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Reproduction of Nature-Inspired Architectural Forms through Artificial Intelligence

*[1] **Gül Şebnem Tutal** , [2] **Fatma Demet Aykal**

[1]*Department of Architecture, Graduate School of Natural and Applied Science, Dicle University, Turkey*

[2] *Department of Architecture, Faculty Of Architecture, Dicle University, Turkey*

[1] E-mail: sebnemtutal@gmail.com, [2] E-mail: demetaykal@gmail.com

[1] **ORCID**: https://orcid.org/0000-0002-1871-287X, [2] **ORCID**: https://orcid.org/0000-0003-2424-0407

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ABSTRACT

This study aims to evaluate the effectiveness of AI-based visualization tools in reinterpreting biomimetic architectural designs. To this end, three iconic nature-inspired buildings—Eastgate Building, Clyde Auditorium, and the Bahá'í Temple—were selected. For each, visual representations were generated using different AI models: DALL-E, DeepAI, and Midjourney. These AI-generated visuals were compared with the original structures based on architectural criteria, including form similarity, structural feasibility, scale and proportion, environmental integration, and SSIM (Structural Similarity Index Measure) scores.The findings demonstrate that while AI models can interpret and reproduce formal diversity inspired by nature, their architectural realism, scale coherence, and environmental responsiveness vary considerably. Midjourney stood out for its integration with landscape, DALL-E achieved the highest visual similarity scores, and DeepAI produced simplified forms with limited detailing. Overall, AI-generated biomimetic designs show promise in conceptual design phases, but to enhance practical applicability, more integrated approaches with engineering systems are needed.

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* Corresponding Author

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1. Introduction

In recent years, increasing environmental problems, the rapid depletion of natural resources, and the negative effects of urbanization on ecosystems have made it necessary to seek more nature-friendly, innovative, and sustainable designs in the field of architecture. Designing buildings inspired by nature has emerged as a key strategy in this pursuit (Chayaamor-Heil & Hannachi-Belkadi, 2017). In this context, biomimicry principles enable the design of energy-efficient, aesthetic, and environmentally compatible structures by modeling the structural and functional solutions developed by nature over millions of years of evolution (Pawlyn, 2019). Implementing biomimicry-based architectural designs with traditional methods requires complex calculations and modeling processes. However, in recent years, the development of artificial intelligence technologies has made it possible to produce these designs in in a more systematic, faster, and more creative way. Artificial intelligence (AI) is a field of technology that involves the development of systems that mimic cognitive functions such as learning, problem solving, and decision making. With sub-disciplines such as deep learning and machine learning, AI is bringing innovation to many fields, from engineering to design (Russell, 2016; Tiwari et al., 2018). While machine learning offers an approach focused on making predictions that are accurate enough to be useful rather than perfect, deep learning provides flexible and powerful solutions by representing concepts in a layered structure.

In the fields of architecture and engineering, artificial intelligence is used as a powerful tool to accelerate design processes, provide optimization, and increase energy efficiency. In particular, "text-to-image" technologies enable the rapid and effective visualization of design ideas, thereby supporting the creative process (Sukkar et al., 2024). Thanks to these technologies, architectural designs can be evaluated not only in terms of general form production but also fundamental design criteria such as form similarity, structural suitability, measurement and proportion relationships, and environmental compatibility. However, some studies have shown that artificial intelligence is insufficient in traditional architectural details and limited in reflecting local identity (Maganga, 2023). For this reason, biomimicry-based architectural approaches, which offer a more limited and defined design area, were selected in this study. AI-supported visualization methods are important for demonstrating the applicability of these approaches and observing their contribution to architectural design.

However, nature-inspired architectural approaches should not be evaluated solely based on formal similarity. According to the biophilic design approach, the connection with nature means establishing a sensory and experiential relationship with elements such as light, air, water, plants, materials, orientation, and natural landscapes (Aykal & Erbaş Özil, 2021). Therefore, in this study, which evaluates the productions of artificial intelligence models, not only visual similarity but also the transferability of natural experience is indirectly questioned. This framework reveals the need to evaluate the contribution of AI productions to architectural design not only in terms of aesthetics but also in terms of environmental and user-oriented integrity.

Text-to-image generative artificial intelligence models have become an important tool in architectural visualization processes in recent years. Among these models, DALL-E, DeepAI, and Midjourney produce architectural images in different styles based on textual inputs from the user. Deep AI generally refers to a family of generative models based on Generative Adversarial Networks (GANs) designed to produce visuals from text inputs. The primary objective of this model is to create images corresponding to textual descriptions from comprehensive datasets containing text-image pairs. Convolutional and recurrent neural networks are commonly used to process text and generate corresponding visuals (Bansal et al., 2024). DeepAI, which can generate original, high-resolution images based on user-written prompts, stands out as an important tool, especially for artists, designers, and digital content creators. Thanks to its AI-powered algorithms, it can generate images in different styles, such as realistic, abstract, futuristic, or cartoonish, and accelerate users' creative processes. DeepAI can also perform image editing tasks such as modifying, adding, or removing specific parts of existing images, creating alternative versions to enhance visual diversity. While architectural approaches may vary, the fundamental goal is to transform prompts into meaningful and structured visuals.

Founded in April 2022 by a San Francisco-based company, Midjourney-AI began shaping global trends in AI-powered art shortly after its inception, paving the way for experimental work in various fields such as graphics, art, sculpture, and architecture (Maganga, 2023). MidJourney-AI operates based on a "text to image" system. The model focuses on computational efficiency, so it typically produces stylized or abstract interpretations. This approach enables faster visual production with fewer resources, allowing creative ideas to be brought to life quickly. However, in exchange for this speed and efficiency, difficulties may arise in the detailed processing of complex scenes and the creation of realistic visuals (Bansal et al., 2024).

This study aims to evaluate the reproduction of nature-inspired architectural forms using AI-supported tools in the context of formal and structural integrity. In particular, structures developed in line with biomimicry principles were compared with their visual representations created by generative artificial intelligence models such as DALL-E, DeepAI, and Midjourney; an analysis was conducted based on criteria such as form similarity, structural suitability, measurement and proportion relationships, and environmental harmony, which are the basic components of architectural design. This comparison process not only determines the level of visual similarity but also initiates a critical evaluation of the functionality, creative potential, and limitations of generative AI tools in the architectural design process in terms of physical applicability. Therefore, this study aims to question the relationship between biomimicry-based production in architecture and artificial intelligence, as well as the possible contributions of this relationship to sustainable design, on both conceptual and technical levels. Below, the methodological approach followed, the models used, and the evaluation criteria are presented in detail.

2. Method

In this study, biomimetic structures were re-visualized through generative artificial intelligence models and evaluated in comparison with constructed real structures. The research method was structured within the framework of a systematic comparison approach based on architectural criteria. The evaluation process was supported by numerical data. The study method was designed in six stages (Figure 1).

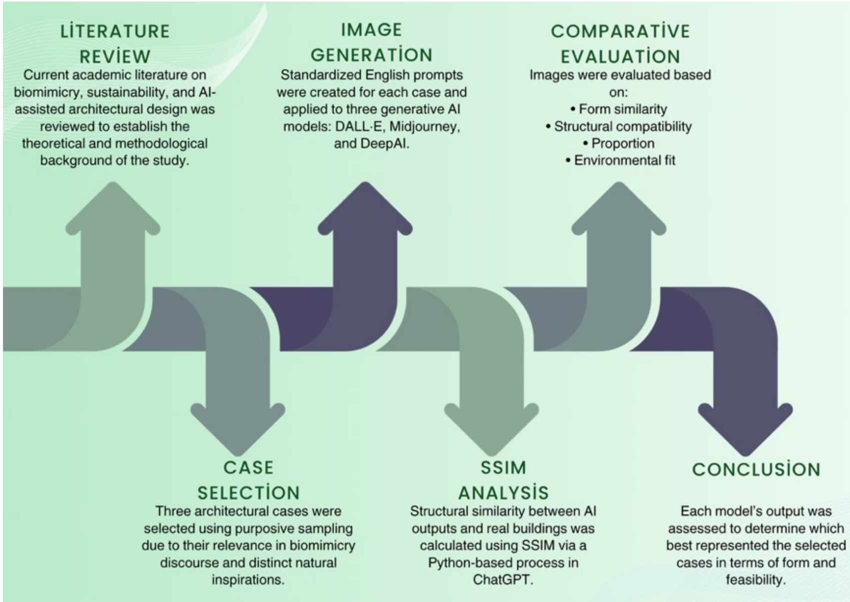

Figure 1. Study method diagram (Created and by the author).

A purposive sampling method was used to select the sample.Three structures that were designed based on biomimicry principles, prominent in the literature, and formally unique were selected. The Eastgate Center, Clyde Auditorium, and Bahai Temple were selected based on their forms of inspiration from nature and the different morphological approaches they represent. The three structures were visualized using DALL-E, Midjourney, and DeepAI generative artificial intelligence models. Prompts were written in English with the same content for all models. These prompts were designed by considering each structure's unique biological inspiration source, architectural formal characteristics, functional sustainability elements, and environmental context. This approach aimed to ensure the content consistency of the visuals. Each model produced a different number of visuals according to its own algorithm. DeepAI produced a single visual. DALL-E produced two visuals. Midjourney produced four visuals. The number of visuals was not determined by the user but was determined by each system's own generation algorithm. In the comparative analysis, only the first image produced by each model was evaluated. This choice was made to avoid subjectivity based on aesthetic preferences and to objectively compare the production tendencies of the models based on their initial response reflexes. The generated images were analyzed based on criteria such as form similarity, structural suitability, measurement and proportion relationships, and environmental compatibility, which are fundamental components of architectural design. The comparison process also opens up a discussion on the functionality of generative artificial intelligence tools in the architectural design process, their creative potential, and their limitations in terms of physical applicability. The images generated by artificial intelligence were analyzed comparatively according to the defined criteria. These criteria are, in order, form similarity (morphological integrity, symmetry, organic structure), structural suitability (traceability of the load-bearing system, compliance with engineering limits), measurement and proportion (connectivity with human scale, mass balance), and environmental harmony (integration with the landscape and relationship with the topography). The SSIM (Structural Similarity Index) method was used to support the qualitative evaluation process numerically. The need to evaluate images not only at the pixel level but also based on structural integrity has become an important agenda item, particularly in the analysis of generative artificial intelligence outputs

In this context, the Structural Similarity Index (SSIM) provides a measurement approach that is close to human visual perception, quantitatively revealing the similarity of the compared images in terms of brightness, contrast, and structural components (Bakurov et al., 2022). SSIM compares the structural integrity, contrast, and brightness between two images and produces a score between 0 and 1. The closer the score is to 1, the greater the similarity. In this study, structural similarity analyses between images were performed using a Python-based computing infrastructure through the ChatGPT generative artificial intelligence model developed by OpenAI. Each model output was directly compared to the corresponding original structure image. Zhang et al. (2025) noted that SSIM is an effective criterion for determining content accuracy in style transfer-based image generation. Xia (2025) found that SSIM scores in architectural representations largely corresponded with expert opinions. In this context, SSIM analysis was used not only to quantify visual similarity but also as a supporting criterion to enhance the reliability of qualitative analyses.

3. Biomimicry-Based Design

Biomimicry is an approach that refers to design processes inspired by nature. This approach is gaining increasing importance in sustainable architecture. Benyus (1997) defines biomimicry as the process of adapting solutions developed by nature over millions of years of evolution to the fields of technology, engineering, and architecture. In this context, it is stated that the understanding of sustainable architecture has developed through a process of learning from nature.

Biomimicry in architecture includes approaches such as examining methods and systems found in nature and adapting them to modern architecture, designing self-repairing buildings, and increasing efficiency in climate control processes by drawing inspiration from living organisms (Pawlyn, 2019). Sustainability, on the other hand, is an approach that aims for balanced development in ecological, economic, and social dimensions and is based on the conservation of natural resources (Kaya and Taylan Susan, 2020). In sustainable architecture, the goal is to develop architectural designs that save energy, minimize waste, and use environmentally friendly materials. At this point, biomimicry and sustainability exhibit similar characteristics.

In ecosystem-based design, the goal is to increase the ecological compatibility of architectural designs by modeling the functioning of natural ecosystems. Designs developed by drawing inspiration from forest ecosystems, in particular, are effective in ensuring the integration of buildings with the natural environment (Oğurlu & Uç, 2024). Furthermore, research on biomimicry and ecomimicry approaches in ecological architectural design reveals the positive effects of nature-inspired designs on sustainability (Uç, 2023). In this design approach, energy-efficient systems found in nature are imitated to reduce the energy consumption of buildings and achieve sustainability goals. As a result, the environmental footprint of buildings is reduced, and a contribution is made to ecological balance. One example of a design inspired by nature and showcasing the advantages of biomimicry is the Eastgate Building. Designed by architect Mick Pearce and completed in 1996, the Eastgate Building's design was inspired by the natural ventilation and heat balancing systems of termite mounds (Figure 2).

Figure 2. (a) Termite Mound, (b) Eastgate Center (Chayaamor-Heil & Vitalis, 2021). (Labeled by the author).

Ant nests consist of holes that provide advanced airflow to maintain a constant indoor temperature. In this structure, warm air rises and escapes during the day, while cool air is drawn in from the bottom. The natural circulation system ensures a constant, balanced airflow inside the building. The Eastgate Building has significantly reduced the need for traditional HVAC (Heating, Ventilation, and Air Conditioning) systems, lowering energy consumption by up to 90% (Makram & Abou Ouf, 2019). Passive ventilation and natural cooling systems were used in the building, thereby reducing costs and ensuring environmental sustainability. This structure demonstrates how effective biomimicry can be in sustainable architecture.

One of the most important examples of this is the Clyde Auditorium (SEC Armadillo), designed by Norman Foster's architecture firm Foster + Partners in 1997. The design was inspired by the armadillo (Figure 3).

Figure 3. (a) Armadillo (b) SEC Armadillo (Labeled by the author).

The layered form of the structure resembles the armadillo's armor-like protective outer shell. This layered design gives the structure a dynamic rhythm while also providing structural integrity. Clyde Auditorium is a structure directly inspired by nature, representing the harmony between form and function.

Another biomimicry-based design is the Bahai Temple, designed by Iranian architect Fariborz Sahba in 1986, inspired by the lotus flower (Figure 4).

Figure 4. (a) Lotus Flower (b) Bahai Temple (Labeled by the author).

The lotus flower, a symbol of purity, peace, and spirituality, adds a powerful aesthetic value to architecture. The exterior of the building consists of nine wings resembling the petals of an open lotus flower. The Bahai Temple has become an iconic symbol as a structure that reflects the geometric and symmetrical order of nature. The projects examined are concrete examples of the biomimicry approach, which transfers the relationship between form and function in nature to the structure. Biomimicry, as in the examples discussed, offers a dynamic design language that brings together form, function, and structure in architecture. It is believed that such designs could form the basis for more sustainable and innovative architectural projects in the future, and AI-supported visualizations have been created based on this idea.

4. Findings

In this section, the Eastgate Building, Clyde Auditorium, and Bahai Temple, whose information was provided in previous sections, were compared with models developed by AI. To ensure consistency in the comparison, the same prompt was written for all models.

The Eastgate Building was constructed inspired by termite mounds. The prompt in the study was also written in this direction.

Prompt: *A biomimetic corporate headquarters inspired by termite mounds, featuring a curvilinear, honeycomb-like structure with natural ventilation shafts. The building incorporates rainwater harvesting and self-cooling mechanisms, promoting sustainable urban development. Drone shot, warm sunlight reflections, futuristic architecture, high-tech materials, immersive composition --ar 16:9 --v 6.0*

The visualizations created based on this are shown below (Figure 5).

Figure 5. Eastgate Building and Visualizations.

The visual similarity level between the artificial intelligence productions of the Eastgate Building and the original structure was analyzed using the SSIM (Structural Similarity Index Measure) method. In the difference maps below, light tones indicate high similarity, while dark tones indicate visual differences (Figure 6).

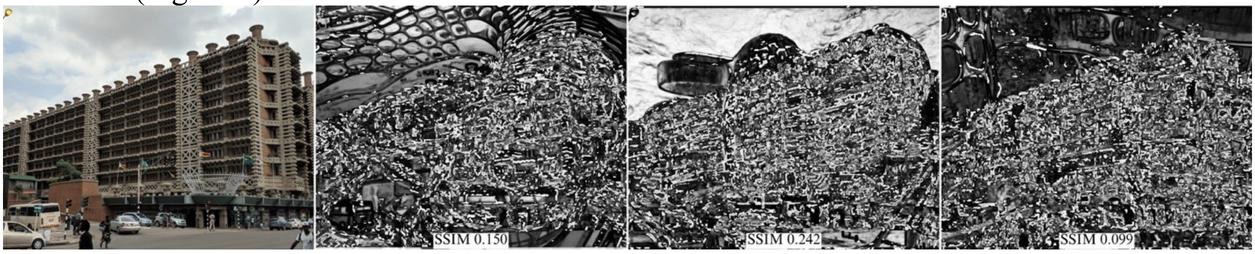

Figure 6. Eastgate Building and AI-Based Visualizations and SSIM Difference Maps.

The difference maps shown above support the architectural evaluation table below with numerical data.

The evaluation of the images produced for the Eastgate Building example is shown in Table 1.

Table 1: Architectural Evaluation of Eastgate Building Visualizations Generated by AI.

	Form Similarity	Structural Feasibility	Scale and Proportion	Environmental Integration	SSIM
DeepAI	The concept of the form is grasped, but interpreted quite freely.	Complex curves and voids were used, resulting in outputs that are structurally challenging from an engineering perspective.	Some elements are exaggerated; the building scale is incompatible with its surroundings.	Weak relationship with the environment; the building is designed as a self-contained entity.	0.150
DALL-	The original form is largely retained, but details are made more dynamic and complex.	High level of detailing, but constructability remains ambiguous.	Human scale is lost; massiveness dominates.	The building shows weak integration with the ground and the urban context.	0.242
Midjourney	The organic design language is preserved, but the overall character of the structure has been reimagined in a unique way.	Realization would be difficult; visual lacks readable traces of the structural system.	Proportional balance is generally maintained.	Strong interaction with the landscape; open areas are emphasized.	0.099

When evaluated in this context, it can be seen that the artificial intelligence productions belonging to the Eastgate Building exhibit different trends in terms of formal similarity levels and environmental compatibility. SSIM data indicates that the DALL-E model achieved the highest similarity ratio to the original structure (0.242), while Midjourney, despite having the lowest similarity value (0.099), produced the most successful results in terms of environmental harmony. DeepAI, on the other hand, increased structural complexity while maintaining formal originality, resulting in a moderate similarity score (0.150).

Following the evaluation of the first example, the second phase of the study focused on the Clyde Auditorium, which stands out for its biomimicry-based design. This structure, which attracts attention with its armadillo-shell-like facade form and layered shell structure, provides a valuable example for understanding the reflection of natural organisms on architectural surfaces.

Prompt: *A sustainable cultural center modeled after an armadillo's shell, with organic, layered exoskeleton structures providing shade and insulation. The structure integrates natural materials and green rooftops, harmonizing with the environment. Drone shot, soft golden hour lighting, ultra-detailed, immersive biophilic architecture --ar 16:9 --v 6.0*

The relevant visualizations are shown below (Figure 7).

Figure 7. Clyde Auditorium and Visualizations

For the artificial intelligence visuals of Clyde Auditorium, SSIM analysis was applied to objectively demonstrate the formal similarity with the original structure. The difference maps below present a comparative analysis of the similarity ratio of each model with the original structure at the visual level (Figure 8).

Figure 8. Clyde Auditorium and AI-Based Visualizations and SSIM Difference Maps

The architectural evaluation of the visual productions of the Clyde Auditorium example is presented comparatively in the table below, based on criteria such as formal qualities and environmental harmony (Table 2).

Table 2. Architectural Evaluation of Clyde Auditorium Visualizations Generated by AI.

	Form Similarity	Structural Feasibility	Scale and Proportion	Environmental Integration	SSIM
DeepAI	The shell concept is reinterpreted; surfaces show clear deviations from the original form.	The form is complex, but the overall structure is partially readable.	Mass dominance is evident; the scale is exaggerated compared to the surroundings.	Visual integration with the urban context is limited. Use of light on the façade creates a visual distinction.	0.158
DALL-E	The segmented structure is partially referenced, but lines and layering are distinctly reconfigured.	Multi-layered form includes details difficult to construct with current technology.	Monumental in scale, with weak relation to human scale.	Weak connection with landscape; the structure dominates the scene.	0.196
Midjourne	The form is simplified and not directly interpreted as a shell.	Curved surfaces and green roofs are structurally feasible.	The scale is more controlled; a balanced relationship with the surroundings is established.	Integrated with the landscape; strong connection with water and vegetation is achieved.	0.137

Following the analysis of Clyde Auditorium, we move on to the example of the Bahai Temple, which stands out with its symbolic form and nature-inspired architecture. The Bahai Temple is a structure

inspired by the lotus flower, attracting attention with its symbolic form and displaying biomimicry-based approaches in its facade design.
Prompt: A modern spiritual sanctuary with a lotus-inspired structure, its soft, curved petals arranged in a symmetrical, flower-like formation. The temple is surrounded by lush gardens and flowing water, emphasizing harmony with nature. Majestic, high-resolution, ultra-realistic architectural rendering, ethereal lighting, peaceful ambiance --ar 16:9 --v 6.0
The relevant visualizations are shown below (Figure 9).

Figure 9. Bahai Temple and Visualizations.

In the case of the Bahai Temple, how the lotus form was interpreted by different artificial intelligence models was compared visually using the SSIM method. In particular, the interpretation of the lotus form was evaluated comparatively based on the areas highlighted in the difference maps (Figure 10).

Figure 10. Bahai Temple AI-Based Visualizations and SSIM Difference Maps.

The architectural evaluation of the Bahai Temple productions is presented in the table below, supported by numerical findings. The differences shown by artificial intelligence models in terms of formal similarity, structural suitability, and environmental harmony are examined comparatively through this evaluation.
The evaluation of the images produced for the Bahai Temple example is shown in Table 3.

Table 3. Architectural Evaluation of Bahai Temple Visualizations Generated by AI.

	Form Similarity	Structural Feasibility	Scale and Proportion	Environmental Integration	SSIM
DeepAI	The lotus form has been adopted; however, the interpretation of the shells is simplified with limited detailing.	The overall form is presented consistently, but no clues are given on how the structural system operates. Connections between surfaces and structural elements remain unclear.	The relation to human scale is closer; the structure is represented at a controlled scale.	The landscape impact of the building is weak.	0.320
DALL-E	The lotus form is preserved, but the shape has evolved into a more layered and complex structure.	The connection between the shells suggests difficulty in terms of structural feasibility.	The scale is exaggerated; the structure appears dominant compared to its surroundings.	Weak relationship with the landscape; the building stands out as a central element.	0.355
Midjourne	The form closely overlaps with a lotus flower, but the interpretation adds a sculptural quality to the building.	The wider angle at which the lotus petals meet the ground has created a more complex structure from an engineering perspective.	Monumental in scale, the structure dominates its surroundings.	A strong unity is achieved with the water surface, reflections, and topography.	0.423

5. Evaluation

This study aimed to explore the formal potential of artificial intelligence outputs by evaluating three AI-generated visuals and their corresponding sample structures using five layered criteria. Analyses based on criteria such as formal similarity, structural suitability, scale and proportion, environmental compatibility, and SSIM scores show that each model and each structure stands out in different ways. In terms of formal similarity, all artificial intelligence models were able to identify the basic formal elements of the original structures, but the level of similarity varied depending on the model. DALL-E attracted attention with its detailed productions close to the original in the Eastgate example, while Midjourney reinterpreted the form in a more abstract but original way in the Clyde Auditorium. In the Bahai Temple example, although all three models strongly reflected the lotus form, Midjourney stood out by integrating this similarity with the visual atmosphere.

Structural suitability and scale-proportion criteria made the limitations of the models more evident. DeepAI generally produces simpler, more practical structures, while DALL-E presents more complex but technically problematic visuals. Midjourney, on the other hand, produces more balanced results in terms of scale control, but in some examples, it has replaced architectural reality with artistic interpretations. In the case of the Bahai Temple, Midjourney's ability to establish a strong environmental context reveals that this model is creative in terms of architectural visualization but limited in technical terms.

Notable differences were also observed between the structures in terms of environmental compatibility criteria. Although the Eastgate Building's environmental reference was based on a termite mound, it lacked visual integration with its surrounding environment. The Clyde Auditorium appears to be more successful in Midjourney productions in terms of its connection to the landscape, while the Bahai Temple is the structure that establishes the strongest environmental relationship through elements such as water surface, landscape, and reflection.

SSIM scores support these interpretations at a numerical level and reveal the extent to which the visuals resemble the original structures. The highest similarity scores obtained in the Bahai Temple example show that formal transfer was more strongly realized at both the model and structure levels. On the other hand, SSIM scores remained low in the Eastgate example, indicating that complex natural forms are more difficult for artificial intelligence to interpret.

These findings provide important clues not only about the production capacity of the models but also about the architectural character of the selected structures. The successful visual and environmental interpretation of biomimicry-based architectural structures is related not only to the symbolic power of the structure but also to the form and context that directly touch nature. Therefore, in evaluating AI-generated outputs, both the model's performance and the formal-contextual richness of the selected structures play a decisive role.

6. Conclusion

This study aimed to evaluate the extent to which artificial intelligence-supported visualization tools can reproduce nature-inspired structural forms and establish similarities with original structures. Within the scope of the study, the outputs of the Eastgate Building, Clyde Auditorium, and Bahai Temple were analyzed comparatively based on form similarity, structural suitability, scale and proportion, environmental compatibility, and SSIM data.

The findings show that artificial intelligence models produce successful results, particularly in terms of form similarity, but are limited in more technically complex areas such as structural suitability and scaling. DALL-E stood out with its high level of detail and production of forms close to the original structure; DeepAI produced simpler but engineering-consistent forms; and Midjourney attracted attention with its aesthetic relationship with the environmental context. SSIM data also numerically supports these differences, with Midjourney achieving the highest similarity score in the Bahai Temple example, demonstrating that environmental integrity and visual proximity can be correctly interpreted by artificial intelligence.

Comparisons between the structures reveal the following differences: The Eastgate Building offers the highest consistency in terms of form similarity, while the Clyde Auditorium is limited in terms of environmental harmony. The Bahai Temple, on the other hand, provides the most balanced results in terms of form, environment, and proportion, particularly standing out for its similarity level supported by SSIM data.

In this context, artificial intelligence models enhance architectural representation power, offer new possibilities for visual research, and produce inspiring results, especially in the conceptual design phase. In this context, artificial intelligence models are increasing architectural representation power, offering new opportunities for visual research, and producing inspiring results, especially in the conceptual design phase. However, a significant portion of these productions are not yet sufficient to be transferred to concrete architectural practice in terms of engineering reality, scale compatibility, and structural applicability. While the visuals are aesthetically strong, their lack of information regarding scale and proportion balance or structural systems indicates that these tools remain valuable in the initial idea generation phase of design but fall short in the implementation phase. In conclusion, AI-supported biomimetic visualizations are important tools that enrich creative thinking in architecture, support formal diversity, and strengthen the practice of drawing inspiration from nature. However, the integration of these tools with architectural criteria depends on their development in a way that ensures consistency not only in terms of visual appeal but also in structural and contextual terms. In order for these models to be more effectively integrated into architectural practice in the future, visualization tools must be supported by engineering data, measurements and proportions must be integrated into algorithms, and interaction with the environmental context must be modeled based on data. Approaches developed in this direction can enable artificial intelligence to become not only a creative tool but also an applicable and sustainable design support element.

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Conflicts of Interest

The Authors declare that there is no conflict of interest.

Data availability statement

The datasets, AI-generated visual materials, and SSIM outputs used in this study are available from the corresponding author upon reasonable request.

Institutional Review Board Statement

Not applicable.

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