JARINA - Journal of Artificial Intelligence in Architecture
Vol. 2, No. 1, February 2024

E-ISSN: 2829-6257
P-ISSN: 2962-5629

The Organic Challenge: Cultivating Conscious Design for Biodigital Tectonics within AI's Prompt-to-Pixel Process

Farina Shahid[1]
[1] Department of Architecture, Lahore College for Women University, Jail Road, Lahore, Pakistan.

Article Info

Article history:

Received October 25th,2023
Revised December 1st, 2023
Accepted December 1st, 2023

Keywords:

Biodigital Architecture
Artificial Intelligence (AI)
Midjourney
Digital Tectonics
Digital Design Process

ABSTRACT

The fusion of digital advancements and biological systems is transforming modern-day architecture, and this bio-digital approach, when paired with AI image generation models, promises novel design possibilities. The major drawback of this merger is the dismal performance of AI text-to-image models in translating organic tectonic details into architecture. This study examines the complexity of processes, materials, and techniques necessary in a bio-digital architectural approach. Through a series of digital trials, it identifies the need for sophisticated computational models that can capture the complex intricacies and subtle nuances present in living organisms. Before the testing, a set of parameters considered the limitation of how much tectonic information an image could portray. The Nautilus Shell, ferns, mushrooms, seahorses, and grasshoppers were taken as inspiration models because of varying biological configurations. Next, two AI image-generating tools, Midjourney and Stable Diffusion, were used with three different prompt types, each with varying degrees of complexity drawn from five organic systems. A critical analysis of AI-generated images led to the conclusion that, despite AI's exceptional abilities in creating visual content, the complex comprehension of biological systems and their conversion into architectural designs faced significant challenges.

Corresponding Author:

Farina Shahid,
Department of Architecture, Lahore College for Women University,
Jail Road, Lahore, Pakistan,
Email: feenarts@gmail.com, arfareenashahid@gmail.com

1. INTRODUCTION

Architectural tectonics has evolved throughout millennia, changing periodically in terms of materials, methods, application of technology, design philosophy, and culture. The primary division within the spectrum is between classical and digital tectonics, which moved apart through time; in other words, digital tectonics became much more "a-tectonic" [1]. As the precision control on digital topologies grew, the detachment of materiality in digital tectonics became apparent [2]. Due to the endless possibilities and capacity to cope with complexity a lot better in digital mediums, architects began to rely more and more on organic beings by incorporating natural forms, processes, and techniques into their designs due to their inherent complexity, efficiency, and adaptability. With the groundbreaking development of text-to-image generation models based on artificial intelligence (AI), digital experimentation with "organic" ideas gained even more interest because 'structured textual descriptions' or prompts could now translate the entire idea into visuals. These AI text-to-image-based tools are now used by aspiring architects and prominent firms in the conceptual stage. The 'ability' to transform organic concepts into images has dramatically improved thanks to AI technologies, but at the same time, the body of knowledge surrounding the use of organic configurations and genetic structures to achieve architectural goals is also improving immensely. These two growing phenomena drive an intriguing intersection: the process of conceptualizing digital architecture using AI-based text-to-image tools and the level of sensitivity required in both the human and AI models translating the most complex and intricate tectonic details via prompts.

1.1. Tectonics at The Confluence of Architecture and Nature

When combined with organic beings, tectonics suggests that architectural design aims to integrate buildings harmoniously and sustainably with the natural environment rather than construct structures as autonomous entities [3]. Biodigital is a novel field in architecture and design that integrates digital technology with biological principles to produce inventive, environmentally friendly, and sustainable buildings [4]. A few applications of digital architecture include form generation through biomimicry, structural optimization, adaptable and responsive environments, sustainable design, energy-efficient material innovation, systematic fabrication, ecological integration, and urban planning. Natural tectonics have been used increasingly in digital architecture to inform and improve building design.

Studying basic biological computation processes and understanding the notions of action, reaction, interaction, input, mutation, growth, relation, and discourse while designing buildings are made possible by digital architecture [5]. Integrating bioinformatics and computational biology with architecture has led to the development of new vocabulary that has fundamentally changed the methods, materiality, and meaning of applying abstract concepts. The desire to understand and incorporate concepts of behavior, information, and biological cognition into the design process, leading to the form of ‘Emerging Design Strategies’ rather than studying it as merely representative, formalist stylistic deception, has contributed significantly to the shifts in tectonic learning, i.e., processes, materiality, and technique.

The development within **processes** in the form of Morphogenesis (emerging and evolving forms and structures, often inspired by biological growth patterns and self-organization found in nature), Biofabrication (leverage living organisms or their byproducts to grow materials, supporting the development of sustainable and biodegradable construction materials), Eco-mimicry (employs to create sustainable urban spaces that function harmoniously with the surrounding ecosystem, promoting biodiversity), biomimicry (to draw inspiration from natural forms, behaviours, and systems, applying these concepts in architectural designs for enhanced sustainability and efficiency) reduce the over excessive reliance on human ‘intuition’ for design, and the process itself find its cues from an already existing example, making it more specific and as a result reducing the ‘abstraction’ [6]. **Materiality** with self-healing materials (vascular channels, microcapsules, ionomers, and shape memory materials), Mycelium-Based composite, Aerogels and Nanostructures, Hygroscopic Materialsm and Thermo-Responsive Materials [7] and **techniques** like self-assembly (spontaneous organization of components into structures without external guidance or intervention), folding structures (mimic the folding mechanisms observed in natural organisms to create adaptable, transformable, and space-efficient structures), branching structures (emulate the branching patterns found in trees and plants for optimizing natural light, ventilation, and structural stability), and tensegrity or tensional integrity (structural principle where components are held together in a delicate balance of pushing and pulling forces to create lightweight and stable structures, resembling the tensional balance observed in natural organisms) [8]. This level of tectonic ‘rearrangement’ within the subdomains of a somewhat abstract umbrella of organic architecture is not just confined to the fluidity of forms and curves. Still, it has produced essential foundations for comprehending geometry, evolution, and architecture as a dynamic process and structurally changing organism.

This study considers prominent tectonic arrangements, like fractal arrangement, segmentation, logarithmic spiral curves, exoskeleton, and modular interconnected networks. A list of five species was selected for each tectonic arrangement, each from a different biological family. Table 1 provides an overview of the basic anatomy of the species chosen for this study and in-depth tectonic descriptions.

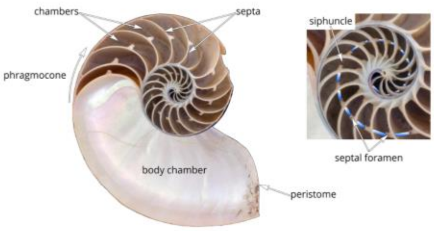
1.2. Working of Text to Image Generation AI Tools

Created under the direction of David Holz, MidJourney is a generative software system that can produce digital graphics based on text parameters supplied. To start creating images, AI-based models gather much information in various forms, i.e., textures, lighting, and color schemes [16]. The algorithm analyzes this data to determine the underlying correlations and patterns. It is important to note that inputting the exact keywords again will never get the same results because the program randomly chooses from various similar photos and visuals available on the Internet for each instance, giving them a different proportion in the final image. Additionally, as the script learns to produce ever-better visualizations through the ongoing study of user selections, it may adapt and change. As a result, each image generated by the script is distinct and can be traced back to its original moment. Thus, the outcome of the process depends heavily on two sets of data, i.e., the structured text prompt used as input and the level of visual 'understanding' these diffusion models develop based on the existing images related to the keywords inserted [17]. Two AI text-to-image generating models—Midjourney and Stable Diffusion XL—were chosen for this study to provide various results depending on the prompts for improved analysis.

Table 1. Selection of organisms and their tectonic descriptions.

<table>
<tr><th>No.</th><th>Basic Anatomy</th><th>Tectonic Description</th></tr>
<tr><td>1</td><td>

Specie type: Living Fossil **Name: Nautilus Shell**



Source: *Digital Encyclopedia of Ancient Life.*

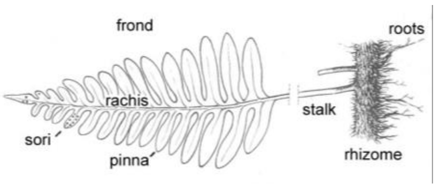
</td><td>

The Nautilus Shell exhibits a logarithmic spiral pattern, a natural growth pattern found in various organisms. This spiral pattern provides structural integrity and efficient use of space.

The main tectonic components are chambers, septa (partitions), phragmocone, body chamber, and Peristome [9]. Chambers hold significant value while studying the basic anatomy of a nautilus Shell as it grows by continuously adding chambers to its spiral structure as it matures [10]. Another significant structure is the siphuncle, a thin, tube-like structure connecting them. It extends from the innermost chamber to the outermost chamber.

</td></tr>
<tr><td>2</td><td>

Specie type: Non-flowering Plant **Name: Ferns**



Source: Cazadero

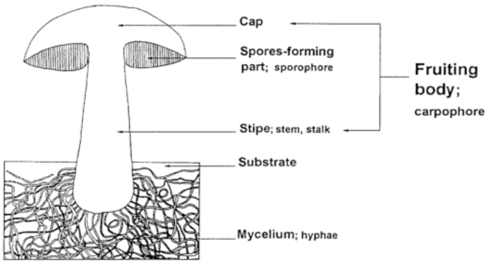
</td><td>

Ferns exhibit fractal geometry in their leaf structure. The smaller leaflets replicate the overall shape of the entire frond, creating a self-similar pattern at different scales.

The main tectonic components are rachises (main stems), pinnae (leaflets), roots, and fronds (compound leaves). Fronds are crucial for tectonics study as ferns often grow in clusters of modular fronds [11]. Fern leaves allow efficient airflow with their small, often finely divided leaflets. This natural ventilation adaptation helps the plant exchange gasses and optimize photosynthesis.

</td></tr>
<tr><td>3</td><td>

Specie type: Fungi **Name: Mushroom**



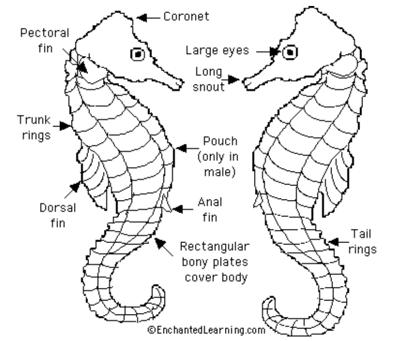
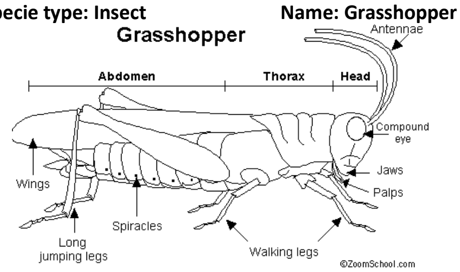
Source: '*A review of edible mushroom radioactivity*' by Pavel Kalacˇ

</td><td>

Mushrooms grow in a modular fashion, with mycelium forming intricate networks. They adapt their structure based on environmental conditions, space availability, and resources. Mycelium, the root-like structure of mushrooms, a web of thread-like structures, makes up the majority of the fungi in mushrooms.

Mycelium is a plant with remarkable structural qualities that may be grown to provide robust, lightweight building materials [12]. Mushrooms exhibit phototropism, growing toward light sources to optimize spore dispersal. Certain mushrooms exhibit bioluminescence, emitting light in low-light conditions.

</td></tr>
</table>

No.	Basic Anatomy	Tectonic Description
4	**Specie type: Marine Creature Syngnathidae family** **Name: Sea Horse**  Source: *Enchanted Learning* Seahorse Printout- Enchanted Learning Software	Seahorses have a unique skeletal structure consisting of bony plates arranged in interconnected rings. This design provides strength and protection while allowing flexibility. Seahorses have a streamlined body shape, allowing them to move easily through water. Their tail is prehensile and can grip onto objects, providing stability [13]. Seahorses have a protective exoskeleton made of a series of bony plates located beneath their skin. This idea can inspire the creation of modular architectural components that provide structural support and protection, like an exoskeleton surrounding a building. The seahorse can grasp and cling onto anything thanks to its prehensile tail. This adaptability can be used figuratively to emphasize flexibility and adjustability in architectural designs. Seahorses have the ability to change color and can blend in any environment.
5	**Specie type: Insect** **Name: Grasshopper**  Source: Enchanted Learning Grasshopper- Enchanted Learning Software	Grasshoppers have lightweight exoskeletons and powerful hind legs, allowing them to jump great distances. Grasshoppers have keen sensory organs, including compound eyes and antennae, enabling them to perceive their environment. Grasshoppers use camouflage to blend into their surroundings, avoiding predators [14]. Grasshoppers go through various life stages, including egg, nymph, and adult, each with specific adaptations. Grasshoppers use antennas for sensory perception. This concept inspires the integration of sensors and smart technologies in architectural designs [15].

2. RESEARCH METHOD

The study uses exploratory research methods to determine how AI text-to-image production techniques can catch up with building post-digital tectonics and inspire architects. The five species from diverse family types were chosen for this purpose: the nautilus shell (living fossil), the fern (non-flowering plant), the mushrooms (fungi), the seahorse (marine life), and the grasshopper (insect) since they all have varied habitats and, consequently, tectonics. Two AI text-to-image creation tools, i.e., Midjourney and Stable Diffusion XL, were used in this digital trial to examine the effectiveness of digital prompts. Given the importance of prompt structuring for the process's conclusion, three different kinds of thoughtfully crafted prompt types A, B, and C—from the most basic to the most intricate—were used, with the last one being based on the architectural aesthetics of designers employed in the biodigital fields. Structuring the prompts was crucial since previously completed projects could act as "cues" for the AI diffusion models, as they had been trained using much image-based data.

A set of criteria was designed using a binary system of 0 and 1 to score each image category to avoid abstracting the results during the analysis stage. Figure 1 shows the research design process with data breakdowns at each stage. Concluding the use of AI tools during the conceptual stage of an architectural project that required tectonic and biodynamic inspiration, a comparative analysis was then derived using criteria that indicated which type of guidance was more appropriate for each AI-based tool.

2.1 Tectonics of 'Inspiration models'

The anatomy and tectonic significance of species that serve as inspiration models for experiments are highlighted in this section. The selection criteria for selecting organic beings focused on the types of tectonics each species exhibits: the Nautilus Shell's logarithmic spiral pattern, the fern's fractal geometry, the mushrooms' intricate networks growing in a modular fashion, the seahorse's unique skeletal structure with interconnected rings, and the grasshopper's lightweight exoskeletons. The constraints of the study methodology were considered when crafting the tectonic descriptions, as the functional and performance-related translation of organisms and how these living things respond to environmental elements like wind, gravity, and water may not be incorporated into the image-based output through text. As a result, aspects like assembly techniques, material inspiration, structural stability, and general morphological elements were focused more profoundly.

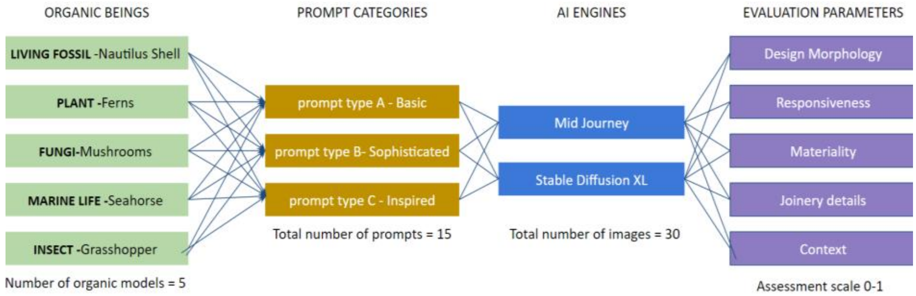


Figure 1. Research flow and methodology adopted for evaluation

2.2 Prompt Structuring

Generating images from textual descriptions using AI tools involves a back-and-forth between human and artificial intelligence; therefore, understanding how a prompt affects the procedure's result is essential. To find out if text-to-image AI tools are 'capable' of translating complex, organic, conceptual descriptions into components of architectural entities and how sensitive these tools are to the level of knowledge the human engaging with them holds, type A concentrated on the simpler phrases, type B was composed of more sophisticated and specific terms and type C employed the works of the architects. The various degrees of detail used to organize the three categories of prompts for each of the five organic entities are displayed in Table 2, which was fruitful for the sensitivity analysis of the generated images at a later stage. Type B prompts were structured with specific terms pertinent to the tectonics of each organic being, along with the material specification. A few of the architectural practices used for references in type C prompts are Paris-based practice Vincent Callebaut architectures led by Belgian architect Vincent Callebaut (architect of TAO ZHU YIN YUAN, Carbon-absorbing green tower, Taipei, Taiwan), Nicholas Grimshaw (architect of the Eden Project Master Plan. Cornwall, UK), Jeanne Gang (architect of Aqua Tower, Chicago, USA), Moritz Dörstelmann (architect of ICD ITKE Research Pavilion, Stuttgart, Germany) and Santiago Calatrava (architect of Polytechnical University, Florida).

Table 2. Types of Prompt Structures used with descriptions

No.	Prompt Structure type	Description
1	Prompt Structure type A **(Basic)**: Simple text description	Basic category prompts are simple phrases structured without any specific tectonic detail, material or any 'direction' for the outcome.
2	Prompt Structure type B **(Sophisticated)**: Semantic Prompting and Contextual Input	Examination of the impact of context via cognitively complex and richly contextualized prompts by adding specific terms derived from the tectonic study of each organic being, material specificity, and assembly methods arranged with prompt weights.
3	Prompt Structure type C **(Inspired)**: Driven by the works of renowned architects	The third type of prompt was structured around the work completed by various architects to examine the possibility of producing an outcome more sensitive to joinery, materials, etc.

2.3 Assessment Parameters

The use of biological organisms in architecture spans various applications, from simple form mimicry to more advanced performance-based long-term architectural solutions. However, the limitations of the present investigation's methodology were considered when defining the evaluation criteria for each outcome. Since imagery-based architecture is insufficient to reveal the increased level of detail regarding the performance or functional efficiency of the structures, parameters were maintained only to visible indicators. Thus, materials, technique or joinery details, and fluidity of form are tectonic aspects that stood crucial for assessment. Each parameter is shown in Table 3, along with the indicators used to evaluate the image-based results.

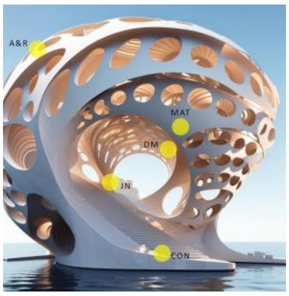
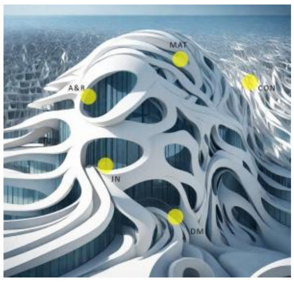
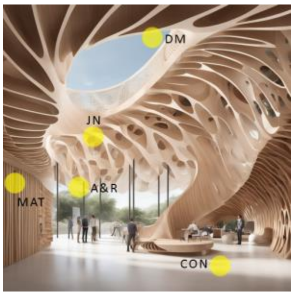
Table 3. Parameters and Indicators to assess biodigital tectonics in AI-generated images.

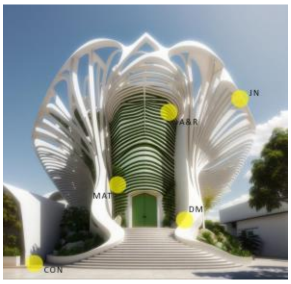
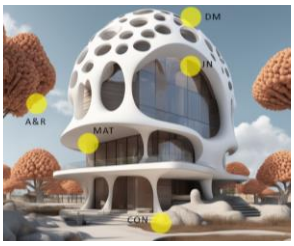
No.	Parameter	Indicators
1	Adoption in Design Morphology (DM)	The building's structure, façade, and distinct elements reflect natural forms, behaviors, and processes.
2	Adaptability and Responsiveness (A&R)	Adaptive façades, natural ventilation systems, responsive lighting, Modular Construction and Flexible Spaces
3	Materiality (MAT)	Surfaces and textures resembling natural organisms, such as skin, scales, or plant structures
4	Joinery (JN)	The utilization of cutting-edge construction methods inspired by natural beings with practical joinery systems
5	Context (CON)	Human scale and other 'realistic' aspects reflected in images to be rendered as an actual human scale architectural proposal

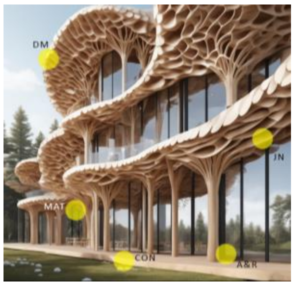
2.4 AI-Image Generation

Midjourney produced four photos at each attempt; the most pertinent image was chosen. Stable diffusion also produced fifteen images. A total of thirty images were evaluated using five parameter indicators. Each image was later marked with yellow dots highlighting the AI adaptation of all five indicators. Table 4 presents the output for each prompt type and the assessment of how much AI could envision.

Table 4. Prompts, AI-generated images and Parameter Score of five inspiration models.

Prompt	Midjourney	Parameter Score		Stable Diffusion XL	Parameter Score	
Model # 1 **Prompt type A:** Generate a 3D building inspired by Nautilus Shell tectonics **(1-A)**		(DM)	1		(DM)	0
		(A&R)	0		(A&R)	0
		(MAT)	1		(MAT)	0
		(JN)	0		(JN)	0
		(CON)	0		(CON)	0
Prompt type B: Generate a 3D building inspired by Nautilus Shell tectonics with helical structures, siphuncle as structural columns and chamber as façade developed in folding technique with wood and graphene material enhancing natural ventilation **(1-B)**		(DM)	1		(DM)	0
		(A&R)	1		(A&R)	0
		(MAT)	1		(MAT)	1
		(JN)	1		(JN)	0
		(CON)	1		(CON)	1

Prompt	Midjourney	Parameter Score		Stable Diffusion XL	Parameter Score	
Prompt type C: Generate a 3D building inspired by Nautilus Shell tectonics based on Vincent Callebaut's Nautilus architecture **(1-C)**		(DM) (A&R) (MAT) (JN) (CON)	1 1 1 1 1		(DM) (A&R) (MAT) (JN) (CON)	1 0 0 0 1
Model # 2 Prompt type A: Generate a 3D building inspired by Fern tectonics **(2-A)**		(DM) (A&R) (MAT) (JN) (CON)	1 0 0 1 1		(DM) (A&R) (MAT) (JN) (CON)	1 0 0 0 0
Prompt type B: Generate a 3D building inspired by Fern with Rachises and pinnae as a facade for ventilation, roots and fronds as structural columns in stacking technique with regenerative concretes and hydrodynamics **(2-B)**		(DM) (A&R) (MAT) (JN) (CON)	1 1 0 0 1		(DM) (A&R) (MAT) (JN) (CON)	1 0 0 0 1
Prompt type C: Generate a 3D building inspired by Fern tectonics based on Nicholas Grimshaw architecture **(2-C)**		(DM) (A&R) (MAT) (JN) (CON)	1 0 0 0 1		(DM) (A&R) (MAT) (JN) (CON)	1 1 0 0 1
Model # 3 Prompt type A: Generate a 3D building inspired by Mushroom tectonics **(3-A)**		(DM) (A&R) (MAT) (JN) (CON)	1 0 1 0 1		(DM) (A&R) (MAT) (JN) (CON)	0 0 0 0 0

Prompt	Midjourney	Parameter Score	Stable Diffusion XL	Parameter Score
Prompt type B: Generate a 3D building inspired by Mushroom's Cap-Inspired Roof, Sporophore-Inspired Building Facade, and Stipe-Inspired Structural Columns in a self-organizing technique with Mycelium-Based Construction Materials combined with transparent wood **(3-B)**		(DM) 1 (A&R) 0 (MAT) 0 (JN) 0 (CON) 1		(DM) 0 (A&R) 0 (MAT) 0 (JN) 1 (CON) 1
Prompt type C: Generate a 3D building inspired by Mushroom tectonics based on Jeanne Gang architectural style **(3-C)**		(DM) 1 (A&R) 0 (MAT) 1 (JN) 1 (CON) 1		(DM) 0 (A&R) 0 (MAT) 0 (JN) 0 (CON) 1
Model # 4 Prompt type A: Generate a 3D building inspired by Seahorse tectonics **(4-A)**		(DM) 0 (A&R) 0 (MAT) 0 (JN) 0 (CON) 0		(DM) 0 (A&R) 0 (MAT) 0 (JN) 0 (CON) 0
Prompt type B: Generate a 3D building inspired by a Seahorse with cornet-shaped spires, Trunk Rings-Inspired Structural columns, Dorsal Fins-Inspired Roof and seahorse body Plates-Inspired Façade with tensile integrity in Carbon Concrete and straw **(4-B)**		(DM) 1 (A&R) 1 (MAT) 0 (JN) 1 (CON) 1		(DM) 0 (A&R) 1 (MAT) 1 (JN) 1 (CON) 1

Prompt	Midjourney	Parameter Score	Stable Diffusion XL	Parameter Score
Prompt type C: Generate a 3D building inspired by seahorse tectonics based on Moritz Dörstelmann architectural style **(4-C)**		(DM) 1 (A&R) 0 (MAT) 1 (JN) 1 (CON) 1		(DM) 0 (A&R) 0 (MAT) 1 (JN) 1 (CON) 1
Model # 5 **Prompt type A:** Generate a 3D building inspired by Grasshopper tectonics **(5-A)**		(DM) 1 (A&R) 0 (MAT) 1 (JN) 0 (CON) 1		(DM) 0 (A&R) 0 (MAT) 0 (JN) 0 (CON) 1
Prompt type B: GGenerate a 3D building inspired by a grasshopper with Wings-Inspired Kinetic Façades with branching technique, Spiracles-Inspired Ventilation Systems, Jumping Legs-Inspired Structural Columns and antennae-inspired ornamentation in Regenerative Pigmented concrete and Carbon fibre **(5-B)**		(DM) 1 (A&R) 0 (MAT) 0 (JN) 0 (CON) 0		(DM) 0 (A&R) 0 (MAT) 0 (JN) 0 (CON) 1
Prompt type C: Generate a 3D building inspired by Grasshopper tectonics based on Santiago Calatrava architectural style **(5-C)**		(DM) 1 (A&R) 1 (MAT) 0 (JN) 0 (CON) 1		(DM) 0 (A&R) 0 (MAT) 1 (JN) 0 (CON) 1

3. RESULTS AND DISCUSSION

The sum of the results from all of these experiments indicates a predictable outcome. Of all the parameters, "context" (CON), or the surroundings and the building's scale relative to the people around it, is the easiest for AI technologies to translate into architectural proposals. The characteristics with the lowest performance were Joinery (JN) and Adaptability and Responsiveness (A&R), closely related to implementing biodigital architecture. Midjourney's AI techniques generated far superior photos than Stable Diffusion, which needed to be improved in technical and realistic features. When an architect's work was used as a reference for these tools, i.e., type C, the prompt structure performed at its best. Compared to simple prompts (type A), the more sophisticated prompts (type B) received higher scores, suggesting that human expertise plays a significant role when interacting with AI systems. Even though it might not fully capture everything, the imagery-based results are often far more thorough than a prompt structured around a few terms. The overall score of each image according to parameters is presented in Table 5. Each prompt parameter assessment is further discussed in the following subsections.

Table 5. Parameter Score for all thirty biodigital proposals created by Midjourney & Stable Diffusion

No	Parameter	Midjourney			Stable Diffusion XL			Total
		Prompt A (Basic)	Prompt B (Sophisticated)	Prompt C (Inspired)	Prompt A (Basic)	Prompt B (Sophisticated)	Prompt C (Inspired)	
1	Design Morphology (DM)	4/5	5/5	5/5	0/5	1/5	2/5	17/30
2	Adaptability and Responsiveness	0/5	3/5	2/5	0/5	1/5	2/5	8/30
3	Materiality (MAT)	3/5	1/5	3/5	0/5	2/5	5/5	14/30
4	Joinery (JN)	1/5	2/5	3/5	0/5	2/5	1/5	9/30
5	Context (CON)	3/5	4/5	5/5	1/5	5/5	5/5	23/30
	Total	11/25	15/25	18/25	1/25	11/25	15/25	

3.1 Basic (Type A) Prompts

Midjourney: Type A prompts, when inserted in mid-journey, the design morphology (DM) and the context (CON) were the more vital areas in the architectural proposals. However, the materiality (MAT), joinery (JN) and Adaptability (A&R) should have been more prominent. The elements of translating the organs into architectural expression were visible for both nautilus shells and ferns. For example, in 1-A, the shell's chambers were translated into perforations; in 2-A, the veins were translated into extended shading for the structure. The created designs in 3-A and 5-A, where the inspiration models were mushrooms and grasshoppers, respectively, had fewer inspirations from their models; however, in 4-A, where the seahorse was used as an example, there is a high level of "abstraction" and no clear form inspiration from the model. The overall outputs are dismal and have little to no "inventive" quality when one considers that designers are now using these AI technologies at the conception stage of a design process.

Stable Diffusion XL: The total score was appalling for stable diffusion with simple cues (type A). The result was not "fine" enough to be dubbed an architectural image since it too literally adapted the tectonics of ferns and mushrooms, i.e. 2-A and 3-A, respectively, since both were too abstract. The 1-A of the nautilus shell, the 4-A of the seahorse, and the 5-A of the grasshopper models failed to translate the biological tectonics that served as prompts and did not give the realistic 3D context required for an architectural conclusion.

3.2 Sophisticated (Type B) Prompts

Midjourney: When given complex (type B) cues, architectural imagery's overall level of detail increased. The architectural designs for the nautilus shells and seahorses, or 1-B and 4-B, respectively, were clear in terms of details, and their forms were based on the corresponding biological models. Nonetheless, ferns and mushrooms translate poorly into building designs. Although 2B's excessively packed greenery and absence of windows providing natural light or ventilation made it dull, it may still be deemed acceptable for the ideation stage. Conversely, 4B had excessive ludicrous mushroom adoption and little to no physical detail in the picture. The least successful biodigital translation was that of grasshopper, where the 5B result barely resembles a structured space and instead has the details and setting of a monument-style construction with no functional needs and only a symbolic existence.

Stable Diffusion XL: Although the findings for complex prompts showed some improvement in Stable Diffusion, they still needed to be up to the level of those produced by mid-journey. The nautilus shells, ferns, and mushrooms that inspired 1-A, 2-B, and 3-B produced results that needed to be clearer, lacked a biological model translation, and needed better image quality. 4-B, inspired by the seahorse, was architecturally sound as it had the materials structured according to the prompt but barely translated morphology of the seahorse. Once more, 5-C could have been a better architectural interpretation lacking solid structural elements. The result was less realistic regarding materiality and technique due to the literal adaptation of the grasshopper's jumping legs.

3.3 Inspired (Type C) Prompts

Midjourney: Of the three Type C prompts, they worked the best. The notion that the AI picture-generating process significantly benefited from the reference of architects who have designed digital structures. When the Nautilus shell was used with Vincent Callebaut's works, 1-C produced an extremely dynamic image while maintaining the clarity of the context, scale, and surroundings. Nevertheless, the fern tectonic characteristics of 2-C, which were influenced by Nicholas Grimshaw's architectural style, were unable to produce an architectural result that was coherent and, hence, devoid of structural tectonics. A decent image was produced by combining the 3-C architectural style, detailed based on mushrooms, with Jeanne Gang's architectural style; yet the curves need to be more dense for a realistic viewpoint. When coupled, the seahorse model and Moritz Dörstelmann's distinctive style produced an architecturally feasible image, 4-C, which was relatively dynamic like its biological model but with minimal regard for flexibility and responsive characteristics. The Grasshopper model converted into Santiago Calatrava's architectural style resulted in a somewhat exaggerated yet dimensional product, i.e., 5-C, that can be considered at the idea stage.

Stable Diffusion XL: In stable diffusion, the pattern of obtaining the best of all results for the "inspired" category (type C) persists. Still needing improvement, though, was the clarity surrounding tectonics and materiality. The massive construction inspired by Vincent Callebaut's architectural style of the Nautilus shell inspired in 1-C looks unfeasible in terms of materials, technical aspects, and adaptability since it's wrapped with fibrous material. The somewhat literal 2-C fern leaf mimic, which Nicholas Grimshaw influenced, lacked the tectonic features and structural strength necessary to make the structure viable. 3-C was inspired by mushrooms and Jeanne Gang's artwork to create a timber pavilion-style construction with a poor-quality image and somewhat distorted technical information. The material could have been clearer, and the morphological translation of the seahorse in 4-C could have been more impressive. From a technological perspective, 5-C is a less innovative architectural offering.

4. CONCLUSION

After performing this experiment, it is straightforward to conclude that for designers to use AI text-to-image creation techniques as a source of inspiration for digital architecture, they must also acquire the necessary knowledge and cognitive framework. MidJourney, one of the two AI tools employed in this experiment, translated the organic structures, tectonics, assembly techniques, and materials more accurately than Stable Diffusion. Additionally, the translation also varied depending on the kind of organic creature. For instance, compared to the others, AI incorporated the morphology and tectonic characteristics of the Nautilus shell more easily into architectural contexts. Complex organic systems, such as grasshoppers and seahorses, took much work to translate into architecture.

In contrast, ferns and mushrooms are positioned in the middle of this difficulty range. Compared to more ordinary materials like wood, concrete, and so forth. Novel materials, like graphene and carbon fiber, were more challenging to translate into AI images. Similarly, catering to the technique-related prompt elements, such as the folding structures and the kinetic facade, took much work.

Three different prompt types were essential to comprehend the same organic model as inspiration into different degrees of architectural sensitivities. The fact that the inspired prompts (type C) performed significantly better than the other two (type A & type B) also indicates that the model's ability to adapt to the digital architectural tectonics will increase with the amount of complicated data in the domain utilized to train them. However, given how "reliable" these technologies are on a trajectory to be considered, the overall results of text-to-image generating tools are lousy. It's concerning that these tools, which greatly excel in the "beautification" aspect of architecture but fall short in the technique department, could cause an even worse degradation if designers don't equip themselves to engage with AI tools on an equal footing rather than submitting to them.

REFERENCES

[1] H. Al-Alwan and Y. B. Mahmood, "The Connotation of Tectonics in Architectural Theory," IOP Conference Series: Materials Science and Engineering, vol. 745, p. 012161, Mar. 2020, doi: https://doi.org/10.1088/1757-899x/745/1/012161.

[2] R. Hermanson and J. Bermudez, "Tectonics After Virtuality: Returning to the Body," Proceedings of ACSA International Conference: "Constructions of Tectonics for the Postindustrial World, Jan. 1996, Accessed: Oct. 23, 2023. [Online]. Available: https://www.academia.edu/2902364/Tectonics_After_Virtuality_Re_turning_to_the_Body

[3] D. Pearson, New Organic Architecture: The Breaking Wave. Univ of California Press, 2001. Accessed: Oct. 23, 2023. [Online]. Available: https://books.google.com.pk/books?hl=en&lr=&id=5fncJliXFdgC&oi=fnd&pg=PA58&dq=organic+architecture&ots=ngKjJgFXhw&sig=_DOaCkL9icPT0mOfvssLsYWF-tc&redir_esc=y#v=onepage&q=organic%20architecture&f=false

[4] H. Al-Alwan and Y. B. Mahmood, "The Connotation of Tectonics in Architectural Theory," IOP Conference Series: Materials Science and Engineering, vol. 745, p. 012161, Mar. 2020, doi: https://doi.org/10.1088/1757-899x/745/1/012161.

[5] A. T. Estévez and D. Navarro, "Biomanufacturing the Future: Biodigital Architecture & Genetics," Procedia Manufacturing, vol. 12, pp. 7–16, 2017, doi: https://doi.org/10.1016/j.promfg.2017.08.002.

[6] P. Gruber, T. McGinley, and M. Muehlbauer, Towards an agile biodigital architecture - Supporting a dynamic evolutionary and developmental view of architecture. 2017.

[7] D. Ozkan, M. Dade-Robertson, R. Morrow, and M. Zhang, "Designing a Living Material Through Bio-Digital-Fabrication: Guiding the growth of fungi through a robotic system," vol. 1, V. Stojaković and B. Tepavčević, Eds., Brussels: Education and Research in Computer Aided Architectural Design in Europe (eCAADe), 2021, pp. 77–84. Accessed: Oct. 23, 2023. [Online]. Available: http://papers.cumincad.org/cgi-bin/works/paper/ecaade2021_022

[8] D. Dollens, "Architecture as Nature: a Biodigital Hypothesis," Leonardo, vol. 42, no. 5, pp. 412–420, Oct. 2009, doi: https://doi.org/10.1162/leon.2009.42.5.412.

[9] C. Naglik, F. Rikhtegar, and C. Klug, "Buoyancy of some Palaeozoic ammonoids and their hydrostatic properties based on empirical 3D-models," Lethaia, vol. 49, no. 1, pp. 3–12, Jan. 2016, doi: 10.1111/let.12125.

[10] A. Lukeneder, "Ammonoid Habitats and Life History," in Ammonoid Paleobiology: From anatomy to ecology, C. Klug, D. Korn, K. De Baets, I. Kruta, and R. H. Mapes, Eds., in Topics in Geobiology. , Dordrecht: Springer Netherlands, 2015, pp. 689–791. doi: https://doi.org/10.1007/978-94-017-9630-9_18

[11] J. Pšenička, R. Rößler, J. Frojdová, S. Opluštil, and M. Merbitz, "A new anatomically preserved Alloiopteris fern from Moscovian (Bolsovian) volcaniclastics of Flöha (Flöha Basin, SE Germany)," PalZ, vol. 93, no. 3, pp. 395–407, Sep. 2019, doi: https://doi.org/10.1007/s12542-019-00482-x

[12] D. S. Hibbett, D. Grimaldi, and M. J. Donoghue, "Fossil mushrooms from Miocene and Cretaceous ambers and the evolution of Homobasidiomycetes," American Journal of Botany, vol. 84, no. 7, pp. 981–991, 1997, doi: https://onlinelibrary.wiley.com/doi/abs/10.2307/2446289

[13] J. Žalohar, T. Hitij, and M. Križnar, "Two new species of seahorses (Syngnathidae, Hippocampus) from the Middle Miocene (Sarmatian) Coprolitic Horizon in Tunjice Hills, Slovenia: The oldest fossil record of seahorses," Annales de Paléontologie, vol. 95, no. 2, pp. 71–96, Apr. 2009, doi: https://www.sciencedirect.com/science/article/pii/S0753396909000172

[14] G. S. Boyan, J. L. D. Williams, and H. Reichert, "Morphogenetic reorganisation of the brain during embryogenesis in the grasshopper," Journal of Comparative Neurology, vol. 361, no. 3, pp. 429–440, 1995, doi:https://onlinelibrary.wiley.com/doi/abs/10.1002/cne.903610307

[15] N. ShaoXiang, J. JianJun, W. JieChen, G. AiQi, W. WeiJuan, and F. Voss, "Environmental conditions affecting grasshopper epidemic in the region around Qinghai Lake.," Acta Prataculturae Sinica, vol. 9, no. 1, pp. 43–47, 2000.

[16] P. J. Cobb, "Large Language Models and Generative AI, Oh My!: Archaeology in the Time of ChatGPT, Midjourney, and Beyond," Advances in Archaeological Practice, vol. 11, no. 3, pp. 363–369, Aug. 2023, doi: https://www.cambridge.org/core/journals/advances-in-archaeological-practice/article/large-language-models-and-generative-ai-oh-my/314BA1339E6908606B90202C0DEF266E

[17] T. K. F. Chiu, "The impact of Generative AI (GenAI) on practices, policies and research direction in education: a case of ChatGPT and Midjourney," Interactive Learning Environments, vol. 0, no. 0, pp. 1–17, 2023, doi: https://doi.org/10.1080/10494820.2023.2253861

BIOGRAPHY OF AUTHOR

Farina Shahid	Architect, academic and entrepreneur currently based in Lahore, Pakistan. Her practice at Feynarts fuses technology, nature and architecture through research backed design solutions resulting in spaces that captivate, inspire, and engage. She envisions a future where architecture seamlessly integrates with technology, creating spaces that respond to human needs, emotions, and interactions. Her project 'Sverchok Compartments' gained immense critical acclaim from the judges of Param challenge, Spain. Her master's thesis, Human-Centric Digital Symbiosis in Architecture, denotes a groundbreaking investigation into the confluence of technology and human experience. Her research has contributed valuable insights to the evolving field of human-centered computational architecture. In addition to her practice, Farina is a passionate educator. Her expertise lies in guiding the next generation of architects, imparting knowledge about computational design methodologies and the transformative power of artificial intelligence in architecture. Her teaching approach emphasizes the importance of human-centric design principles, ensuring that students are well-equipped to address real-world challenges.In her role as educator, she has supervised thesis projects that explored the futuristic aspects of Human life with techno-architectural rules of industry 4.0.