

ИЗКУСТВЕНИЯТ ИНТЕЛЕКТ В АРХИТЕКТУРНОТО ПРОЕКТИРАНЕ: ТРАНСФОРМАЦИЯ НА ПРОЕКТАНТСКИТЕ МЕТОДИ И УСТОЙЧИВОСТТА НА АВТОРСТВОТО

Ши Руюу

ARTIFICIAL INTELLIGENCE IN ARCHITECTURAL DESIGN: TRANSFORMATION OF DESIGN METHODS AND THE PERSISTENCE OF DESIGNER AGENCY

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Abstract:

Currently, artificial intelligence (AI) technology is gradually entering various industries, including architectural design, and AI has significantly impacted the design process and methods. In contemporary architectural design, parametric modeling, generative design, and AI-assisted concept generation are collectively changing design tools and workflows, but the computational mechanisms they rely on and the ways in which they intervene in the design process are not the same. However, the impact of AI on architectural design methods still lacks systematic discussion and research, especially at the level of design logic and decision-making mechanisms. Furthermore, the role of designers under the influence of AI remains controversial. This study explores how computational design and artificial intelligence-assisted methods can be integrated into the architectural design process from the perspective of experimental design. Through literature analysis and case studies, it analyzes how the design process has shifted from an experience-driven linear model to a data-driven, algorithm-generated, and iterative feedback system. This study argues that although artificial intelligence plays an increasingly important role in contemporary design processes, it cannot replace the role of designers. Instead, it assists designers in judgment, selection, and control during the design process; the decision-making power remains with the designer. Moreover, future architectural design may exhibit a more pronounced trend of human-machine collaboration.

Keywords:

Artificial Intelligence; Architectural Design; Design Methods; Generative Design; Human-AI Collaboration

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1. INTRODUCTION

Artificial intelligence (AI) technology is entering various industries, including architectural design. With the development of digital computing technology and artificial intelligence, methods such as parametric modeling, generative design, structural optimization, and environmental analysis have gradually entered the architectural design process, changing some traditional working methods. These methods rely on different technological mechanisms and therefore cannot all be directly categorized as artificial intelligence. As AI capabilities improve, the question of whether it can replace the designer's role has gradually become a topic of concern in the architectural industry and academia [10, 11].

Although AI plays an increasingly important role in design, its role is still mainly reflected in computation, generation, and auxiliary analysis. On other levels, AI also has significant limitations. For example, AI cannot independently judge non-quantifiable issues such as aesthetics, culture, value judgments, and social responsibility; it cannot independently complete the screening, integration, and final decision-making process when faced with a large number of generated solutions [9, 11]. Therefore, AI can assist designers in judgment, selection, and control during the design process, but the decision-making power remains in the hands of the designers. In the future, architectural design may exhibit a more pronounced trend of human-machine collaboration.

Based on these considerations, this study examines how AI is changing architectural design methods and analyzes why designers retain a central role amid continuing technological development. It also considers the growing importance of human-machine collaboration in the future of architectural design.

2. IMPACT OF COMPUTATIONAL AND AI-ASSISTED METHODS ON ARCHITECTURAL DESIGN

Digital computing and artificial intelligence have provided new tools for architectural design and have also changed some design methods and workflows. Traditional architectural design typically relies on the designer's experience, gradually forming a scheme through sketches, models, and iterative revisions, resulting in a highly linear process. Computational design and AI-assisted design, on the other hand, make greater use of data, algorithms, and rapid feedback, enabling the design process to explore multiple possibilities simultaneously and continuously adjust based on evaluation results [6, 7, 10]. While parametric design, generative design, and AI-assisted design can be combined, they rely on different technological mechanisms. This section will compare the traditional design process with computational and AI-assisted design processes, and analyze how design work has shifted from a relatively linear scheme development approach to an iterative process that includes generation, evaluation, and feedback.

2.1. Traditional Design Process

Traditional architectural design relies heavily on the architect's experience and intuition, following a linear process. Designers typically develop design proposals based on their professional training and past experience, gradually completing the design through sketches, models, and final drawings. In this process, the designer's experience influences functional layout, spatial organization, scale, and formal expression, among other aspects.

Before the widespread use of digital technology, the architectural design field lacked tools for efficient data analysis and rapid simulation. Many solutions and decisions relied on the designer's long-accumulated knowledge and experience. For example, regarding spatial proportions, pedestrian route design, and building form, designers usually predict and adjust based on their experience rather than comparing numerous results. This approach, which relies on experience to make judgments step by step, is significantly different from computational design and AI-assisted design processes that use computing tools to quickly generate, simulate, and compare multiple solutions.

This traditional design approach is often highly personalized and creative, reflecting the designer's unique aesthetic and way of thinking. However, this approach also has its limitations. For instance, comparing a large number of alternative solutions simultaneously throughout the design process is difficult, and some results are highly dependent on the designer's personal ability and subjective experience.

2.2. Computational and AI-Assisted Design Processes

Digital methods in contemporary architectural design can intervene in the design process at different levels [3]. Parametric design establishes relationships between architectural elements through variables and rules [5, 6]. Designers can set conditions such as floor height, window-to-wall ratio, and facade module; changes in these parameters will synchronously update the relevant parts of the model. Rhino and Grasshopper are representative tools of this type of computational design method [12], but parametric design itself is not necessarily a form of artificial intelligence.

Generative design generates multiple comparable solutions under given goals and constraints [7]. Designers can input functional requirements, area limitations, and circulation and lighting goals; the system then generates different results and provides evaluation information according to preset indicators. Autodesk Generative Design is a representative tool of this method [7, 13]. Compared to parametric design, generative design not only adjusts variables in the model but also searches and compares multiple solutions within a certain range, although the scope of generation still depends on the conditions set by the designer.

Artificial intelligence image generation primarily intervenes in the conceptual expression stage of design. AI image-generation tools can generate images from text prompts, providing designers with visual references for exploring spatial atmosphere and formal directions [8, 10]. However, these images do not provide reliable architectural scale, functional organization, or construction details and therefore require further evaluation and development by the designer [8, 9].

These methods can collectively improve the speed of scheme exploration and feedback, but they cannot be considered the same technology. Designers must define parameters, objectives, or textual prompts according to the operational requirements of each tool and then compare and refine the generated results. The design process thus shifts from the gradual refinement of a single scheme to a cycle of generation, evaluation, and readjustment. Computational systems expand the scope of design exploration, while the designer remains responsible for defining the problem, interpreting the results, and making the final decision.

3. CASE STUDIES OF COMPUTATIONAL AND AI-ASSISTED DESIGN IN ARCHITECTURAL PRACTICE

3.1. Research Method and Case-Selection Criteria

This study employs a qualitative research approach that combines literature analysis with comparative analysis of representative cases. Section 2 analyzes the differences among traditional, computational, and AI-assisted design processes through a review of the relevant literature. Section 3 examines how different technologies intervene in the architectural design process through a comparative analysis of publicly documented cases and an AI-assisted concept-generation experiment conducted by the author. The cases were selected purposefully, corresponding to parametric control of complex geometric forms, algorithmic generation of design schemes, and AI-powered image representation of design concepts, reflecting different ways technology intervenes in architectural design. The cases were selected primarily according to their relevance to architectural design practice, the verifiability of the available information, and their capacity to reveal the working relationship between designers and computational

systems. Zaha Hadid Architects' practice is considered a representative precedent for computational and parametric design, rather than a narrow AI case study; Autodesk Generative Design and the author's AI-assisted concept-generation experiment demonstrate the more direct participation of algorithms and AI in design activities.

To move beyond a descriptive account of technological applications and formal characteristics, this study applies a unified analytical framework to the three cases. The analysis includes the initial conditions provided by the designer, the tasks undertaken by the computational tools, the design results generated by the system, and the stages where the designer re-evaluates and intervenes. The study also examines the changes that different technologies introduce into the design process and analyzes their limitations in spatial understanding, technical feasibility, and contextual judgment. Because the three cases differ in their application objectives and technological levels, this study does not undertake a statistical comparison of their performance. Instead, it compares their roles in the design process to illustrate how computational systems reallocate some design tasks. Within this framework, the case studies are used to examine the study's core argument: computational and AI-assisted technologies can expand the scope of design exploration and improve the efficiency of solution generation, but responsibility for determining design goals, evaluating results, modifying solutions, and making final decisions remains with the designer.

3.2. Zaha Hadid Architects' Computational Design

Zaha Hadid Architects is a representative example of a contemporary architectural firm that uses computational design and parametric methods. As shown in Figure 1, the Heydar Aliyev Center has a continuous curved external envelope. Based on the architectural concept and spatial judgment, the design team established the relationship between the curved geometry, structural segmentation, and skin system through a parametric model, enabling the building form to respond to structural and construction requirements while maintaining overall continuity [14]. Therefore, the parametric model does not generate the building independently of the designer, but rather transforms the design intent into adjustable and coordinated geometric relationships.

In this process, the designer needs to determine the direction of the building form's development and set rules to control curvature, structural networks, and skin segmentation. Parameter changes allow the model to be updated rapidly, generating multiple comparable results. The designer then judges these results based on spatial effects, structural conditions, and implementation requirements, and continues to modify the rules and parameters in the model. As Schumacher points out, “Parametricist urbanism aims to construct new field logics” [2, p. 19]. Parametric methods thus change the way schemes are adjusted, shifting the design process from repeatedly modifying a single form to controlling the relationships between generation rules and their results.

This case illustrates that computational tools handle geometric calculations, model updates, and coordination between different schemes, while the determination of architectural goals and the evaluation of results still rely on the designer. Parametric models can improve the efficiency of controlling complex forms, but their generation scope is limited by predefined variables and relationships, and they cannot independently determine whether the architectural form has appropriate spatial meaning and cultural value. Therefore, this case should not be directly regarded as narrowly defined artificial intelligence design, but rather as an important computational design precedent before the intervention of artificial intelligence in architectural design. The core change it embodies is that the designer's work has gradually expanded from directly shaping a single form to establishing rules, comparing results, and controlling the generation process.



Figure 1. Heydar Aliyev Center (photo by Avisadehh, CC0) [15].

3.3. Autodesk Generative Design

Generative design does not directly provide a predetermined solution. Instead, it generates multiple comparable results based on the goals, constraints, and generation rules set by the designer. In architectural floor plans or office space design, designers can input functional requirements, area limitations, and circulation requirements, and translate performance goals such as lighting into evaluation conditions that the system can process. The computational system generates different solutions within these constraints and compares them using preset evaluation indicators. Therefore, the generated results are not freely determined by the system but are controlled by the goals and rules established by the designer [7, 13].

Compared with the preceding parametric example, generative design is not limited to adjusting a single model; it also involves searching for multiple possible solutions within a defined range. However, the scope of generation still depends on the conditions specified by the designer, and the system is better suited to handling quantifiable objectives. Spatial experience, cultural context, and the value trade-offs between different design requirements still cannot be fully translated into computational metrics. Autodesk Generative Design drives solution generation through predefined rules and algorithms; therefore, it cannot be directly equated with artificial intelligence in every case. This study considers it an intermediate computational approach between parametric design and more explicitly AI-assisted design. The designer's work shifts from conceiving and modifying solutions one by one to setting the generation scope, comparing system results, and making a final choice, but their control over the design direction is not replaced.

3.4. AI-Assisted Concept Generation

Figure 2 presents the selected output of an AI-assisted concept-generation experiment conducted by the author for a small waterfront public pavilion. The author established “flowing space and soft spatial boundary” as the conceptual theme and translated requirements such as openness, natural light, public interaction, and landscape integration into textual prompts, which were submitted to an AI image-generation tool provided by OpenAI [16] to generate the

conceptual site-plan visualization shown in Figure 2. The tool was used solely to generate the preliminary visual material; the conceptual framing, prompt formulation, output selection, and interpretation were undertaken by the author. The purpose of this experiment was not to obtain an implementable architectural solution directly, but to examine how textual design intentions are translated into visual form. The author then evaluated whether the selected output responded to the established theme and extracted spatial clues for further development. Architectural scale, functional organization, and structural relationships would still need to be developed through subsequent drawing and modeling. Therefore, the AI-generated image served as a means of conceptual exploration and visual communication in this experiment, but it could not replace the subsequent development of the architectural design.

Compared with parametric and generative design, AI image generation does not rely on explicit geometric relationships or performance indicators as its primary basis for generation; its results emphasize the visual expression of form and atmosphere. This characteristic expands the scope of conceptual exploration, but it also makes the generated images prone to incomplete spatial logic, unclear structural relationships, or unrealizable construction conditions [8, 9]. The system can quickly combine visual features based on textual prompts, but it cannot independently determine whether an image responds appropriately to site-specific conditions and practical requirements. Designers are therefore responsible not only for formulating prompts but also for identifying useful information in the generated results and translating it into architectural content that can be developed further. This case demonstrates that although AI can participate in design conception, it cannot independently determine the final design outcome.

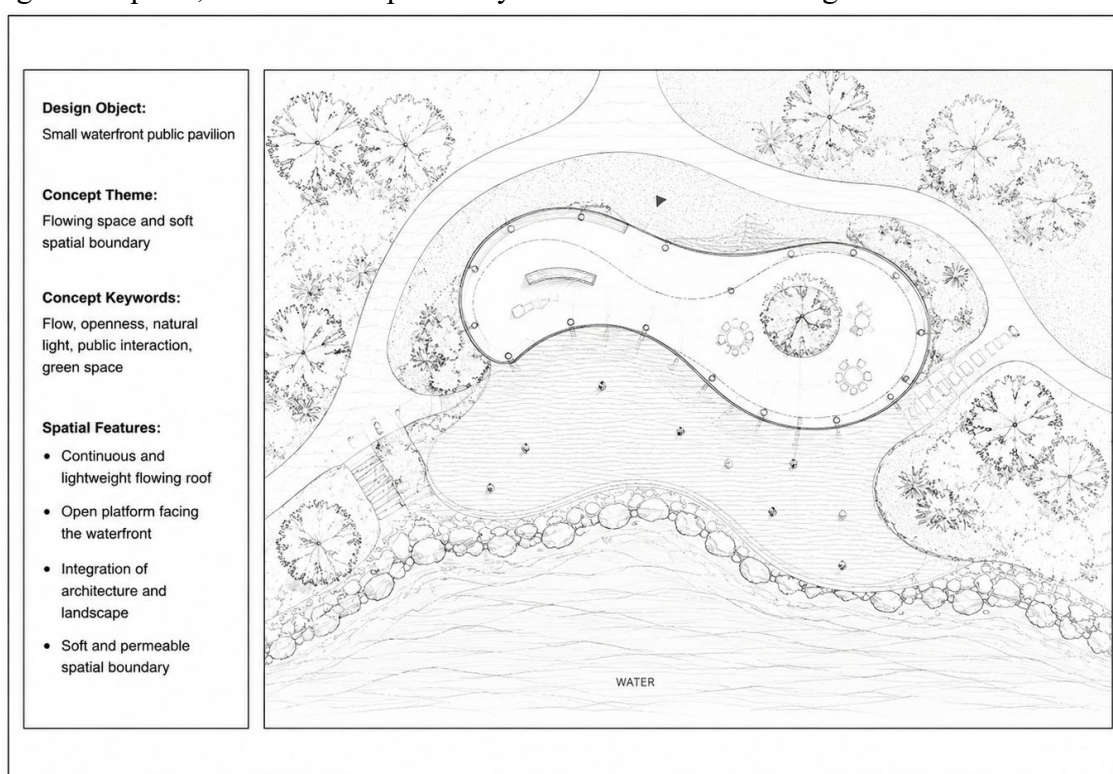


Figure 2. AI-generated conceptual site-plan visualization of a small waterfront public pavilion based on prompts developed by the author.

4. DESIGNER AGENCY REMAINS CENTRAL

Although AI plays an increasingly important role in architectural design, AI image-generation tools still have significant limitations in representing spatial logic, structural

rationality, and construction feasibility [9, 11]. These tools function primarily as aids to concept generation rather than as substitutes for design decision-making. Designers must still evaluate, select, and further develop these outputs before they can become feasible architectural solutions.

4.1. AI Cannot Replace Judgment

At the aesthetic level, AI can generate multiple design schemes based on existing data, but it cannot independently determine which of them has genuine aesthetic value. Aesthetic judgment still relies on the designer's experience and perception, not simply data matching. At the cultural level, architectural expression varies across regions and historical contexts, and AI cannot fully interpret these complex factors. Architectural design also entails ethical responsibility for public safety and social impact. When design outcomes give rise to risks or controversies, responsibility remains with the design team rather than with AI. Therefore, even if AI can participate in scheme generation, the design results still require judgment and selection by the designer. As Nicholas Negroponte states, “the partnership is not one of master and slave but rather of two associates that have a potential and a desire for self-improvement” [1, Preface].

In conclusion, AI's role in architectural design is primarily reflected in generation and analysis, whereas designers remain indispensable in aesthetic judgment, cultural interpretation, and professional responsibility.

4.2. Designers Are Responsible for Selection and Control

AI tools can quickly generate a large number of design solutions. The designer's focus is no longer solely on proposing solutions but also on evaluating and selecting among the alternatives generated by AI. In the AI-assisted design process, designers must first define goals and parameters related to spatial function, environmental performance, and formal control. These initial settings directly affect the scope and direction of the generated results. After AI generates multiple alternatives, designers must compare and evaluate them against specific requirements before selecting the most appropriate or valuable design direction. As Stanislas Chaillou states, “AI will soon massively empower architects in their day-to-day practice” [4, p. 117].

Designers must also maintain control throughout the design process. During each cycle of solution generation and adjustment, designers modify parameters, refine objectives, or guide the generation process so that the design progressively approaches the intended outcome. This approach indicates that the designer's role is shifting from directly shaping form to organizing, guiding, and controlling the design process.

Therefore, in an AI-assisted design environment, designers do not withdraw from the design process but rather lead design development in a different way. Their core responsibility shifts from "drawing solutions" to "setting rules, filtering results, and controlling the process," thereby ensuring the rationality and feasibility of the design results.

4.3. Human Creativity Is Irreplaceable

Beyond judgment and decision-making, architectural design depends on creativity and imagination, areas in which AI is least capable of replacing designers. Although AI can generate novel combinations from large datasets, these outputs remain dependent on learned patterns and require human interpretation to acquire architectural meaning [10, 11].

By contrast, designers can formulate original concepts in response to complex conditions and establish meaningful connections across cultural and social contexts; this capacity is central to human creativity in design. Creativity is also evident in the ability to redefine problems: designers not only respond to given questions but also formulate new ones, thereby expanding the range of design possibilities. AI, by contrast, typically operates within predetermined objectives and parameters and has limited capacity to move beyond those frameworks.

Therefore, although AI can provide substantial support throughout the design process, its limitations in creative reasoning mean that designers remain indispensable to architectural design.

5. FUTURE TRENDS IN HUMAN-MACHINE COLLABORATION

With the continuous development of artificial intelligence technology, the relationship between humans and machines in architectural design is shifting from tool use to collaborative participation [11]. Future design processes will rely increasingly on iterative feedback mechanisms. Designers first define functional requirements, constraints, and evaluation criteria; AI then generates multiple design schemes under these conditions and evaluates their performance. Designers then compare the results, select and adjust suitable alternatives, and feed their evaluations back into the system, thereby establishing an iterative design process.

Based on the preceding analysis of AI applications and limitations in architectural design, a clear trajectory of human-machine collaboration can be identified. AI has significant advantages in data processing, scheme generation, and performance analysis, whereas designers remain indispensable in judgment, decision-making, and creative conception. Therefore, human-machine collaboration is likely to become a defining characteristic of future architectural design.

5.1. Collaborative Design Model

In this emerging collaborative model, design tasks are redistributed between designers and computational systems across successive stages of the design process.

In the initial design phase, designers are responsible for proposing design goals, functional requirements, and constraints, such as spatial organization, lighting requirements, structural limitations, and site conditions. These requirements are translated into computable parameters and rules that provide the basis for AI-assisted solution generation. Based on these inputs, computational and AI-assisted systems can generate multiple design schemes using parametric or generative methods and evaluate their performance [7, 10]. During scheme evaluation and selection, designers no longer develop alternatives one by one; instead, they compare the spatial qualities, functional adaptability, and performance of different schemes before selecting the option that best aligns with their design intent. In this process, computational and AI-assisted systems expand the range of available alternatives, whereas designers remain responsible for evaluation and selection.

Building on this foundation, the design process enters a continuous feedback and adjustment phase. Based on the evaluation results, designers can revise parameters, adjust formal control rules, refine structural logic, or modify environmental response criteria. This cyclical mechanism makes the design process highly dynamic and open.

Computational and AI-assisted systems support generation and analysis, whereas designers retain responsibility for evaluation and decision-making; this division of responsibilities structures their interaction throughout the design process. In this way, designers can explore a wider range of possibilities within a shorter period and identify a suitable solution through comparative evaluation.

5.2. New Professional Roles

As human-machine collaborative design models emerge, the professional roles of architects are also changing. Traditionally, designers primarily shaped architectural forms directly through manual or digital tools. However, in design environments involving artificial intelligence, this process is being redistributed and restructured.

Designers are gradually shifting from "form creators" to "system builders." In parametric and generative design methods, designers need to establish design systems by defining rules, setting parameters, and constructing logical relationships, thereby indirectly generating design results. This shift means that the core of design is no longer merely the final form, but the mechanism that generates that form itself [6, 7, 11].

The designer's responsibilities further expand to include "decision-making and evaluation." When faced with a large number of design schemes generated by AI, designers must evaluate and filter them according to spatial quality, cultural context, and practical requirements. This selection process relies not only on data analysis results but also on the designer's experience and aesthetic judgment to ensure the rationality and expressiveness of the design results.

With the development of data-driven design, architects also need to possess interdisciplinary capabilities, gradually transforming into "design coordinators" or "technology integrators." In actual projects, designers must coordinate interactions among algorithmic tools, engineering systems, and construction processes to ensure that these technologies effectively serve the design objectives.

Despite the changing professional roles, the designer's central role in the design process has not been diminished. On the contrary, as designers confront complex systems and multiple variables, their control over the overall direction and final decisions becomes even more crucial. Therefore, these emerging responsibilities do not replace the architect's traditional role; rather, they extend it in response to changes in the technological environment.

6. CONCLUSION

This study explores how computational design and AI-assisted methods influence architectural design approaches and processes. A comparison of traditional design, computational design, and AI-assisted design processes reveals that computational tools and AI can improve the efficiency of scheme exploration, generation, and feedback while altering the organizational logic of the design process to varying degrees. Furthermore, parametric design, generative design, and AI-assisted image generation operate through different mechanisms and modes of intervention and therefore cannot be regarded as the same technology.

Case studies reveal that parametric design, generative design, and AI-assisted image generation have been integrated into architectural practice at different stages and levels. However, this expansion has not diminished the role of designers; rather, it highlights their crucial importance in judgment and decision-making.

This study argues that although AI offers significant advantages in generation and analysis, it remains limited in aesthetic judgment, cultural interpretation, and decision-making. Creative thinking in architectural design still relies on the designer's experience and knowledge. Therefore, AI cannot replace designers; instead, its integration into design practice contributes to a transformation of their professional role.

In the future, architectural design is likely to move toward closer human-machine collaboration. AI is likely to function as an auxiliary tool that expands the range of design possibilities and supports analysis, while designers retain responsibility for judgment and decision-making. Such collaboration may become an important factor in the continuing development of architectural design.

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