

Implementing a Generative AI Model in the Architectural Concept Development: Context-based Research

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In the context of the continual evolution of advanced architectural design tools, driven by computational and artificial intelligence technologies, the practice of design can now benefit from contextually-driven and iterative design workflows. Thus, computational and AI tools have huge potential to enhance the conceptual design processes in architecture, due to their advanced workflow qualities.

Node-based interfaces of these tools serve as a catalyst, enabling workflows that are adaptable to different requirements and needs of the design processes.

This paper explores juxtaposing node-based computational design and AI tools in a dependent workflow process using Grasshopper3D and ComfyUI, within the framework of an experimental architectural concept development process, through a qualitative Research-through-Design methodology (RtD). Through a series of controlled experiments, multiple architectural design schemes are generated and categorized into four distinct visual identities: blob, biophilic, vernacular, and modern. These categories serve as a comparative framework to evaluate the adaptability and responsiveness of the integrated workflow across different design intentions. The process emphasizes iteration and variation, but with contextual responsiveness, testing a more streamlined refinement process of design schemes.

The findings demonstrate that integrating node-based computational scripting with AI-driven workflows enhances the capacity for rapid iteration, supports the generation of diverse and contextually relevant architectural concepts, and enables more fluid transitions between abstract and representational stages of design. This research contributes to the advancement of architectural design methodologies by implementing a hybrid workflow model that bridges computational logic and generative AI capabilities, showcasing new potentials for concept development in contemporary architectural practice.

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Mimari Konsept Geliştirme Aşamasında Bir Yapay Zekâ Modelinin Uygulanması: Bağlam Temelli Araştırma

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Hesaplamalı tasarım ve yapay zekâ teknolojilerinin gelişimiyle birlikte, bugünkü mimari tasarım süreci artık daha çeşitli yöntemlerle yürütülebilmektedir. Mimari tasarım daha tekrarlayan ve hızla gelişen bir yapıya büründü, özellikle kavramsal tasarım aşaması için bu kaliteleri kullanmak çok önemlidir. Bu bağlamda, hesaplamalı ve yapay zekâ araçları, sahip oldukları yinelemeli iş akışları sayesinde kavramsal tasarım süreçlerini geliştirme açısından büyük bir potansiyele sahiptir. Ayrıca, bu araçların birlikte ve paralel kullanımının, mimari tasarım sürecine kazandırdığı yeni tasarım olanaklarının test edilmesi de önem arz etmektedir.

Bu çalışmada, Grasshopper3D ve ComfyUI programları kullanılarak düğüm tabanlı hesaplamalı tasarım ile yapay zekâ modelinin bir arada çalıştığı bağımlı bir iş akışı süreci incelenmektedir. Araştırma, Tasarımla Araştırma (Research-through-Design – RtD) yöntemi çerçevesinde deneysel bir kavramsal tasarım geliştirme süreci olarak yürütülmüştür. Çalışmanın amacı, farklı iş akışlarını deneyerek hem bağlama duyarlı hem de yinelemeli yöntemlerle elde edilen çeşitli tasarım şemaları ortaya koymaktır.

Bu kapsamda, dört farklı mimari üsluba (blob, biyofilik, yerel ve modern) uygun soyut formlar üretilmiş, bu formlar üzerinden veriler toplanmış ve süreç bütüncül olarak analiz edilmiştir. Elde edilen bulgular, ayrıntılı mimari özellikler barındıran, veriye dayalı ve yinelemeli tasarım çıktılarının kavramsal tasarım aşamasında nasıl geliştirilebileceğini göstermektedir. Sonuç olarak, çalışma mimari tasarım sürecine hem bağlamsal açıdan duyarlı hem de ayrıntılı çözümler sunan yeni bir metodolojik katkı sağlamaktadır.

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1. INTRODUCTION

Design is a manifestation of the human consciousness, logic, and reasoning, where abstract ideas are translated into functional outputs. Crafting effective artefacts that contribute to human-related fields is based on diverse thoughts and concepts brought together. This act of making sense of things and applying logical inferences to develop a product is intrinsic to the nature of human-related practices and workflows.

In the process of developing architecture, the first step is to determine the physical configuration, driven by a design concept that tackles different contextual challenges, examined through detailed analytical and schematic studies, which requires logical inferences as well as diverse referential design inputs to consider. Ching (2015) elaborates that the initial phase of a design process should encapsulate the recognition of a problematic condition and propose a relevant solution. Today's period highlights constantly evolving digital design tools. By incorporating computational and AI capabilities, the benefits of automation, parametric design, and iterative visualization techniques are now accessible to users. They push the design processes towards more advanced approaches with data-driven design capabilities.

One of the most familiar computational tools that is heavily used in the industry is Grasshopper3D, a node-based visual programming interface for Rhino3D, allowing users to construct visual programming scripts through connecting different operational components.

On the other hand, AI tools are still evolving to define significant contexts in the design field. ComfyUI, like Grasshopper3D, operates within a node-based interface. It captures strong capabilities for users to implement generative AI models in various design-related purposes. By employing Grasshopper3D, design schemes can involve direct contextual inputs such as site-specific climatic data, topography, and urban morphology. Then, by using ComfyUI as a further step in the design process, the visual construction of architectural concepts can be achieved in a generative and iterative manner. Moreover, this

dependent process plays as a constant exchange between multiple design schemes and their contextual constraints.

These advantages present a critical opportunity to explore the benefits of both tools in parallel for achieving conceptual design workflows that are relevant to contextual parameters.

1.1 Purpose of the Study

Computational and AI tools encapsulate a huge potential to be utilized for producing data-driven design outputs in relevance to different extracted contextual parameters. The purpose of this research is to explore ComfyUI's Generative AI workflows in parallel with Grasshopper3D scripts applied within a conceptual design process.

This research hypothesizes that integrating ComfyUI's generative AI workflows in parallel with Grasshopper3D's computational design scripting can enhance the conceptual design process by enabling iterative, data-driven design outputs that respond effectively to contextual parameters. Although each tool serves a distinctive design purpose, their combined use has the potential to achieve contextually relevant architectural concepts.

1.2 Scope of Study

The research is a design-specific experimental process, focusing on exploring the tools' potential within the conceptual stage of an architectural design process. Rather than conducting quantitative measurements, the research emphasizes the experimental nature of node-based tools (Grasshopper3D and ComfyUI), within a research-through-design methodology. Moreover, reflecting on the outputs of the experiment qualitatively.

Since the aim is to explore the contribution of the experiment, the method integrates wind environmental data into the design process as a primary contextual parameter for the massing development inside Grasshopper3D, rather than considering broader architectural context considerations, such as site analysis, structural, and other analytical elements, which will require significant data collection and a

documentation process. Afterwards, detailing the massing through AI workflows to achieve numerous architectural schemes.

1.3 Research Questions

Despite observing the integration of AI and computational tools in the architectural practice, their application within the conceptual design in relation to contextual parameters still has frontiers as these tools develop with constant updates. There is a lack of a framework that addresses the contributions of Grasshopper3D and ComfyUI in parallel for developing contextually driven conceptual design workflows. The research questions how computational scripting and generative AI workflows can be integrated in a dependent process to enhance contextually relevant design schemes during the early design and analytical processes.

1.4 Significance of Study

It is significant to explore how the current evolution of AI and computational design workflows could allow architects and designers to construct alternative ways of approaching design processes through a particular node-based interface. Using various custom-made scripts and workflows.

The research will tackle the application of this dual pipeline to establish identities of four deeply different architectural styles, including blob, biophilic, vernacular, and modern approaches. Furthermore, the experiment and the discussion highlight the dynamic role of both tools for the architectural concept development processes, helping to explore multiples of design configurations while also taking the contextual data and qualities into the process.

2. LITERATURE REVIEW

During the industrial era, with the rise of new technological developments and tools, the utopic ideal and narratives prospered, looking for new potentials for architecture, and sparking a re-evaluation of the field in practice.

Martin Heidegger states, “modern technology too is a means to an end” (Heidegger, 1977, p. 5), suggesting that technology’s core value lies in

the ability to serve the human understanding and purpose, which exemplifies the same intent of any other human-made product.

In architecture, architects such as Tony Garnier have envisioned new urban configurations driven by industrial tools and frameworks “The architectural scheme presented here in a long series of plates focuses on the establishment of a new town, an industrial town” (Garnier, 1990, p. 43).

Although the proposal of the “An Industrial City” project was not physically implemented, rather it would be expressed as an experimental approach, the concept affected the urban planning genre as a whole and acted as a reference model, expressing how alternative design thinking would be influential for allocating important insights of future works.

Le Corbusier has also explored how such technological products can lead to a different practical version of architecture (Le Corbusier, 2007), drawing analogies between technological products, such as airplanes, with architecture.

The Archigram platform, aimed to iterate with experimental works of future cities and architecture in a utopic visual intent, reimagining the existing standards of modern configuration.

Although there are no physical outcomes produced by these explorations, they all had an effect by pushing alternative design approaches and mindsets for architecture, driving a new conceptual framework and thinking for solving architectural design challenges.

Computational tools, too, have significantly transformed the way architectural challenges are addressed by reconfiguring the design processes themselves.

2.1 Contextualization in Design Concepts

One of the initial stages of a design is defining the concept behind it. Nigel Cross proposed that, in general terms, a design is an ill-defined problem, relying on the human’s intelligence and unique ability that formulate such designs, “It seems possible to make a reasonable claim that design ability is a form of natural intelligence” (Cross, 2006, p. 22).

The same point is valid for architecture. Architecture encapsulates various models and approaches that could be implemented and applied; each approach relies on a different design thinking, rationale, and philosophy.

These models express how the practice keeps fostering differing alternatives of concluding a design, not only through different paradigms, but also through diverse design methodologies, materials, and tools.

The contextual parameters, such as materials, data, and environmental references, all act as a system for the conceptual process. Each context has particular demands and parameters to be considered within the process. “To illustrate the fact that a great variety of actual building systems can be developed, based on these patterns,” (Alexander et al., 1977, p. 937).

Design tools also play a significant role in aligning the design output to a certain extent. In that sense, the conceptual thinking process plays best in relation to sketch drawings. The digital design tools have been lacking the ability to address contextual parameters during conceptual processes.

2.2 Digital Relevance

As digitalization spread, it gave rise to new paradigms in design. Alan Turing’s concept of the “Turing Machine” laid the groundwork for cybernetics and machine-human communication systems. Opening new possibilities for tools and technologies to be based on computational logic.

In this context, Menges and Ahlquist (2011) address key figures such as Gordon Pask, who emphasized the influence of cybernetics in architectural design, “In the late 1960s, cybernetics, system theory and electronic computers were seen primarily as tools to facilitate the logic of problem solving and decision making in architectural design” (Carpo, 2013, p. 48). Moreover, new design tools evolved, captured in a digital environment, and through a computational framework.

One of the most significant initiatives to apply computational logic in a design tool was the Sketchpad developed by Ivan Sutherland. This digital tool allowed the user to manipulate and play with geometric forms. Chaillou (2022) mentions how it provides flexibility and comfort level for drafters.

The use of digital tools featured new design benefits, due to their unique system that is unbound to the physical world, enabling more efficient design experimentation and iteration, reducing material loss and design prototyping costs. In this framework, Carpo (2017) discusses how the architectural field specifically embraces digital changes sooner than other professions.

2.2.1 Computational Potential in Design Concepts

Later developments in digital design tools advanced computation beyond a static object-based approach, introducing a rule-based system where commands and loops are dynamic and iterative. In here, the dependence of a manual design process mindset changed, and new paradigms developed. Menges and Ahlquist (2011) note computational design as processing internal and external properties. Computational design workflows shaped the modeling process in a new framework for users. Through a visual programming node-based interface that follows logical design processes. Allowing custom-made design scripts and algorithms without the need to manually code. Node-based interfaces, as a type of visual dataflow modelling, can accelerate the process of iterative design approaches, allowing more design possibilities to be explored. Burry (2011) argues that applying this process would force a design to be logically deconstructed to be encoded, emphasizing that designs are constructed as a logical system in this regard.

Computation has also highly benefited iterative design approaches through parametric and generative design workflows. Simulating performances of geometries and forms relative to contextual data, adding an effective contribution to the experimental and optimization phases of design paradigms.

Figure 1 showcases a timeline of developments affecting design approaches. With all these new technologies, the architectural practice

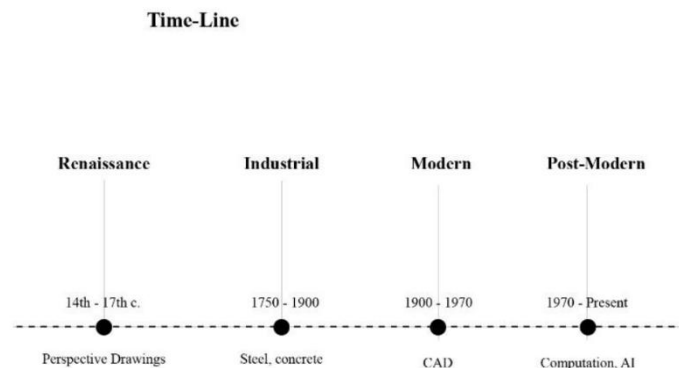
has advanced to aim for contextually adaptive, efficient, and performance-based design outputs.

Menges and Ahlquist (2011) explain computational design's usage as an intellectual investment of alternative material systems. Thus, the design decisions, techniques, and strategies of architectural concepts would now have diverse methods.

Furthermore, Carpo (2013) and Agkathidis (2015) discuss the role of new tools shadowing influential perspectives and the new exploratory approaches in the applied architectural design sphere. Peter Eisenman's image morphing technique expresses this simply by utilizing the potential practical possibilities of the digital image.

Throughout time, the development of design tools contributed to the architectural practice on various practical levels. In this post-modern era, exploring new conceptual design workflows through contemporary tools would open new potentials for addressing contextual properties within the process.

Figure 1: Timeline of developments affecting design approaches.



2.2.2 Generative AI Framework

Just like the paradigm structure of computational design, AI relies on a logic-based framework. Moreover, AI possesses critical potential to advance and diversify numerous architectural design workflows. Its possibilities highly value user control and iterative work.

The key components that make up AI are machine learning and deep learning. Their combination as a system would make the uniform framework of AI. Leach (2022) elaborates their connection through an analogy of onion layers, as deep learning functions as a category under

machine learning, and machine learning under AI. The uses of Generative AI tools in architectural design constantly develop new potential, but the mainstream approach relies solely on a prompt description to generate the output visuals, expressed as a text-to-image workflow process.

Further advancements of AI have reached image-to-image workflows. This includes inserting a base image as an input reference within the workflow, enabling the model to process and modify a base image directly. Bringing a closer relevance to the architectural design process by allowing users to visually detail or further abstract the initial 3D architectural models, sketches, or technical drawings they conduct. The image-to-image workflow allows image manipulation and optimization potential. It can be adjusted according to the user instructions, whether to let the output be closer to the input image or different. In that sense, this step in fact pushes the applications of AI tools to act more practically within the architectural and conceptual design processes. The next section examines necessary AI models theoretically, viewing the main models that are relevant to the overall practical sections of the research.

2.2.3 Generative AI Models Analysis

Diffusion models are an essential model to tackle, specifically focused on image generation. Diffusion model's software architecture employs the U-Net model and other neural network systems, the U-Net model here functions for denoising and reconstruction of data. Its function relies on encoding and decoding, but it is unique in applying noise within the process to produce visual outputs.

There are various diffusion model types existing; they would differ in qualitative aspects according to their properties and performance capacities. Han and Kim (2024) discuss how diffusion models, in applying Gaussian noise inside algorithmic processes, increase visual-related tasks and reduce the computational costs of the processors. Furthermore, examples to mention of a diffusion model type are Stable Diffusion 1.5 and SDXL models, which are unique in their computational efficiency. Stable Diffusion models are one of the most influential AI models in image-related tasks.

All of these are models that suit varying functions. Combining generative AI models under a pipeline process will frame more purposeful outputs. By doing so, the performance and accuracy aspects increase. Wang et al. (2024) concluded a result of how processes of juxtaposing diffusion models with CLIP models would enhance visual understanding tasks.

The CLIP model is also a neural network model that is capable of processing and grasping languages and images together through encoders. VAE neural network is another critical part of the encoding and decoding processes, allowing manipulation of input images. Similarly, Wesego and Rooshenas (2024) conduct another custom implementation that uses diffusion models and VAE frameworks, leading to a higher performance rate of generation tasks.

All these studies showcase a performance push derived from such a combination of AI models within a multimodal generative pipeline. Expressed as a system that combines various Generative AI models uniformly under one workflow. In that sense, ComfyUI allows such a combination of different AI models to achieve a certain output.

3. METHODOLOGY

Computational tools are more familiar with the architectural field, while both keep evolving with new qualities and features. Grasshopper3D is highly used in architecture and design to implement advanced computational workflows. After AI tools were introduced, ComfyUI has increasingly been adopted within architectural design workflows.

The conceptual design processes in architecture include various design studies and analyses, all concerning contextual data considerations. Moreover, the process of form generation and iteration is essential for concept testing and optimization. The methodology gains insight from an experimental process using Grasshopper3D and ComfyUI. Addressing a suitable position of both programs within the design process. The experiment adopts a Research-through-Design (RtD) methodology combined with an experimental qualitative analysis. Wherein knowledge is extracted through the act of designing itself. This

approach facilitates the exploration of contextually relevant and iterative design outputs by interconnecting Grasshopper3D and ComfyUI workflows, allowing insights to emerge through the development, analysis, and qualitative reflection.

3.1 Parametric Modeling Process

Developing architectural concepts requires a wide array of data inputs, parameters, and rules to bind the design accordingly, such as environmental, material, and form relations. Computational design tools enable this kind of relationship between data and form-making. Grasshopper3D is utilized for applying these processes. Thus, the main data reference that will bind the form development within the experiment is prevailing wind data, guiding the configuration of the output form.

By constructing a script that can generate varying geometries and differentiate them according to environmental data references, the conceptual design process can be enriched more in terms of design exploration, form-finding, and form optimization processes.

3.1.1 Setting Geometry & Parameters

The initial step in the procedural node-based Grasshopper3D workflow involves defining a closed boundary curve as the input geometry. This curve establishes the spatial boundaries for the form development, within which the design development will take place.

For introducing environmental responsiveness within the conceptual process, the script integrates nodes that contextualize prevailing wind data from a specified location. This environmental input serves as the primary data-binding parameter in the design logic.

A surface grid is then generated, driven by varying numeric input values. Afterwards, setting up the environmental context, i.e., wind data parameters, using the Ladybug tools plugin. The next step involves establishing rule-based logic to guide form development and variation in response to prevailing wind direction (Figure 2).

Figure 2: Setting up the base surfaces and environmental parameters.



3.1.2 Form Optimization & Synthesis

The next phase focuses on optimizing the design within Grasshopper3D by configuring parameters that enable dynamic manipulation of the form. This portion of the script directly influences the grid's spatial arrangement behavior. In that sense, constructing a line perpendicular to the wind direction, and using it to position the 3D form to face the prevailing wind vector. This sets a rule that can arrange the surfaces in a specific growth pattern. The logic identifies the surfaces closest to the axis line and removes the more distant ones using a culling mechanism. This form development progresses to generate four output variations, each of which increases in size, from a volume of 4,800 m³ for the smallest, reaching 8,800 m³ for the largest. Each form iteration will represent a specific architectural style in the further steps of the experiment. Figure 3 showcases the outputs of four parametrically driven form variations generated.

In the next section, the focus will shift to finetune these base forms by applying architectural features, stylistic refinement, and visual articulation using advanced generative AI workflows within ComfyUI.

3.2 AI Workflows Development

The design approach involves developing four distinct architectural proposals, each representing a different style and methodology: blob, biophilic, vernacular, and modern. The exploration of these styles extends beyond simple geometric refinement and fine-tuning, but through detailed and iterative architectural visualization of preliminary design concepts.

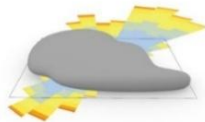
To run a typical image generation workflow inside ComfyUI, it is important to set up the essential AI models, including the Diffusion,

VAE, and CLIP models. Set with other processes under a uniform pipeline.

3.2.1 Form Fine-Tuning Process

There are various diffusion model (DM) types that users could implement within image-to-image ComfyUI workflows. The models that are used in the experiment are Stable Diffusion 1.5 (SD1.5), defined within the first workflow is applied for achieving architectural refinements to further develop the generic 3D form extracted from Grasshopper3D. Furthermore, Stable Diffusion XL (SDXL), is defined for the second workflow for implementing architectural rendering scenes. With the customization capability of ComfyUI, examining the parameters and nodes helped to optimize the outputs and produce relevant content. The most effective parameter in this sense was lowering the denoise rate of the KSampler node. It lowered the model’s effect on the input image. This method produced analogous output contents to the input.

Figure 3: Parametrically-driven form variations.

	Variation 1	Variation 2	Variation 3	Variation 4
				
Volume	4800m3	6000m3	7200m3	8800m3
Style	Vernacular	Biophilic	Modern	Blob

Applying advanced prompt engineering techniques is key to achieving the intended outcomes. For instance, unspecific descriptions won’t help the SD1.5 or the SDXL model to grasp the user’s intentions. Keywords also play a pivotal role in the direction of the output. Furthermore, there are four different prompt descriptions constructed. Each describes a specific architectural type of the four: blob, biophilic, vernacular, and modern styles. By doing so, the outputs of this workflow resemble fine-tuned forms that capture architectural features according to the prompt descriptions. Thus, the workflow is further applied to every form iteration, each iteration is responsible for

capturing a specific architectural style. Figure 4 showcases the first workflow-generated outputs.

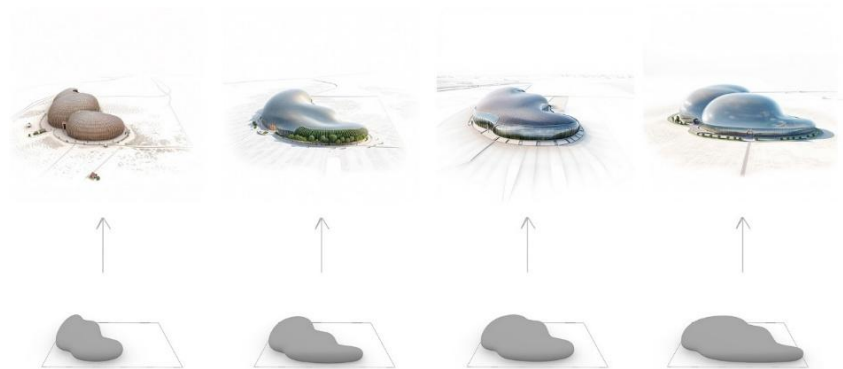


Figure 4: First workflow-generated outputs.

After selecting the fine-tuned versions, the final workflow builds upon them to produce fully rendered architectural visualizations of each style in a more detailed manner. This involves specifying environmental elements, landscape configurations, exterior finishes, and building tectonics before collecting and comparing outputs across architectural styles.

Each output visualizes architectural elements and tectonics for the blob, biophilic, vernacular, and modern architectural approaches. Moreover, each image is inserted as the IPAdapter image reference. The ControlNet and IPAdapter nodes are combined in the second workflow, generating a new form of architectural concept representation that is consistent with the prior design configurations of the first workflow. Figure 5 represents the second workflow-generated outputs.

The following textual prompts were used to guide image generation within ComfyUI across four architectural styles:

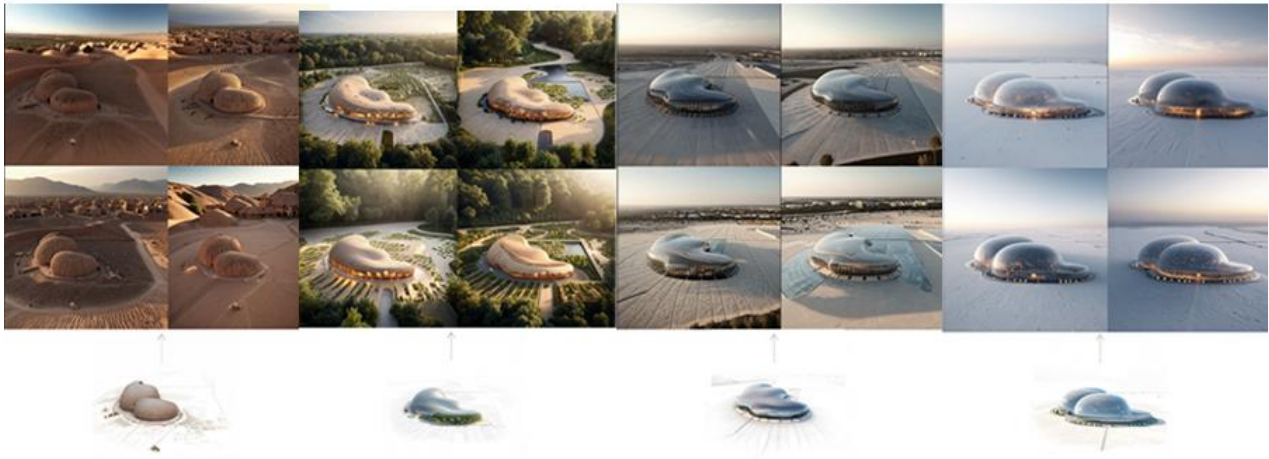
Modern: “photorealistic aerial view of a modern architectural masterpiece, modern architectural elements, modern architectural tectonics, glass curtain walls”.

Blob: “photorealistic aerial view of an architectural masterpiece in a blob style, blob architecture, blob fluid architectural tectonics, glass, curvilinear architecture”.

Biophilic: “photorealistic aerial view of an architectural masterpiece in a biophilic style, biophilic architecture, sustainable biophilic architectural tectonics”.

Vernacular: “photorealistic aerial view of an architectural masterpiece in a vernacular style, vernacular architecture, vernacular local architectural tectonics”.

Figure 5: Second workflow-generated outputs.



4. DISCUSSION

The four architectural styles were represented through a coherent visual narrative and were relevant to the set inputs. However, some outputs exhibited inaccuracies such as illogical site or architectural configurations, or even spatial relationships. These outputs were subsequently filtered out to ensure the integrity and relevance of the results. The textual prompt inputs had a significant influence on shaping the visual and stylistic outcomes of each architectural style. The modern prompt, emphasizing glass curtain walls and tectonic precision, characterized by a clean geometric configuration. The blob-style prompt focused on fluid and curvilinear tectonics, producing organic forms. The vernacular prompt visually expressed regional materiality and contextual adaptation, yet occasionally mixed specific cultural references. The biophilic prompt encouraged integration with natural elements, resulting in outputs that emphasize greenery and organic integration. These outputs highlight how prompt formulation serves as a key design parameter for the user.

The overall experimentation demonstrated a harmonious integration between Grasshopper3D and ComfyUI, enabling the generation of numerous architectural outputs until a visually and conceptually impactful scheme emerges, one that aligns well with the design intention and the contextual inputs.

While both tools allow for diverse uses, the applied experiment was intentionally framed to establish a dynamic relationship between their workflows. The first workflow phase conducted in Grasshopper3D focused on generating varying massing geometry that adapts to the wind data, playing as the main contextual input to bind the form development. The second workflow phase executed in ComfyUI, enriched these raw masses with visual qualities through AI-based rendering. The Stable Diffusion 1.5 model was employed in the first ComfyUI workflow to introduce architectural detailing to the massing, whereas the SDXL model was utilized in the subsequent workflow to enhance the visual realism. The results of using Grasshopper3D and ComfyUI within an interconnected process highlight beneficial design potentials. Facilitating rapid, iterative, and contextually relevant explorations during the conceptual stage of architectural design processes. Figure 6 represents the used Grasshopper3D script and ComfyUI workflow.

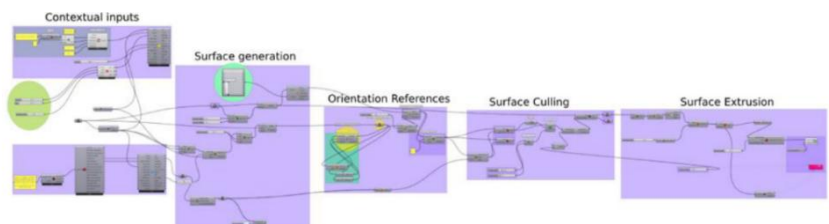


Figure 6: The used Grasshopper3D script & ComfyUI workflow.

5. CONCLUSION

In summary, conceptual design processes involve extracting contextual data, conducting analysis, referencing relevant information, and exploring different design schemes through various approaches. New technologies and tools have further supported achieving these qualities, evolving advanced workflows for setting contextual parameters within the design development stage.

This research contributes to the field by demonstrating a framework that integrates node-based computational scripting (Grasshopper3D) with generative AI workflows (ComfyUI) to enhance conceptual design development. The study demonstrates that such integration enables aligning contextual data into the generation of various design schemes, in a high-quality visual representation during the early design phases. The node-based interface of both tools provides an adaptable environment for developing customized workflows, allowing to link parametric processes, data, and AI-visualization within a harmonious process.

The main contribution of this research lies in establishing and testing a hybrid design method that bridges parametric modeling and AI-based image generation. The experiment conducts incremental steps. Firstly, developing raw 3D form iterations within Grasshopper3D that are driven by an environmental parameter, achieving data-driven and contextually relevant geometries.

Afterwards, by implementing two ComfyUI AI workflows to detail these raw 3D forms and fine-tune them. The first workflow adds architectural features to the forms, while the second workflow generates an overall rendering scene according to a given prompt description. Relevant to four distinct architectural styles and methods. From blob, biophilic, vernacular, and modern styles.

The research acknowledges several limitations. The visual outputs from the AI-based workflows occasionally showcased structural or proportional inconsistencies, reflecting the current limitations of the used AI models. Additionally, the scope of the study focused primarily

on visual and context-related aspects rather than detailed spatial or technical performance qualities.

For future research, further exploration could involve integrating quantitative evaluation methods, such as other environmental data, in a more documentative manner. Also, in expanding the workflow processes to include the latest AI models or multi-modal pipelines. Ultimately, this study underscores the benefits of node-based design workflows, their modularity and flexibility, allowing users to construct dynamic workflow systems for the early architectural design processes. Bridging the qualities of computational scripting to achieve contextually relevant geometries and AI-based workflows to achieve iterative and detailed architectural representations.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

Author Contribution

Zeyd Elabbasi (First Author - 80%): literature review, methodology, experiments, writing, computational and AI workflows implementation, analysis and original manuscript preparation.

Çağda Özbaki (Second Author - 20%): methodological guidance, supervision, review and manuscript editing.

AI Use Disclosure

The authors declare that generative AI and AI-assisted tools were used during the preparation of this manuscript solely for language editing, improving clarity, and refining the structure of the text. These tools were not used to generate scientific ideas, conduct analysis, interpret data, or produce original research content. All intellectual contributions, research design, and conceptual development presented in this study are the sole work of the authors. The authors carefully reviewed and validated all AI-assisted outputs and take full responsibility for the accuracy, integrity, and originality of the final manuscript.

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