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VISUAL PROGRAMMING AS A TOOL TO COMPUTE FLORISM-INSPIRED GEOMETRIES FOR THE DESIGN OF EXHIBITION BOOTHS

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PROGRAMACIÓN VISUAL COMO HERRAMIENTA PARA EL CÁLCULO DE GEOMETRÍAS INSPIRADAS EN EL FLORISMO PARA EL DISEÑO DE STANDS DE EXPOSICIÓN

PROGRAMAÇÃO VISUAL COMO FERRAMENTA DE CÁLCULO DE GEOMETRIAS INSPIRADAS NA ARTE FLORÍSTICA PARA O DESIGN DE ESTANDES DE EXPOSIÇÃO

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ABSTRACT

Akin to the introduction of computers into the design field, the use of computational thinking as a cognitive tool is driving a paradigm shift in terms of how we approach problem-solving in architecture. Computational modeling techniques and technologies require not only technological expertise but also new ways of ideation, which allow both computational thinking and even deeper levels of cognition. In the current demand for sustainable solutions in the design field, Biomimetic approaches, which go beyond a mere metaphor, are becoming imperative. Beyond providing an overview of computational thinking (CT) in general, this paper discusses various counterparts associated with CT, including decomposition, pattern recognition, abstraction, and algorithms. Grasshopper, as a Visual programming tool, is used in this experimentation to visualize design data. The aim of this paper is to revisit the framework of computational thinking skills involved in translating design ideas from nature, such as floral formations, into a sample pavilion geometry compatible with booth designs at trade fairs. This research will examine the process and framework for these abilities to extract pavilion-geometry design references from floral morphology. As a result, this work would provide a structured design outline for modeling design concepts derived from Biomimetic principles using computational thinking and visual algorithms.

Keywords
biomimicry, exhibition booths, computational thinking, design abstraction

RESUMEN

De forma similar a la introducción de los computadores en el campo del diseño, el uso del pensamiento computacional como herramienta cognitiva está generando un cambio de paradigma en la resolución de problemas arquitectónicos. Las técnicas y tecnologías de modelado computacional requieren no solo experiencia tecnológica, sino también nuevas formas de ideación que permitan el pensamiento computacional y niveles de cognición aún más profundos. Ante la demanda actual de soluciones sostenibles en el campo del diseño, los enfoques biomiméticos, que van más allá de la mera metáfora, se vuelven imperativos. Además de ofrecer una visión general del pensamiento computacional (PC), este artículo analiza diversas contrapartes asociadas al PC, como la descomposición, el reconocimiento de patrones, la abstracción y la algoritmia. En esta experimentación, se utiliza Grasshopper, como herramienta de programación visual, para la visualización de datos de diseño. El objetivo de este artículo es revisar el marco de las habilidades de pensamiento computacional implicadas en la traducción de ideas de diseño de la naturaleza, como las formaciones florales, a una geometría de pabellón de muestra compatible con el diseño de stands en ferias comerciales. En esta investigación se examinarán el proceso y el marco de estas habilidades para extraer referencias de diseño geométrico de pabellones a partir de la morfología floral. Con el fin de modelar conceptos de diseño a partir de principios biomiméticos mediante el pensamiento computacional, empleando algoritmos visuales, este trabajo ofrecería un esquema de diseño estructurado.

Palabras clave
biomímesis, stand de exposición, pensamiento computacional, abstracción de diseño

RESUMO

À semelhança da introdução dos computadores no campo do design, o uso do pensamento computacional como ferramenta cognitiva está provocando uma mudança de paradigma na forma como abordamos a resolução de problemas na arquitetura. As técnicas e tecnologias de modelagem computacional exigem não apenas conhecimento tecnológico, mas também novas formas de ideação, que permitem tanto o pensamento computacional quanto níveis ainda mais profundos de cognição. Com a atual demanda por soluções sustentáveis na área do design, as abordagens biomiméticas, que vão além de uma mera metáfora, estão se tornando imperativas. Além de fornecer uma visão geral do pensamento computacional (PC) , este artigo discute vários aspectos associados ao PC, como a decomposição, o reconhecimento de padrões, a abstração e os algoritmos. O Grasshopper, como ferramenta de programação visual, é utilizado nesta experiência para a visualização de dados de projeto. O objetivo deste artigo é revisitar a estrutura das habilidades de pensamento computacional envolvidas na tradução de ideias de design da natureza, como formações florais, em uma geometria de pavilhão compatível com projetos de estandes em feiras comerciais. Esta pesquisa examinará o processo e a estrutura dessas habilidades para extrair referências de design geométrico de pavilhões a partir da morfologia floral. Como resultado, este trabalho forneceria um esboço de design estruturado para modelar conceitos de design extraídos dos princípios biomiméticos, utilizando pensamento computacional e algoritmos visuais.

Palavras-chave
biomimética, estandes de exposição, pensamento computacional, abstração de projeto

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INTRODUCTION

The perception and actualization of architectural form, space, and structure are significantly influenced by computation. As a result of decades of scientific, technological, and cultural breakthroughs, the computational perspective has emerged at the intersection of several ways of thinking. Put simply, computational thinking in architecture is a cognitive skill supported by several stages in the process that precede the computational design, including, but not limited to, form, creation, optimization, task automation, evaluation, and aesthetic expression (Kelly & Gero, 2021). Computational thinking has four important parts: Decomposition, Abstraction, Pattern recognition, and Algorithm design (Öksüz & Çağdaş, 2020). A spatial volume is traditionally thought of as an enclosure defined by the composition of a set of planar surfaces, each with characteristics unique to the space's floor, walls, and ceiling. This is done in order to develop ideas for architectural design. This method has reduced the amount of space for experimentation by allowing architects to construct the design using only tried-and-true, preconceived solutions and tectonic systems. Conversely, designers can now think of space as a collection of algorithm-controlled characteristics, including coordinates, distances, surfaces, and geometric equations. Design iterations in CT have been automated to the point where architects may see the creation of design possibilities by altering an algorithmic parameter. Figure 1 shows an infographic comparison of conventional thinking and computational thinking.

MATERIALS AND METHODS

The methodology of this study begins with understanding the process of computational thinking involved in translating design ideas from Biomimetic information. For instance, in November 2012, the Institute for Computational Design and Construction (ICD) and the Institute of Building Structures and Structural Design (ITKE) at the University of Stuttgart adopted the exoskeleton of a lobster (the cuticle) as a biological role model for their pavilion project to create the architecture and structural strategy. Although an exoskeleton provides multiple layers of biological complexity, such as material anisotropy and functional morphology of arthropods, a thoughtful abstraction was applied to convert the morphological geometry into viable design principles (Knippers et al., 2015). Prior to selecting the appropriate model for study, a collection of online resources on flowers was compiled to assess the floral morphology of petals, which served as the source object in this study. Eventually, after abstracting the source object, the decomposition and pattern recognition of floral geometry to fit the desired design were performed, leading to the configuration of the algorithm. The required competency for computational modelling was developed using the Grasshopper tool in a process that supports coding the Biomimetic design's geometrical character. Computational modelling, as a creative process integrated with design, results in the generation of a desired model. The methodology adopted in this study is visually represented in Figure 2.

COMPUTATIONAL THINKING IN ARCHITECTURE

In the era of computation, thinking for crafts and design can be classified as two main approaches: result-oriented and process-oriented. In a result-oriented approach, the designers may have an image of the product that gets altered and takes shape through various decisions during the process. In the latter, the designers focus on improvising the process by setting up rules interpreted from nature or any other source object that determines the result (Yabanigül, 2025). For instance, Jalali and Charkhab (Jalali & Charkhab, 2020) discuss a process-oriented approach by determining a set of rules abstracted from crystallization, whereas Walczak (Walczak, 2017), in his paper, has developed algorithms to fit the image of the pavilion design he had in his mind.

Pioneers in architectural design, such as Gaudí, Isler, Otto, and Musmeci, in the late 19th century, employed novel form-finding techniques that challenged conventional wisdom by examining forms through parametric interdependencies among materials, shape, and structures. Analog devices like soap films, hung cloth, and chains were used in these studies during the pre-computer era for catenary simulations. This physical modeling-based structural optimization is comparable to manual computation that uses shape, design constraints, materials, and gravity to mimic natural forces. As a result, this gravity-based method is limited and mono-parametric (Boller & Schwartz, 2020). The multi-parametric design that incorporated heterogeneous data, such as geometry, multiple forces, environment, materiality, and social data, etc., relies heavily on computers, thereby marking a trajectory towards computational thinking. In many contexts, computational thinking (CT) is often misinterpreted as the process of designing using algorithms. Though Algorithmic design plays a pivotal role in CT, one cannot negate the underpinning of other skills, such as Abstraction, Decomposition, and Pattern recognition, that precede the algorithm (Cansu & Cansu, 2019). Thus, computational modelling has become a viable medium for experiencing, exploring, and learning different levels of complexity and dimensions. Changing a parameter symbolizes the form-finding design process because parameters are used to characterize the model.

ABSTRACTION

The concept of abstraction is one of the essential skills that aids in addressing different forms of complex problems

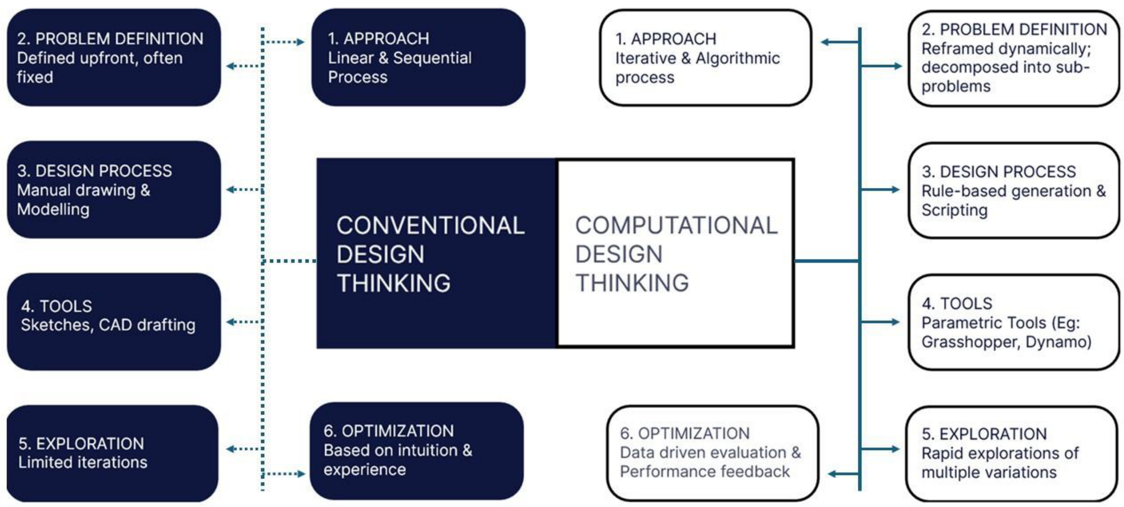

Figure 1. Conventional vs. Computational Design Thinking. Source: Produced by the authors.

in simpler ways. It generalizes problems by identifying required details and cutting out irrelevant information. Goldschmidt (2011) argues that, in the field of design science, successful abstraction from external sources aids creative thinking that transfers only essential links between the source and the design. In a recent obsession with bio-inspired phenomena for sustainable solutions across art, engineering, medicine, and architecture, etc., computational thinking has become an imperative strategy for modelling and simulation to achieve faster results, greater accuracy, and real-time data integration (Sorguç & Selçuk, 2013).

A structured abstraction is required to translate natural phenomena such as coralline formations, crustacean topology, and crystallization into a design strategy. In most cases, natural shapes yield highly sophisticated geometry, prompting architects and designers to rely on computational and algorithmic thinking to advance. Considering the absence of a synthesized understanding, abstraction is very elusive. To overcome the gap in abstraction, a synthesized abstraction framework is conceptualized, streamlining the cognitive process. The stages of the framework are: Filtering information, Locating similarities, and Mapping problem structures.

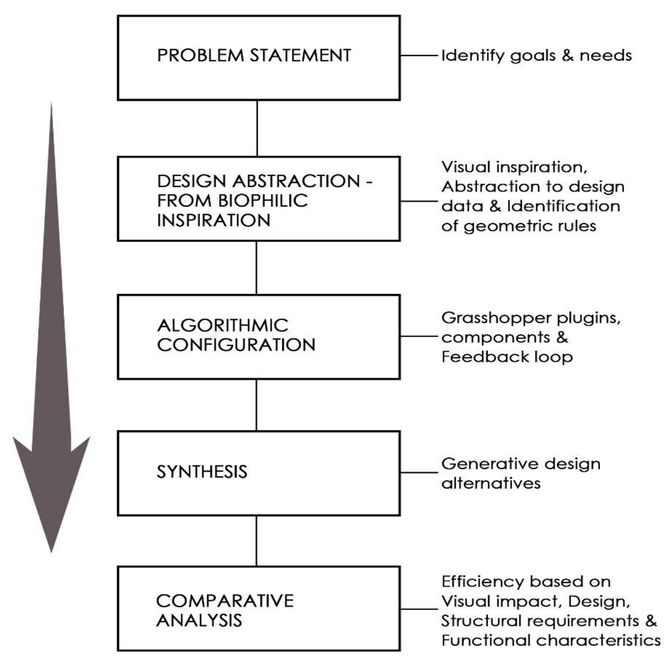

Figure 2. Methodology of the study. Source: Produced by the authors.

Floral morphology as a source object

Biomimetic design demonstrates economic and environmental stability, displaying the inherent genius behind the symbiotic link between nature's wisdom and humans' inventiveness (Ibrahim & Al-Chaderchi, 2023). Biophilia and biomimicry will become core drivers in the construction of spaces that enhance human welfare and environmental protection, where the built environment of the future is integrated into life's symphony rather than just acting as shelter. Biomimetic architecture, which draws inspiration from nature, transforms biological processes and forms into sophisticated structures that not only reflect the complex natural aspects but also convey novel spatial and motion sensations. Biomimetic architecture is diversely inspired by morphological, functional, structural, and aesthetic features of flora and fauna. A novel design flower-inspired approach for sustainability-oriented design principles in the spirit of incorporating various parts of flowers is becoming apparent in architectural practices; and built structures such as Singapore's Art and Science Museum by Safdie Architects and The Lotus Building in China by Studio 505 substantiate this concept. This method begins with an in-depth understanding of florism and its application in architectural design (Fonseka & Romanov, 2025). Beyond the merely floral

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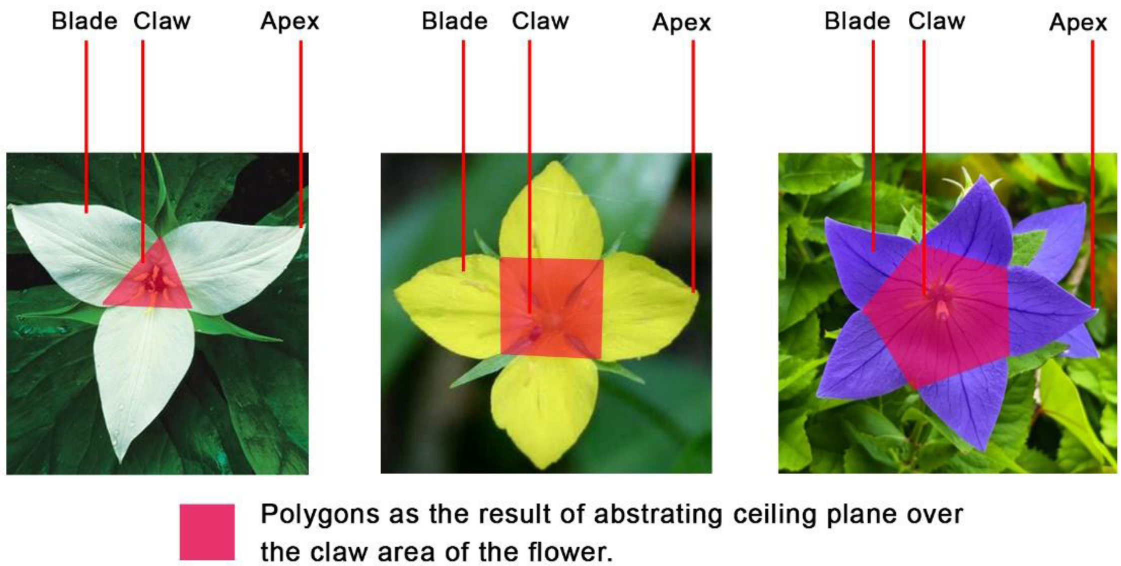

Figure 3. Actinomorphic Flower showing petal arrangement – From Left to Right – Trillium. Source: Andrews & Moore (s.f.); Cruciform. Source: First Nature (s.f.); Pentamerous. Source: Produced by the authors.

shapes employed in design, a variety of plants have been used as inspiration for biomorphic forms. Furthermore, a number of building designs have been influenced by the beauty of flowers and their fundamental structure and form, which are based on simple geometric shapes (Čučaković et al., 2018). Natural forms serve as a wealth of inspiration for designers, who can then adapt them to match architectural applications and enhance the design's aesthetic and functional effectiveness. According to the study by Bijari et al. (Bijari et al., 2025), they mention five imitation levels of biomimetics, such as Shape, Material, Construction, Process, and Function. Patterns can also be transferred from biology to architecture at three different levels: direct form inspiration, pattern recognition, and the functional level. However, according to Biomimetics, the most crucial factor of all is shape (Vincent, 2009). In this study, the shape and geometry of petals are abstracted to generate ideas for booth pavilions that can be used in exhibitions. In contrast to previous studies, this work positions floristic morphology within computational thinking. This allows the abstraction of floral principles into algorithmic rules for practical ways of using these techniques to create pavilion design geometries. Through computationally generated floral forms, this study contributes to architectural practice through a methodological framework.

Florism: understanding the petals

Petals have complex patterns and come in a variety of sizes, shapes, and arrangements. By emulating the sculptural beauty of petals, producing organic and flowing shapes, adding an artistic touch, and providing the illusion of being surrounded by the splendor of nature, these characteristics can open the way for the creation of curved architectural elements, such as curved walls, roofs, or facades (Fonseka & Romanov, 2025).

The different parts of the petal can be identified as: The broader upper portion called the Blade, the lower, narrower portion called the Claw, and the furthest end portion called the tip or apex. Based on the number of petals, floral morphology can be divided into: Trillium (Three petals), Cruciform (Four petals), and Pentamerous (Five petals). For design feasibility, the study is limited to Actinomorphic flowers with pointed tips that exhibit greater symmetry. Figure 3 shows the labelling of different parts of the petal and the arrangement of petals behind the aforementioned categorization.

Design abstraction

For a visual thinker, abstraction necessitates handling a variety of representational genres and forms outside of drawing, sketching, and modeling; this typically happens during the translation process between these representational forms. As a result, perceptual interpretations are necessary. For example, students studying architecture are taught to visualize their ideas using various kinds of representation and to develop visual interpretations. And as they continue to use these techniques, they cultivate their visual interpretation, which ultimately establishes their design-centric approaches to abstract ideas (Öksüz & Çağdaş, 2020). The goal of design abstraction is to derive design expressions from the logic of nature. The polygonal area layered over the petals (Figure 3) may become the pavilion's ceiling plane during the process of instinctively identifying design concepts from the way things appear, and the Blade and Apex components can be moved to create a wall plane. One potential source of structural support is the petal's apex, which reaches the ground plane. This would produce an enclosure and surface that are dynamic and undulating.

The Cruciform configuration has been chosen for further investigation. This was not drawn at random; rather, the fourfold geometries are easier to tessellate on multiple planes without being interrupted by an additional geometry of a different nature (Dabbour, 2012). The output is intended to create a design for a booth pavilion at an exhibition; hence, a geometry with modular properties, suitable for repetition, would be an appropriate choice.

DECOMPOSITION AND PATTERN RECOGNITION

Decomposition techniques are called divide-and-conquer strategies. The goal is to break down a design problem into sub-problems and then solve them individually (Riley & Hunt, 2014). As a crucial step in computational thinking, the conditions and objectives of the exercise determine the methodology by which decomposition occurs. The framework for decomposition in the design discipline is determined by the product, the process, or, occasionally, by a negotiation between the two (Rich et al., 2019). Some common strategies for decomposition include breaking down 3D into 2D elements, Grip mapping, decoding an element to its point level, etc. As a Biomimetic exercise, the decomposition in this context leads to subcategories such as: Practical constraints, Geometrical limitations, modelling, and visualization.

The angle between the wall enclosure and the ceiling plane, the ceiling height, and the area dimensions are the usual practical requirements for an exhibition booth. Functionally, the design iteration needs to meet the live dimensions, Structure, Spatial enclosure, Accessibility, Scale, and Proportion to improve adaptability in the exhibition environment.

To facilitate a smooth surface transition from the ceiling plane to the wall plane to the centralized anchor on the ground plane, understanding the parameters and their limitations is necessary. While decoding the overall form into individual 2D surfaces, the conversion of ceiling planar surfaces into a mesh determines the mesh as a base element for further manipulation.

Compared to surfaces, meshes are inherently faster for the computations required to display geometry. Considering this limitation, the second step in decomposition is to convert the surface geometry into a mesh, as it may be easier to model a complex shape using this representation. The next step is to understand the mesh geometry's vertices and their role in mesh relaxation. This relaxation facilitates the manipulation of the mesh to model the desired form through design abstraction. As far as pattern recognition is concerned, symmetrical geometry offers an inherent advantage for solving the mesh manipulation on one side and repeating it on the remaining sides to complete the modelling. Besides repetition, common strategies for pattern recognition in architecture include modularity, sequence, interrelationships, loops, grouping, and randomness (Domínguez-Gómez & Celis, 2024).

ALGORITHMIC CONFIGURATION

The algorithm conveys the design's information in an abstract way; only when we execute the program with particular values for its parameters will we achieve a concrete correlation (Branco et al., 2022). Algorithms play a crucial role in establishing relationships among design parameters in the computational design process. The interface of traditional code/computation syntax is the main source of difficulty for designers. Scripting in Python, or coding in C++ or Fortran, are examples of traditional programming interfaces that have not yet reached the degree of abstraction designers are used to. In an effort to convert their language into computer code, designers have had to rely on a group of computational specialists. The translation may lose much of the meaning. But with advancements in the Graphic User Interface like Grasshopper software, a significant obstacle has been overcome (Cantrell & Mekies, 2018).

Visual programming

An algorithmic, script-based form-making approach uses visual programming and coding systems to create, modify, and control geometry as part of parametric design workflows. Instead of manually modeling every geometry, designers employ a variety of algorithms and scripts to produce rich, complex, and dynamic architectural designs. Computational design relies on the designer's specification of connections, actions, and inputs that produce forms that bind to the input data. Scripting forms is a design philosophy that sees algorithms and coding as both a technical technique and a means of encouraging creativity.

Competency to work with visual algorithmic tools such as Grasshopper 3D is imperative for architects in the era of the digital paradigm. The contribution of these tools to the environment, function, and aesthetics makes it unique in the field of design. It facilitates the modeling and visualization of building forms that naturally have intricate architectural expression, geometry that captures the beauty of nature, and a distinct spatial experience influenced by its sculptural volumes (Abbasi, 2025). After design abstraction and decomposition of larger datasets into smaller components, the preset components in Grasshopper help configure an algorithm to develop the desired design outcome. To create scripts for design applications, it is essential to comprehend the elements of a node-based interface, data structures, and methods for manipulating data. Especially in the concept of generative design, every aspect of design is conceived as data, and knowledge on the data flow and its management will help designers avoid stifling the parametric behavior of the

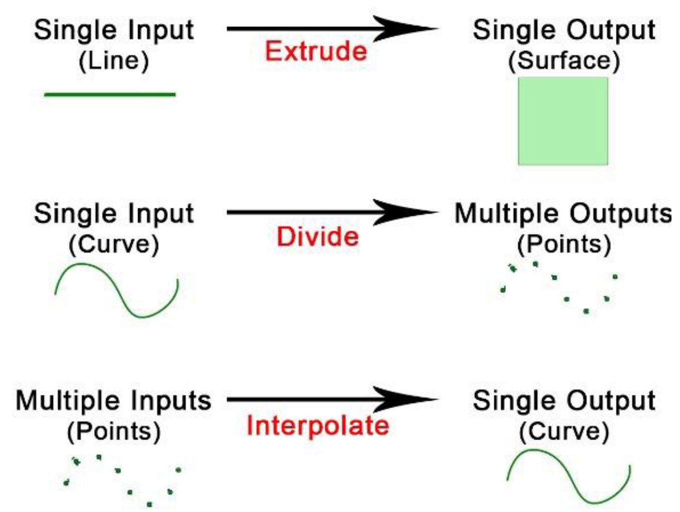

Figure 4. Data Management in the Grasshopper tool.
Source: Produced by the authors.

programming. Otherwise, an error while iterating design options may occur. In order to reform the design in the feedback loops, the algorithm uses a collection of variables and a set of relationships that define a form that can be changed by adjusting certain parameters and setting data (Rashid Dabre & Khan, 2024).

Data structure

The components in the Grasshopper interface will generate output data based on the input supplied by the designer. The Graphical user interface associated with this tool provides data visualization through a simultaneous preview. Based on geometrical articulation, there are three ways data is manipulated: 1 Input datum gives 1 output datum, 1 input datum gives many output data, and many input data give one output datum (Figure 4). In Grasshopper 3D, the flow of data is visualized as a Data tree.

Designers may interact with geometry using Grasshopper not just as a shape but also as a result of relationships, logic, and data. Understanding these data structures and how they are managed through lists, trees, branches, and paths is therefore essential to computing a design. Layered logic, selective data filtering, and feedback loop architecture allow each branch to contain a list of design parameters, such as objects, points, curves, and surfaces, that may be accessed individually or globally (Hassanzadeh, 2025).

FIRST ABSTRACTION: INTERPRETING FLORAL GEOMETRY TO BOOTH DESIGN

A systematic workflow was designed after performing abstraction and strategic decomposition of floral geometry to fit the pavilion design's topology. At every stage, the components of Grasshopper 3D were utilized to decompose every geometrical parameter into vertices and points. For instance, the base geometry is converted into triangulated meshes. The vertices of the mesh geometry were visualized using the Naked vertices component. The visualization of these vertices served as a reference for further mesh manipulation. The mesh vertices can be categorized into two: Naked points and Clothed points. Naked points are the set of vertices that correlate with the mesh edge, whereas the clothed points refer to the vertices surrounded by the faces generated by the mesh edges.

For Mesh Relaxation, the naked points must be structured and categorized based on the number of mesh edges. The Naked points, as an output, will have all the points in a consolidated list without any categorization based on edges. Hence, to perform the categorization, a distance-based mathematical operation was carried out (Figure 5a). All the naked points are pulled towards the edges and listed using distance as the sorting strategy. This, however, had disrupted the order (Figure 5b) and randomized the points' arrangement of the points. Hence, the Sort Along curve component helped rearrange the points according to the direction of the curve: the direction of the edges of the curve along which the points are sorted. Mesh Relaxation is performed using the Kangaroo Physics plugin. Kangaroo Physics, the most popular plugin, operates on the concept of a particle-spring system, in which all objects are represented as sets of points, each characterized by location, mass, and velocity. Consequently, interactive models with parameters that alter geometry in real-time may be developed (Chéraud, 2020). There are two main components in this simulation engine: Goal objects and Solver. Hence, the process is to extrapolate the appropriate goal objects and feed them into the solver component. Similar to floral geometry, the Naked points along each mesh edge are shifted in an undulating way towards the ground plane. These locations will serve as anchor points for mesh relaxation. Nevertheless, the simulation demonstrates that the booth's roof-ceiling design is also changed, moving towards the ground plan and obstructing the users' minimum height clearance (Figure 5c). Thus, two sets of anchor points, the wall plane and the ceiling plane, were used to loosen the mesh. To guarantee the height clearance for the booth design, the clothed points are secured in the same spot.

The final enclosure of the booth pavilion design, based on the number of petals, is shown in Figure 5d. The Biomimetic-based surface design's visual effect may fully satisfy people's utilitarian demands while also being warm and visually responsive, symbolizing humans' innate and inseparable connection with nature. The visual scripting developed for this configuration is shown in Figure 9.

SECOND ABSTRACTION: INTERPRETING FLORAL GEOMETRY TO BOOTH DESIGN

This design abstraction differs from the previous iteration, where the roof plane is disjointed from the wall plane. The

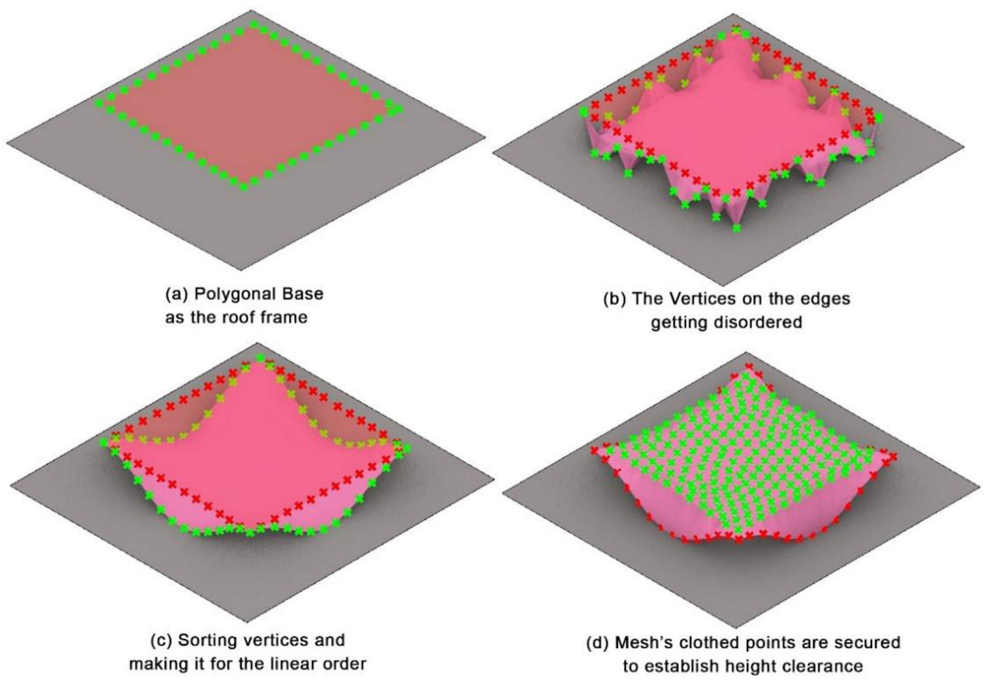

Figure 5. First Design Abstraction. Source: Produced by the authors.

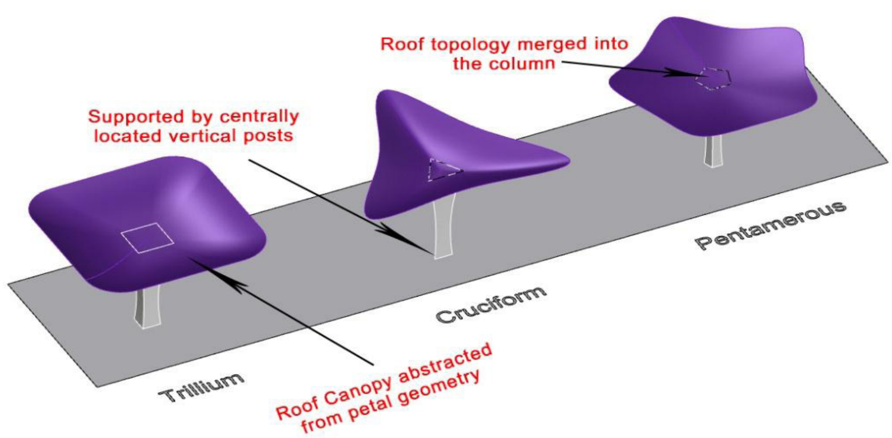

Figure 6. Second Design Abstraction. Source: Produced by the authors.

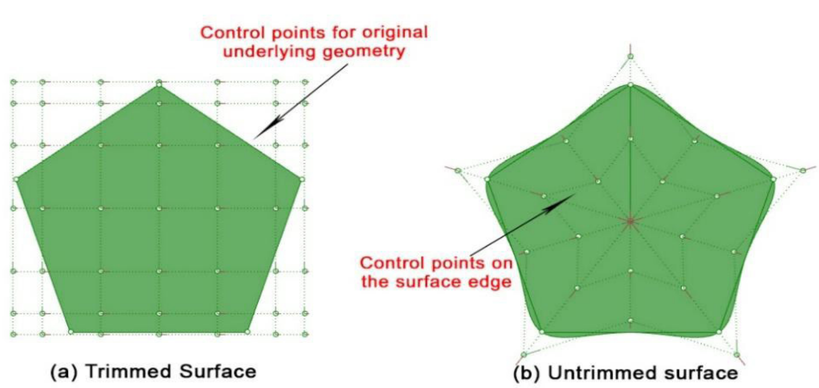

Figure 7. NURBS Surface generation in Rhino. Source: Produced by the authors.

geometry of the roof design is derived from all three parts of the petals, i.e., Claw, Blade, and Apex. In this abstraction, the design parameters of the pavilion roof, such as geometry, surface curvature, and edges, are abstracted directly from the petal geometry without any transformation rules, unlike in the first abstraction (Figure 6).

To support the roof canopy, as suggested by Amancio Williams's design ideas (Müller, 2013), the roof perimeter is merged with the column, whose polygonal shape is defined by the number of petals chosen for design abstraction. The outputs shown in Figure 6 were modelled in Rhino, and the roof's curvature was articulated using control points on the roof surface.

As far as the control points of the surface are concerned, there are two ways in which the control points get laid over the geometry. It depends on whether the surface is trimmed or untrimmed. Typically, surfaces with non-rectangular edges are trimmed from an original underlying geometry to accurately represent it (Figure 7). However, by enhancing the geometry, untrimmed surfaces provide superior control points for maintaining the edge shape. As a result, untrimmed surfaces are employed to model the roof and its curvature. However, the roof surface without wall planes, when supported by the centrally located column, does not offer an essential level of enclosure for the booth pavilion due to the absence of wall planes. Hence, Design abstraction from the first iteration is chosen for further comparative analysis.

COMPARATIVE ANALYSIS: CONVENTIONAL BOOTH VS BIOMIMETIC BOOTH

This section of the study compares and evaluates the design efficiency of the resultant outcome with that of the design under the traditional design approach.

To maximize trade show performance, exhibitors employ a variety of methods to attract attendees, as trade exhibitions are an essential part of business promotion. The booth's design is one of the most important strategies for appeal. A key component of the trade show marketing plan is an effective booth design (Bloch et al., 2017).

After examining the different types of trade show booths, such as Inline booth, Custom booth, Peninsula Booth, Island Booth, Walk-through exhibition stand, and Multi-story exhibition stand (King One Design, 2022), it has been observed that this information focuses much on the layout and planning rather than the architecture of the booth pavilion as a whole. The booth typically follows a standard shell approach, resulting in a box-like structure with an uninviting design, aesthetics, or enclosure. The wall, flooring, and ceiling surfaces are planar in nature and are implemented with preset poles and panels made of standard materials such as aluminum, plastic, and timber (Figure 12a). A designated area defined by main and sub aisles for user movement will be provided to exhibitors, and the boothscape's design is limited by this context (Morsi et al., 2023). Hence, the planar vertical surfaces to determine the enclosure of the booth are inevitable. However, incorporating digital design principles such as computational design, Biomimetic design, and a parametric approach may help suggest design alternatives with an impactful level of interest and aesthetic value.

The florism-inspired booth designs (Figure 8) challenge the design approach involved in the conventional booth setup procedure and simultaneously offer great potential for optimized marketing and visitor circulation. This approach tends to address the real architectural aspects of the booth enclosure rather than focusing solely on planning and the layout of booth decorative elements such as digital boards, advertising stands, and display areas. Geometrical characteristics such as undulating surfaces, sweeping curves, and alternate structural layout enhance the visual impact, aesthetic appeal, and functional efficiency of the boothscapes. As a result of undulating wall surfaces meeting at the corner, creating a dynamic opening for access points, it will promote the easier influx of visitors into the booth, thereby increasing footfall. In addition, there are no vertical poles at the corners for structural support, allowing unhindered access. The load of the ceiling plane can be transferred to the wall surfaces, which are anchored in the middle. Additionally, the design of these booths exhibits modular behavior that can be replicated in an exhibition space if necessary. The symmetrical enclosure with corner openings encourages partitioning a single booth into two or four smaller areas, depending on the exhibitor's space needs (Figure 12b).

DISCUSSION AND ANALYSIS

The florism-inspired shape leads to ideas that transpire into an enclosure and spatiality that rethink the usual method of setting up exhibition booths. The forms taken from petal morphology display a greater degree of accessibility, visual impact, modularity, and artistic value than existing boxlike structures that have compromised functionality. However, biomimetic forms alone cannot address the sustainability issues associated with exhibition booths, especially the mindless discarding of the structure after the show. Attempts to use a pavilion made out of low-impact materials, such as cardboard, tires, and paper, will not be a sustainable solution unless the design and assembly method encourage exhibitors to dismantle and reassemble it whenever required. Hence, only when a system of assembly and sustainable materiality is embedded in biomimetic approaches, will it generate a holistic solution to facilitate the concept of circular economy in regard to booth structures. In Figure 10, the

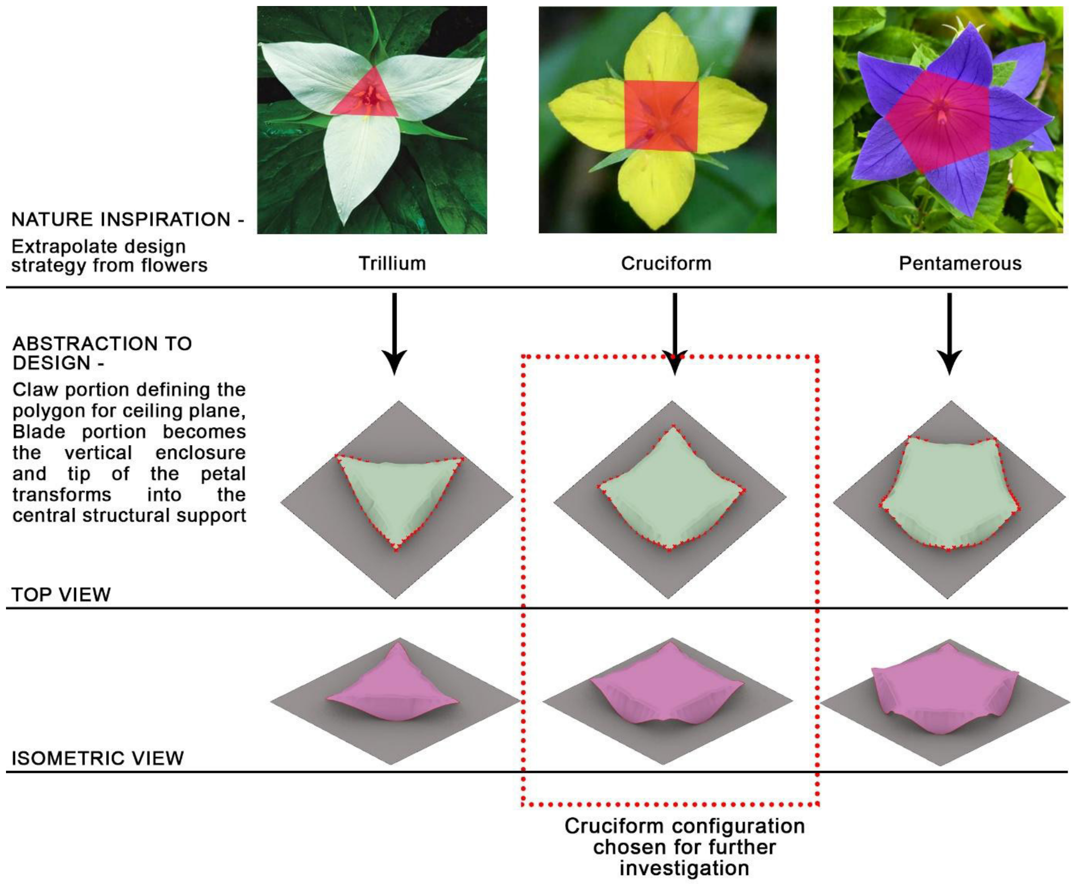

Figure 8. Abstraction to Design Application. Source: Produced by the authors.

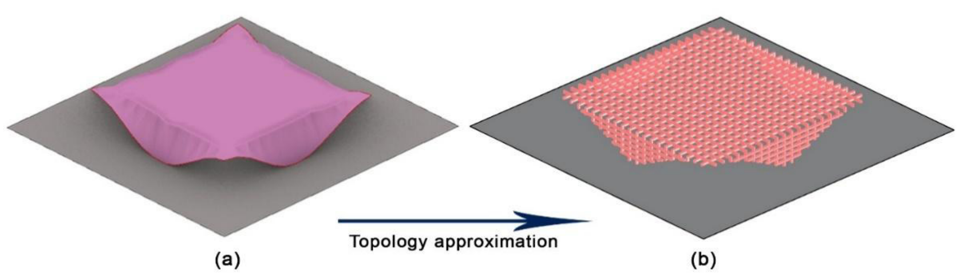

Figure 9. Grasshopper script. Source: Produced by the authors.

slotted approach is based on a bi-directional strategy, in which the 3D geometry is formed from planar parts that are slotted together. To assemble and disassemble, the local elements can be slotted and un-slotted, a technique known as waffling (Tedeschi, 2020). This method not only approximates the design geometry but also increases the form's structural rigidity, allowing it to stand on its own. The upper surfaces of these segmented pieces would serve as built-in display areas for the pavilion.

Material strategies should be considered an integral component of the design process, focusing on lightweight, reusable, and modular components to create an assembly-and-reuse system, in line with circular design principles. This study demonstrates how flower-inspired pavilion design can advance both aesthetic innovation and ecological responsibility, when linked with computational approach, sustainable material strategies, and dismantlable-reusable systems.

VISITOR FLOW SIMULATION

The purpose of the visitor flow simulation was to determine the accessibility and circulation efficiency of the user movement in relation to the design layout of the florism-inspired design outcomes. These factors are

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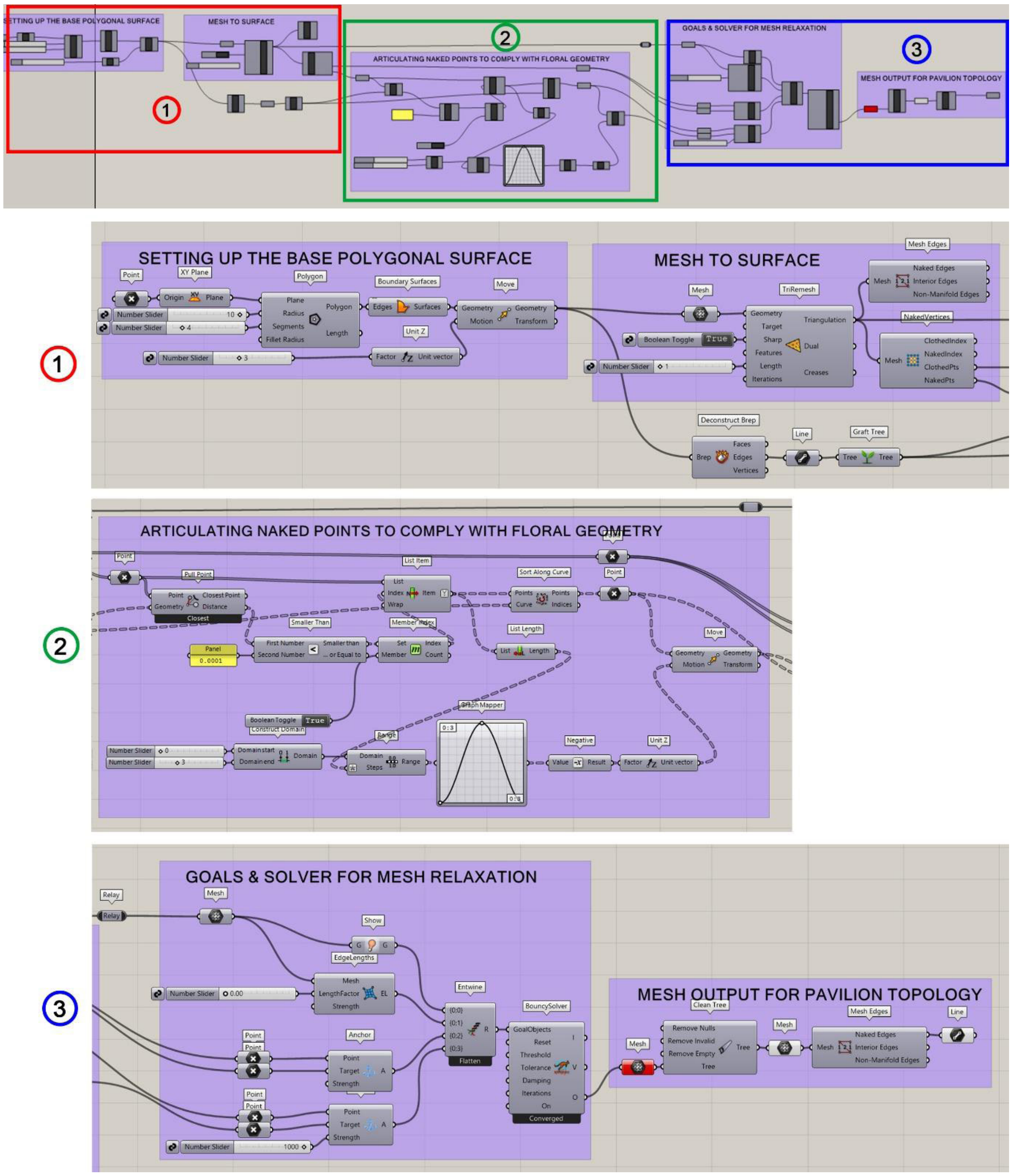

Figure 10. Bi-directional contouring for topology approximation. Source: Produced by the authors.

responsible for enhancing the overall user experience within the pavilion-built form. Neos Explorer, an agent-based simulation tool, was used to conduct the analysis. Using points of interest and avoiding obstacles, hypothetical visitors are modeled as dynamic agents that travel from the starting point to the destination points. Figure 11, which treats the island exhibit area and wall panels as a set of obstacles, displays the simulation of the agent trajectories. The mapped trajectories visualize the directional flows, stagnation points, and density zones within the layout.

In Figure 11c, high-density clustering can be seen near the entry and exit points, indicating potential congestion, while others (Figure 11a and 11b) show relatively low, gradual dispersion. According to these findings, a pentamerous design with more than two entry and exit points may cause congestion and improper directional flow, even though corner openings, a crucial component of florism booth designs, provide stronger spatial cues and draw visitors.

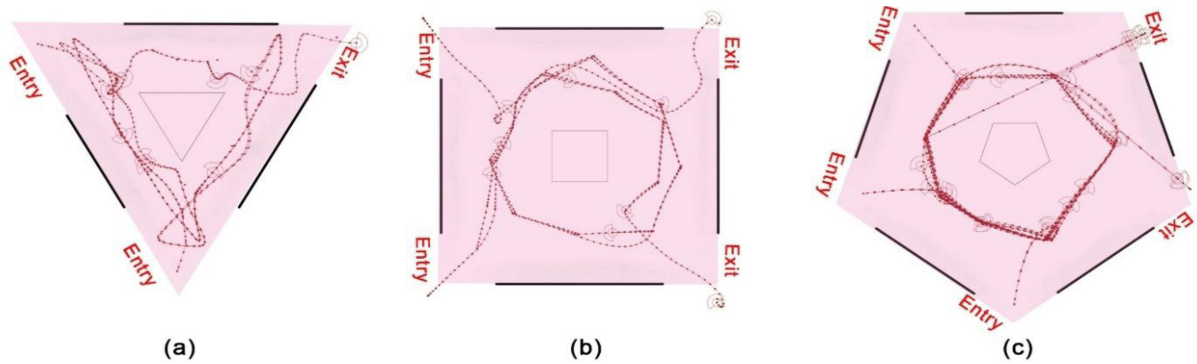

Figure 11. Trajectories: Visitor flow analysis. Source: Produced by the authors.

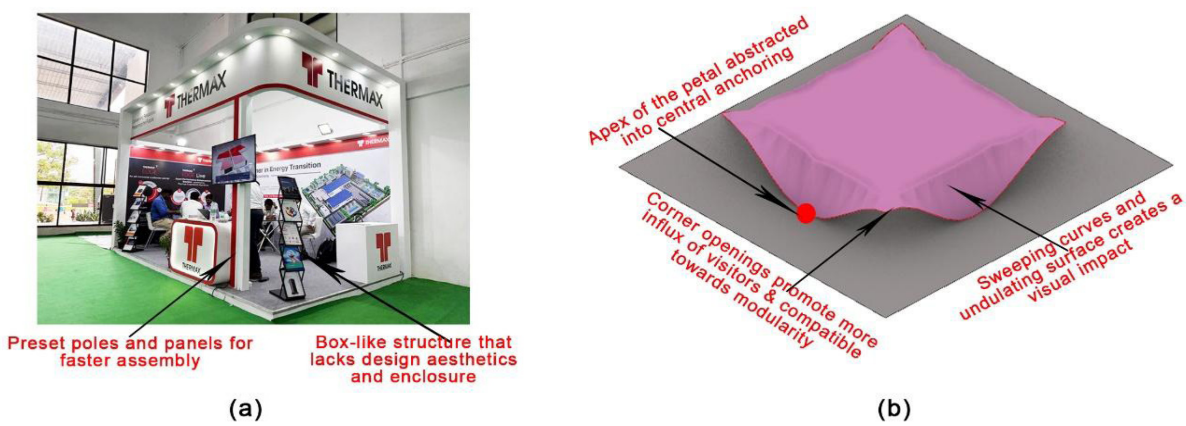

Figure 12. Conventional Booth design and Florism inspired Booth design. Source: Produced by the authors.

Strategic widening of the form, planning of access points, and contextual design adjustments, such as reorientation of exhibits to avoid flow diversion, need to be considered.

CONCLUSION

The practical application of the Biomimetic approach and tools helps designers to ideate and create space, volumes, and surfaces for the built environment. The cognition underpinning creative thinking is streamlined when adapting the design abstraction from Biomimetic principles. Such implementation creates an unprecedented design outcome with non-conventional geometric aspects, thereby enhancing the object's unique character. In this process, visual programming tools such as Grasshopper 3D aid the thinking process through data visualization in a graphical user interface.

In certain situations, the algorithmic configuration is created to fit the designers' mental concept of the finished product (Walczak, 2017). When attempting generative iterations through an algorithm intended for a singular outcome, this might have certain limitations and lead to errors. In conclusion, it has been noted that a predetermined work environment clearly affects the creative process. Furthermore, the absence of essential computational skills can restrict or even stop the creative process. In a creative process, computation may aid in the construction, revelation, improvement, and development of logic; nevertheless, first technical competencies must be obtained. Because of its distinct geometrical features, the booth design that emerged from the computational workflow offers significant advantages over the conventional design when compared to the Biomimetic conclusion. In addition, the booth design has demonstrated greater adaptability and interior space partitioning, enabling efficient layout and planning.

AUTHOR'S CONTRIBUTION

Conceptualization, M.R.; Data Curation, M.R.; Formal Analysis, M.R. and M.A.; Research, M.R. and M.A; Methodology, M.R. and M.A.; Resources, M.A.; Software, M.R.; Supervision, M.A.; Validation, M.A.; Visualization, M.R.; Writing - original draft, M.R.; Writing - review and editing, M.A.

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