternatives for designers seeking more experimental and artistic solutions. However, these outputs tend to show weaker ties to architectural context.
- As emphasized in other studies (Yıldırım, 2023; Avinç, 2024), prompt quality and parameter settings directly affect the success of the generated visuals. Both tools yielded better results when guided by the user.
- In this context, as Hanafy (2023) points out, the human factor still plays a decisive role. Human intuition remains critical for integrating aspects such as aesthetic direction, contextual awareness, and functionality into the design process.

- ChatGPT supports these visual production processes through text-based functionality. It can play an important role in generating conceptual explanations, prompt development, user guidelines, project definitions, and technical documentation.

The results of this study reveal that the evaluated tools offer different outputs in terms of realistic visualization, surface detailing, and material application.

6. Conclusion

This study aimed to evaluate the integration potential of artificial intelligence technologies in architectural design processes and to analyze how human–machine collaboration takes shape from the sketch phase through to 3D visualization. Based on applied experiments and visual analyses, the study revealed how tools such as Air for SketchUp, Leonardo AI, and ChatGPT contribute at different stages and functions to the design process.

The key findings of the study can be summarized as follows:

1. In terms of balancing sketch fidelity and visualization quality, both Air for SketchUp and Leonardo AI were able to preserve the characteristic lines of original architectural sketches to some extent. However, as the level of realism and detail increased in the outputs, fidelity to the original sketches tended to decrease. This shows that the models and settings used by AI systems play a decisive role in the final result.
2. Regarding creativity and the generation of alternatives, both tools offered designers new perspectives and enabled the rapid generation of multiple design options. While Air for SketchUp provided a more technical approach for realistic and professional presentations, Leonardo AI produced more experimental and artistic expressions. This difference indicates that the tools can be used in a complementary manner.
3. Concerning the decisive role of the human factor, although AI systems can generate impressive outputs, these are largely dependent on user inputs—such as prompts, settings, and content guidance. Aesthetic sensibility, contextual awareness, and professional experience remain predominantly human competencies.

In light of these findings, the integration of AI tools into architectural design should not be seen merely as a technical innovation, but rather as a strategic shift that supports creative decision-making processes.

In architectural practice, AI tools can be used effectively in the early design phase for rapid idea development, form exploration, material suggestions, and prototyping in client presentations. In educational settings, guided AI usage can help students experiment with various design strategies, thereby enhancing creative diversity. Moreover, AI can redefine not just the design outputs but design itself as an object of inquiry.

The visual evaluations in this study were based on a qualitative scale and a limited sample set. Future research involving a broader panel of evaluators and systematic scaling would be valuable. It also is recommended that evaluation results be supported by quantitative data such as user experience, production time, and computational cost. While there are existing studies on how AI represents various architectural styles (e.g., brutalism, organic architecture), this topic could be further explored using different arguments. Future work also could involve deeper investigation into user-AI interaction and the development of recommendation algorithms tailored to user profiles. Although this study focused on visual production, future research may incorporate performance-oriented criteria such as functionality, spatial flow, and sustainability.

In conclusion, AI tools have demonstrated the ability to address diverse needs in architectural design processes. These tools enhance human–machine collaboration and offer flexibility to users. However, essential elements such as aesthetic sensitivity, intuition, and contextual awareness still rely heavily on the human factor. Therefore, AI should serve as a complementary element in design, integrated through a balanced and hybrid approach that supports creative production.

Author Contributions

Conceptualization, methodology, software, formal analysis, investigation, resources, data curation, writing-original draft, writing-review and editing, visualization, F.A. Author has read and agreed to the published version of the manuscript.

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During the preparation of this work, the author used [Chat GPT] for [text-to-image generation] and [Air for SketchUp and Leonardo AI] for [creating new renders from text and images]. After using these tools, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

References

Aatty, H. M. S., & Al Slik, G. M. R. (2019). Iconic architecture and sustainability as a tool to attract the global attention. *IOP Conference Series: Materials Science and Engineering, 518*(2), 022076. https://doi.org/10.1088/1757-899x/518/2/022076

Air for SketchUp. (2024). *Artistic inspiration render*. https://www.airforsketchup.com/

Architizer (Ed.). (2022, May 4). *Architects' sketchbooks: Tadao Ando*. https://architizer.com/blog/practice/tools/architects-sketchbooks-tadao-ando/

Architectures. (2024). *Architechtures - AI architecture generator: Building design* [Computer software Online]. https://architechtures.com/en

Aksamija, A. (2018). Methods for integrating parametric design with building performance analysis. In K. Wingert-Playdon (Chair), *ARCC-EAAE 2018 International Conference*. https://www.arcc-journal.org/index.php/repository/article/view/459

Annamalai, N., Bervell, B., Mireku, D. O., & Andoh, R. P. K. (2025). Artificial intelligence in higher education: Modelling students' motivation for continuous use of ChatGPT based on a modified self-determination theory. *Computers and Education: Artificial Intelligence, 8*, 100346. https://doi.org/10.1016/j.caeai.2024.100346

Avinç, G. M. (2024). Mimaride biyofilik tasarım için metinden görüntü üretme potansiyeli olan yapay zekâ araçlarının kullanımı. *Black Sea Journal of Engineering and Science, 7*(4), 641-648. https://doi.org/10.34248/bsengineering.1470411

Aşıkkutlu, B. E. (2023, March 6). *Eskiz Defteri 04: Kengo Kuma*. gzt. https://www.gzt.com/infografik/arkitekt/eskiz-defteri-04-kengo-kuma-20687

Banihashemi, S., Ding, G., & Wang, J. (2017). Developing a hybrid model of prediction and classification algorithms for building energy consumption. *Energy Procedia, 110*, 371-376. https://doi.org/10.1016/j.egypro.2017.03.155

Belhadi, A., Djenouri, Y., Belbachir, A. N., Michalak, T., & Srivastava, G. (2024). Shapley visual transformers for image-to-text generation. *Applied Soft Computing, 166*, 112205. https://doi.org/10.1016/j.asoc.2024.112205

Biswas, S. S. (2023). Potential use of Chat GPT in global warming. *Annals of Biomedical Engineering, 51*, 1126-1127. https://doi.org/10.1007/s10439-023-03171-8

Bölek, B., Tutal, O., & Özbaşaran, H. (2023). A systematic review on artificial intelligence applications in architecture. *Journal of Design for Resilience in Architecture and Planning, 4*(1), 91-104. https://doi.org/10.47818/drarch.2023.v4i1085

Cai, Q., Ma, M., Wang, C., & Li, H. (2023). Image neural style transfer: A review. *Computers and Electrical Engineering, 108*, 108723. https://doi.org/10.1016/j.compeleceng.2023.108723

Caliò, F., Lazzari, C., & Marchetti, E. (2021). Roses in architecture: One symbol, different objects. In P. Magnaghi-Delfino, G. Mele & T. Norando (Eds.), *Faces of Geometry* (2nd ed., pp. 59-73). Springer. https://doi.org/10.1007/978-3-030-63702-6_5

Castiglioni, I., Rundo, L., Codari, M., Di Leo, G., Salvatore, C., Interlenghi, M., Gallivanone, F., Cozzi, A., D'Amico, N. C., & Sardanelli, F. (2021). AI applications to medical images: From machine learning to deep learning. *Physica medica European Journal of Medical Physics, 83*, 9-24. https://doi.org/10.1016/j.ejmp.2021.02.006

Chaillou, S. (2020). *Archigan: Artificial intelligence x architecture. In P. F. Yuan, M. Xie, N. Leach, J. Yao & X. Wang (Eds.), Architectural intelligence: Selected papers from the 1st international conference on computational design and robotic fabrication (CDRF 2019)* (pp. 117-127). Springer. https://doi.org/10.1007/978-981-15-6568-7_8

CompVis, Stability AI & Runway. (2024). *Stable Diffusion* (3.5 version) [Large language model]. https://github.com/CompVis/stable-diffusion

Cano, E. (2024a, Julu 5). *Centro Botín / Renzo Piano building workshop + luis vidal + arquitectos.* [Photograph]. Archdaily. https://www.archdaily.com/875209/centro-botin-renzo-piano-building-workshop

Cano, E. (2024b, Julu 5). *Centro Botín / Renzo Piano building workshop + luis vidal + arquitectos 22/22*. [Photograph]. Archdaily. https://www.archdaily.com/875209/centro-botin-renzo-piano-building-workshop/595d1777b22e38d88b000039-centro-botin-renzo-piano-building-workshop-sketch?next_project=no

Davarpanah, S. (2012). *A query on the impact of place on the formation of iconic buildings in architecture* (Master's thesis, Eastern Mediterranean University). http://hdl.handle.net/11129/59

DeepAI.org. (2024). DeepAI (December 1 version) [Large language model]. https://deepai.org/publication/image-captioning

Disco Diffusion. (2024). *Disco Diffusion* [Computer software Online]. https://github.com/alembics/disco-diffusion

Elhagla, K., Nassar, D. M., & Ragheb, M. A. (2020). Iconic buildings' contribution toward urbanism. *Alexandria Engineering Journal, 59*(2), 803-813. https://doi.org/10.1016/j.aej.2020.01.020

Enjellina, Beyan, E. V. P., & Rossy, A. G. C. (2023). A Review of AI image generator: Influences, challenges, and future prospects for architectural field. *Journal of Artificial Intelligence in Architecture, 2*(1), 53-65. https://doi.org/10.24002/jarina.v2i1.6662

Foroughi, B., Senali, M. G., Iranmanesh, M., Khanfar, A., Ghobakhloo, M., Annamalai, N., & Naghmeh-Abbaspour, B. (2024). Determinants of intention to use ChatGPT for educational purposes: Findings from PLS-SEM and fsQCA. *International Journal of Human–Computer Interaction, 40*(17), 4501-4520. https://doi.org/10.1080/10447318.2023.2226495

Foster and Partners. (2025b). *30 St Mary Axe: 2004-London, UK* [Photograph]. https://www.fosterandpartners.com/projects/30-st-mary-axe

Foster and Partners. (2025a). *30 St Mary Axe Tower/Foster + Partners: sketch 33/35* [Photograph]. Archdaily. https://www.archdaily.com/928285/30-st-mary-axe-tower-foster-plus-partners/5dcac3a13312fd0ac9000033-30-st-mary-axe-tower-foster-plus-partners-sketch

Google LLC. (2024). *Google Cloud Vision API* [Computer software Online]. https://cloud.google.com/vision

Hanafy, N. O. (2023). Artificial intelligence's effects on design process creativity: "A study on used AI text-to-image in architecture". *Journal of Building Engineering, 80*, 107999. https://doi.org/10.1016/j.jobe.2023.107999

Hansaviertel Berlin. (2025). 24 Händelallee 3–9 W. Gropius – TAC, W. Ebert. https://hansaviertel.berlin/en/bauwerke/haendelallee-3-9-w-gropius-tac-w-ebert/

Holzer, D. (2015). BIM and parametric design in academia and practice: The changing context of knowledge acquisition and application in the digital age. *International Journal of Architectural Computing, 13*(1), 65-82. https://doi.org/10.1260/1478-0771.13.1.65

Imagen. (2024). *Imagen* [Computer software Online]. https://imagen-ai.com/

Ikiz, S. U.PA (2023, June 23). *Kengo Kuma-designed Alberni Tower features impressive sculptural symmetr*y. https://parametric-architecture.com/kengo-kuma-designed-alberni-tower-features-impressive-sculptural-symmetry/

Jie, P., Shan, X., & Chung, J. (2023). A comparative analysis between< Leonardo. Ai> and< Meshy> as AI texture generation tools. *International Journal of Advanced Culture Technology, 11*(4), 333-339. https://doi.org/10.17703/IJACT.2023.11.4.333

Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günneman, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., ... Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences, 103*, 102274. https://doi.org/10.1016/j.lindif.2023.102274

Kim, H., & Clayton, M. J. (2020). A multi-objective optimization approach for climate-adaptive building envelope design using parametric behavior maps. *Building and Environment, 185*, 107292. https://doi.org/10.1016/j.buildenv.2020.107292

Kohnke, L. (2022). A qualitative exploration of student perspectives of chatbot use during emergency remote teaching. *International Journal of Mobile Learning and Organisation, 16*(4), 475–488. https://doi.org/10.1504/IJMLO.2022.125966

Krohn, C. (2019). *Walter gropius: Buildings and projects*. Birkhäuser.

Leach, N., & Yuan, P. F. (2020). Introduction. In P. F. Yuan, M. Xie, N. Leach, J. Yao & X. Wang (Eds.), *Architectural intelligence: Selected papers from the 1st International conference on computational design and robotic fabrication (CDRF 2019)* (pp. 3-11). Springer. https://doi.org/10.1007/978-981-15-6568-7_1

Lehmann, S. (2024). Reimaging the library of the future: From social condenser and community hub to regenerative design. *Public Library Quarterly, 43*(2), 223-259. https://doi.org/10.1080/01616846.2023.2242626

Leonardo Interactive Pty Ltd. (2024). *Leonardo AI* (November 16 version) [Large language model]. https://leonardo.ai/

Liu, V., & Chilton, L. B. (2022). Design guidelines for prompt engineering text-to-image generative models. In S. Barbosa, C. Lampe & C. Appert (Eds.), *CHI'22: Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (Article no.384, pp. 1-23). https://doi.org/10.1145/3491102.3501825

Liu, V., Vermeulen, J., Fitzmaurice, G., & Matejka, J. (2023). 3DALL-E: Integrating text-to-image AI in 3D design workflows. In D. Byrne, N. Martelaro, A. Boucher, D. Chatting, S. F. Alaoui, S. Fox, I. Nicenboim & C. MacArthur (Eds.), *DIS'23: Proceedings of the 2023 ACM Designing Interactive Systems Conference* (pp. 1955-1977). https://doi.org/10.1145/3563657.3596098

Lyu, Y., Wang, X., Lin, R., & Wu, J. (2022). Communication in human–AI co-creation: Perceptual analysis of paintings generated by text-to-image system. *Applied Sciences, 12*(22), 11312. https://doi.org/10.3390/app122211312

MacCarthy, F. (2019). *Walter Gropius: Visionary founder of the Bauhau*s. Faber & Faber.

Magnific. (2024). *Magnific AI* [Computer software Online]. https://magnific.ai/

Miao, L., & Yang, F. X. (2023). Text-to-image AI tools and tourism experiences. *Annals of Tourism Research, 102*, 103642. https://doi.org/10.1016/j.annals.2023.103642

Midjourney, Inc. (2024). *Midjourney* [Computer software Online]. https://www.midjourney.com/home

Nandhini Abirami, R., Durai Raj Vincent, P. M., Srinivasan, K., Tariq, U., & Chang, C. Y. (2021). Deep CNN and Deep GAN in computational visual perception-driven image analysis. *Complexity, 2021*(1), 5541134. https://doi.org/10.1155/2021/5541134

Núñez-Morales, J. D., Jung, Y., & Golparvar-Fard, M. (2024). Bi-directional image-to-text mapping for NLP-Based schedule generation and computer vision progress monitoring. In J. S. Shane, K. M. Madson, Y. Mo, C. Poleacovschi & R. E. Sturgill, Jr (Eds.), *Construction research congress 2024: Advanced technologies, automation, and computer applications in construction* (pp. 826-835). https://doi.org/10.1061/9780784485262.084

Open AI. (2024c). *GitHub* (December 1 version) [Large language model]. https://github.com/openai/CLIP

Özel, G. (2020). Interdisciplinary AI: A machine learning system for streamlining external aesthetic and cultural influences in architecture. In P. F. Yuan, M. Xie, N. Leach, J. Yao & X. Wang (Eds.), *Architectural intelligence: Selected Papers from the 1st International Conference on Computational Design and Robotic Fabrication (CDRF 2019)* (pp. 103-116). Springer. https://doi.org/10.1007/978-981-15-6568-7_7

OpenAI. (2024a). *CahtGPT* (December 17 version) [Large language model]. https://chatgpt.com/

OpenAI. (2024b). *DALL-E* (December 13 Version) [Large language model]. https://openai.com/index/dall-e-2/

Pena, M. L. C., Carballal, A., Rodríguez-Fernández, N., Santos, I., & Romero, J. (2021). Artificial intelligence applied to conceptual design: A review of its use in architecture. *Automation in Construction, 12*4, 103550. https://doi.org/10.1016/j.autcon.2021.103550

Piano, R., & Vidal, L. (2015). Centro Botín, en Santander. Un proyecto en tres movimientos [Centro Botín, in Santander. A project in three movements]. *Cercha: Revista de la Arquitectura Técnica, 126*, 16-26. http://hdl.handle.net/20.500.12251/529

Rian, I. M., & Asayama, S. (2016). Computational design of a nature-inspired architectural structure using the concepts of self-similar and random fractals. *Automation in Construction, 66*, 43-58. https://doi.org/10.1016/j.autcon.2016.03.010

Sartori, T., Drogemuller, R., Omrani, S., & Lamari, F. (2021). A schematic framework for life cycle assessment (LCA) and green building rating system (GBRS). *Journal of Building Engineering, 38*, 102180. https://doi.org/10.1016/j.jobe.2021.102180

Serednicki, A. (2024). Here's a Twist: In Vancouver's sea of steely, boxy skyscrapers, the Alberni tower leans into the greatness of the outdoors. *Maclean's, 136*(11), 26-26. link.gale.com/apps/doc/A779055107/AONE?u=anon~63856626&sid=googleScholar&xid=73454301

Sherzad, M., Arar, M., & Jung, C. (2022). Analyzing the architectural characteristics of Tadao Ando's museum projects. *International Journal of Advanced Research in Engineering Innovation, 4*(3), 1-17. https://doi.org/10.55057/ijarei.2022.4.3.1

Soddu, C. (2020). *Generative city design aleatority and urban species, unique, unrepeatable and recognizable identity, like in nature*. Domus Argenia.

Tamke, M., Nicholas, P., & Zwierzycki, M. (2018). Machine learning for architectural design: Practices and infrastructure. *International Journal of Architectural Computing, 16*(2), 123-143. https://doi.org/10.1177/1478077118778580

Tian, Y., Liu, A., Dai, Y., Nagato, K., & Nakao, M. (2024). Systematic synthesis of design prompts for large language models in conceptual design. *CIRP Annals, 73*(1), 85-88. https://doi.org/10.1016/j.cirp.2024.04.062

Ulug, E. (2022). An investigation into the connotations of iconic buildings by using a semiotic model of architecture. *Social Semiotics, 32*(2), 279-300. https://doi.org/10.1080/10350330.2020.1756590

Warchol, P. (2024a, November 3). *Hunters Point Library / Steven Holl architects: Courtesy of Steven Holl architects 4/29.* [Photograph]. Archdaily. https://www.archdaily.com/925389/hunters-point-library-steven-holl-architects/5d8a6080284dd1676d0000c3-hunters-point-library-steven-holl-architects-image

Warchol, P. (2024b, November 3). *Hunters Point Library / Steven Holl architects: Courtesy of Steven Holl architects 26/29.* [Photograph]. Archdaily. https://www.archdaily.com/925389/hunters-point-library-steven-holl-architects/5d8a6339284dd1676d0000cf-hunters-point-library-steven-holl-architects-image?next_project=no

Yeh, I.-C. (2006). Architectural layout optimization using annealed neural network. *Automation in Construction, 15*(4), 531-539. https://doi.org/10.1016/j.autcon.2005.07.002

Yildirim, E. (2023). Comparative analysis of Leonardo AI, Midjourney, and DALL-E: AI's perspective on future cities. *Urbanizm: Journal of Urban Planning and Sustainable Development, 28*, 82-96. https://doi.org/10.58225/urbanizm.2023-28-82-96

You, H., Zhou, L., Xiao, B., Codella, N., Cheng, Y., Xu, R., .Chang, S.-F., & Yuan, L. (2022). Learning visual representation from modality-shared contrastive language-image pre-training. In S. Avidan, G. Brostow, M. Cissé, G. M. Farinella, T. Hassner (Eds.), *Computer Vision – ECCV 2022: 17th European Conference, Tel Aviv, Israel, October 23–27, 2022, Proceedings, Part XXVII* (pp. 69-87). Springer. https://doi.org/10.1007/978-3-031-19812-0_5

Yusheng, L. (2022, December 22). *Flashback: Modern Art Museum of Fort Worth / Tadao Ando Architect & Associates 6/19.* [Photograph]. Archdaily. https://www.archdaily.com/213084/flashback-modern-art-museum-of-fort-worth-tadao-ando/503827bd28ba0d599b001142-flashback-modern-art-museum-of-fort-worth-tadao-ando-photo?next_project=no

Wen, W., Hong, L., & Xueqiang, M. (2010). Application of fractals in architectural shape design. In *2010 IEEE 2nd Symposium on Web Society* (pp. 185-190). IEEE. https://doi.org/10.1109/sws.2010.5607455

Zamparini, A., Gualtieri, G., & Lurati, F. (2023). Iconic buildings in the making of city identity: The role of aspirational identity artefacts. *Urban Studies, 60*(12), 2474-2495. https://doi.org/10.1177/00420980221144157

Zhang, S. (2025). 3D modeling in the art of photographic expansion. *The Imaging Science Journal, 73*(5), 527-542. https://doi.org/10.1080/13682199.2024.2430870