DESIGNING SPACE

Artificial Intelligence and Generative Models between Architecture and Scenography

Alessandra Russo

INTELLIGENZA ARTIFICIALE, ARCHITETTURA DEGLI INTERNI, SPAZIO SCENICO

Storicamente, la scenografia ha rappresentato un campo di sperimentazione nel quale architettura, narrazione e rappresentazione convergono nella costruzione dello spazio scenico. La pratica architettonica ha a lungo influenzato la scenografia, che ne ha adottato e adattato molti strumenti e metodologie. Di conseguenza, diverse tecnologie digitali oggi utilizzate nella progettazione scenografica derivano da strumenti originariamente sviluppati per l'architettura. Più recentemente, l'Intelligenza Artificiale (IA), in particolare con i modelli generativi, ha introdotto nuovi approcci alla progettazione spaziale traducendo istruzioni testuali in configurazioni visive e spaziali. In questo contesto, la ricerca si concentra sempre più su sistemi capaci non solo di generare layout, ma anche di interpretare requisiti, organizzare relazioni spaziali e verificare vincoli geometrici. Questo articolo esamina criticamente tre recenti framework basati sull'IA per la progettazione spaziale. LayoutGPT (2023) impiega un modello linguistico di grandi dimensioni (LLM) come pianificatore visivo intermedio, organizzando gli oggetti e le loro relazioni spaziali prima della generazione visiva. L'Iterated Design System (IDS) (2026) estende questo approccio integrando un tentativo di interpretazione semantica con formalizzazione geometrica, ottimizzazione e revisione iterativa all'interno di un processo gerarchico di progettazione concettuale. StageDesigner (2025) sposta l'attenzione verso la scenografia teatrale, trasformando i copioni in ambienti scenici che tengono conto di entità sceniche, atmosfera, prospettiva dello spettatore e visibilità. Attraverso una lettura critica di questi framework e dei loro differenti approcci alla progettazione spaziale, l'articolo indaga in che modo i sistemi basati sull'IA stiano ridefinendo la progettazione dello spazio e l'agency del progettista in architettura e scenografia. Sostiene che questa trasformazione non dipenda soltanto dai modelli di diffusione (DMs), ma da processi ibridi nei quali interpretazione linguistica, procedure computazionali e giudizio professionale operano congiuntamente.

ARTIFICIAL INTELLIGENCE, INTERIOR ARCHITECTURE, SCENIC SPACE

Historically, scenography has provided a field of experimentation in which architecture, storytelling, and representation converge in the construction of stage space. Architectural practice has long influenced scenography, which has adopted and adapted many of its tools and methodologies. Consequently, several digital technologies currently used in scenographic design derive from instruments originally developed for architecture. More recently, Artificial Intelligence (AI), particularly generative models, has introduced new approaches to spatial design by translating textual instructions into visual and spatial configurations. Within this context, research is increasingly concerned with systems capable not only of generating layouts, but also of interpreting requirements, organizing spatial relationships, and verifying geometric constraints. This paper critically examines three recent AI-based frameworks for spatial design. LayoutGPT (2023) employs a large language model (LLM) as an intermediate visual planner, organizing objects and their spatial relationships before visual generation. The Iterated Design System (IDS) (2026) extends this approach by integrating an attempt at semantic interpretation with geometric formalization, optimization, and iterative revision within a hierarchical conceptual design process. StageDesigner (2025) shifts the focus toward theatrical scenography, transforming scripts into stage environments that account for scenic entities, atmosphere, audience perspective, and visibility. Through a critical reading of these frameworks and their different approaches to spatial design, the article investigates how AI-based systems are reshaping spatial design and the agency of the designer in architecture and scenography. It argues that this transformation does not depend on diffusion models (DMs) alone, but on hybrid processes in which attempts at linguistic interpretation, computational procedures, and professional judgment operate together.

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Architecture and Scenography as spatial practices

It is commonplace to regard architecture as a discipline concerned primarily with the construction of buildings and to reduce scenography to a decorative field associated with temporary materials. In fact, both are complex fields of research in which history and aesthetics are constantly intertwined. Moreover, the plurality of their domains – from the urban scale to the interior for the architect and from theatre to cinema for the scenographer, passing through performance and installation – reveals the broad scope of professionals who share methods and questions. At these points of intersection, space is not merely a material construction, but a perceptual, cultural, and narrative device. Scenography, therefore, cannot be interpreted as a simple ornament of the stage, nor architecture as the mere functional organization of built matter (Mazalán 2018, 1–2).

Both operate through proportions, visual relationships, spatial hierarchies, and devices of meaning. Their dialogue thus also manifests itself on an operational level. The two disciplines share techniques and tools: from hand drawing – with drafting machines, set squares and tracing paper – to CAD software, three-dimensional modelling, and rendering. Scenography, while maintaining its expressive specificity, has assimilated and reworked devices that originated or became consolidated within architectural practice. In recent decades, 2D and 3D design tools have become an integral part of professional workflows and university education, profoundly transforming the way space is represented and communicated. Today, moreover, a new technology is emerging alongside these tools, one that is revolutionizing the paradigms of all professional fields: Artificial Intelligence (AI). AI does not merely enhance existing software, but introduces systems capable of automatic generation through an attempt at semantic interpretation and spatial organization.

AI is a branch of computer science that develops hardware and software systems capable of simulating certain human cognitive functions. *Generative AI* is a type of Artificial Intelligence capable of responding to a textual request – known as a prompt – by producing original content such as texts, images or videos, through processes that simulate forms of human creativity. There are several models of Generative AI. *Large Language Models* (LLMs) are linguistic models that process and generate natural language, interpreting instructions and verbal constraints. *Diffusion Models* (DMs), by contrast, are diffusion-based models that generate images starting from a random configuration, which is then progressively refined. In the generation of layouts, the two models are often combined, since without a phase of conceptual planning, the diffusion model risks producing images that are visually convincing but spatially unstable.

In architecture and scenography, AI is often perceived as a technology capable of replacing professional intervention. However, this interpretation simplifies a far more complex phenomenon. The effectiveness of these systems depends on the quality of the instructions provided, on the expertise of the person formulating the prompt, and on the ability to critically evaluate the results. The relevant issue is therefore not professional replacement, but the changing relationship between human judgment and computational assistance. Accordingly, this study addresses the following research question: How are AI-based systems reshaping spatial design and the agency of the designer in architecture and scenography?

To address this question, the study adopts a critical-comparative approach, examining three recent AI-based frameworks developed within scientific research: LayoutGPT, the Iterated Design System (IDS), and StageDesigner. These cases were selected because they represent three distinct levels of AI-assisted spatial design and introduce different forms of mediation between language and space. LayoutGPT inserts an intermediate organization of spatial relations between textual description and visual output; IDS frames layout generation as an iterative process closer to professional design reasoning. StageDesigner marks the decisive shift in this sequence, as scenography becomes the direct object of AI-oriented research rather than merely a field of application. Considered together, the three frameworks show a progressive expansion of AI's role: from organizing visual composition, to constructing and verifying spatial layouts, and finally to interpreting the narrative and scenographic qualities of designed environments.

LLM as a space generator

The first case examined in this study, LayoutGPT (Feng et al. 2023), addresses the difficulty generative models face in translating verbal instructions into explicit and controllable spatial arrangements. Faced with a prompt such as "three elephants standing next to a pool of water" for example, a model may generate only two elephants, place them inside the pool or fail to reproduce the requested relation correctly. These outcomes reveal the need for an explicit representation of space that can be organized and controlled before visual generation takes place (Feng et al. 2023, 1–2). Comparable problems emerge in the generation of three-dimensional environments. Models trained on interior-furnishing datasets may produce apparently plausible layouts containing overlapping furniture, objects placed beyond spatial boundaries or incoherent functional relationships. From the perspective adopted in this study, LayoutGPT is significant because it introduces an LLM as an intermediate form of mediation between language and visual output, allowing space to be organized before it is translated into an image or a three-dimensional scene (see Figure 1).

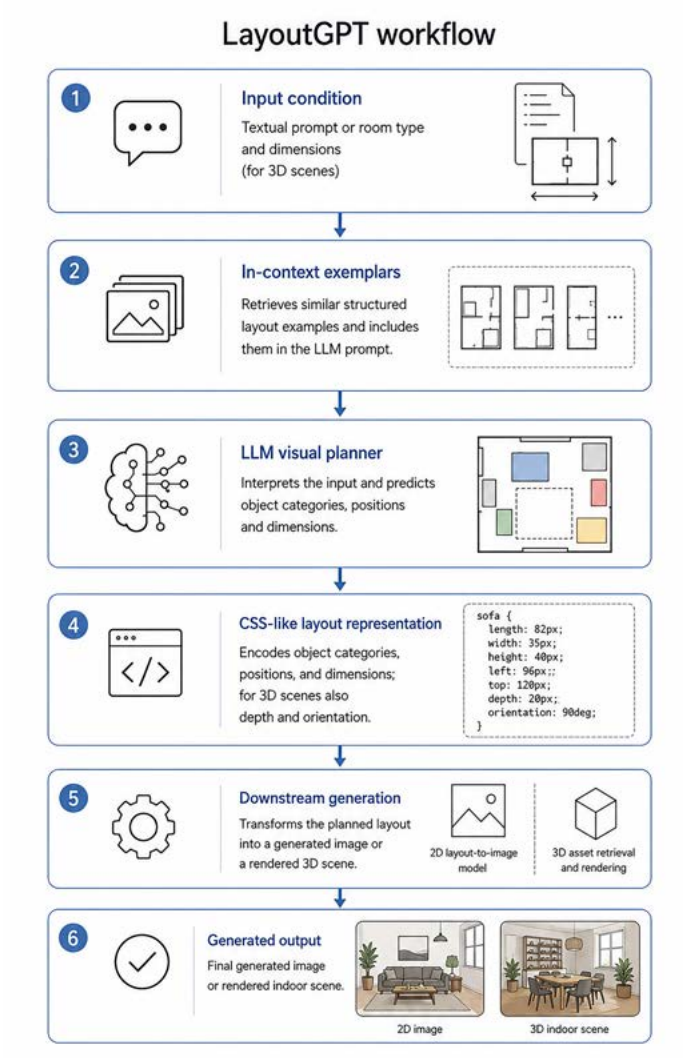

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Diagram by the author, based on Feng et al. (2023). Simplified representation of the LayoutGPT workflow. Content and graphic layout by the author; final aesthetic rendering produced with the assistance of OpenAI

Once the system receives the user's prompt, it automatically retrieves relevant layout examples from the supporting dataset: in two-dimensional cases, the selection is based on AI-driven semantic similarity, whereas in three-dimensional cases it is guided primarily by geometric criteria such as room type and dimensions. The selected examples are then combined with specific instructions and the required output format and submitted to the LLM. The LLM acts as a *visual planner*. It interprets the request and produces a structured description specifying object categories, positions, dimensions and, in three-dimensional scenes, also depth and orientation. This representation is encoded in a CSS-like format, chosen because it makes spatial attributes explicit and can be reliably generated and parsed. It is then passed to the generation stage, where it guides either image generation or the rendering of three-dimensional assets. Through this sequence, LayoutGPT improves control over the spatial arrangement of objects in the final visual output. The process therefore shows that spatial generation depends on first describing and organizing space through relations, dimensions and hierarchies (Feng et al. 2023, 3–4). By translating verbal instructions into a structured spatial layout, the framework can accelerate the early stages of design and provide the designer with greater control over objects and their relations. The resulting three-dimensional layout, however, represents only an initial stage of design exploration within the overall design process. It should therefore be understood as a preliminary spatial proposal rather than as a complete solution, requiring subsequent interpretation, critical evaluation, and development by the designer.

Simulation of the iterative process

The IDS framework, developed by Wu et al. (2026), extends this investigation by integrating AI into a broader design process. Rather than focusing on the final layout, the system is conceived around the ways in which designers interpret and organize space. Its contribution lies in recognizing that design involves several phases in which the designer interprets requirements, formulates hypotheses, and analyzes patterns of use. Spatial design therefore emerges as an iterative process based on alternating cycles of analysis, verification, and revision. For this reason, IDS articulates the design process through a hierarchical and iterative structure. Starting from textual input, the system progressively decomposes the initial request into functional areas, substructures and objects, moving from the general to the particular (Wu et al. 2026, 1–2; see Figure 2).

The first phase is entrusted to the LLM-based module defined by the authors as the Semantics Analyzer. Here, the LLM interprets and expands the textual input into functional, aesthetic, and manufacturing requirements, organizing them into a coherent set of substructures. In IDS, this interpretive process assumes an architectural and user-centered form, grounded in needs, habits, and anticipated patterns of use. When the initial input is incomplete, the LLM supplements it by making plausible assumptions about the user and the activities that the space is expected to support (Wu et al. 2026, 3–5). The second phase is performed by the Geometry Analyzer. Since LLMs are not particularly reliable in the direct management of complex three-dimensional calculations, the system employs a Domain-Specific Language (DSL). This language formalizes relations such as "on the ground", "at the corner", "beside", "in front of", and "above" as geometric operators. The result is a hierarchical semantic-geometric *scene graph* that encodes dimensions, positions, and spatial relations (Wu et al. 2026, 5–6). In the third phase, the scene graph is translated into a mathematical optimization problem using Mixed-Integer Quadratic Programming (MIQP). This engine determines a geometrically feasible configuration by resolving constraints related to proportions, dimensions, and overlaps. The distinctive feature of IDS is then its LLM-in-the-loop operation: when contradictions make the constraint system infeasible, the conflicting conditions are identified and possible modifications are generated. The LLM is therefore reactivated to select the modification that best preserves the meaning of the design. Language and computation therefore operate iteratively: the former interprets, the latter formalizes and verifies, and the former redirects the process when revision is required.

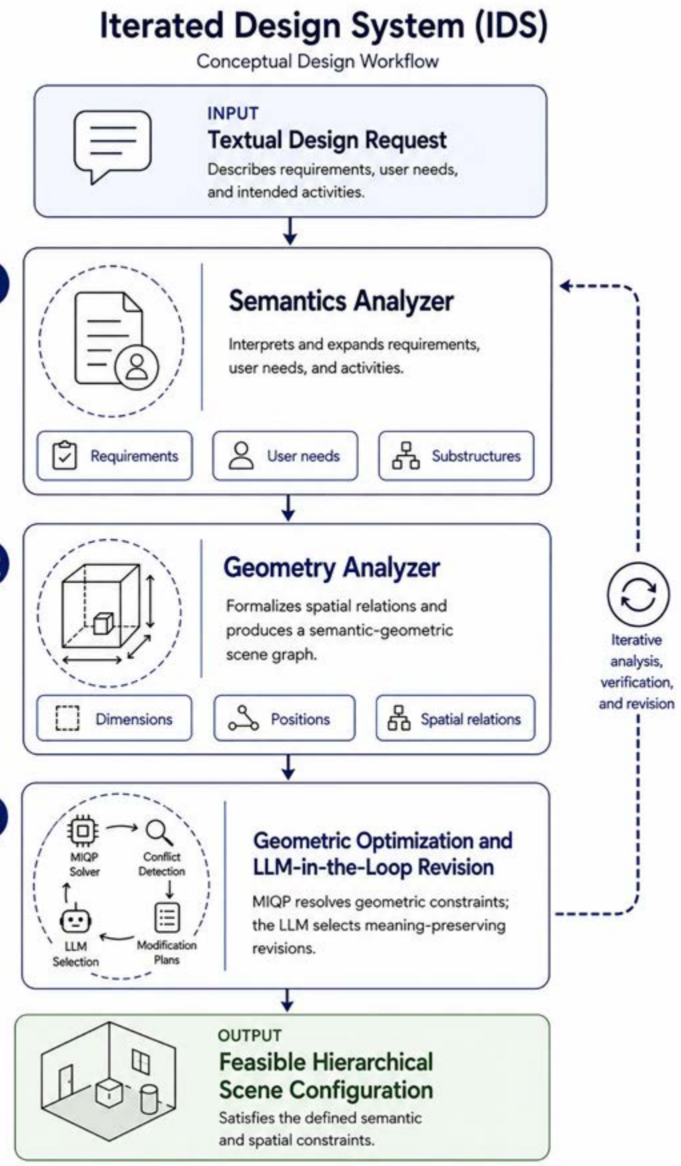

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Diagram by the author, based on Wu et al. (2026). Simplified representation of the IDS workflow. Content and graphic layout by the author; final aesthetic rendering produced with the assistance of OpenAI

The relevance of IDS therefore lies in the direction it suggests for the future development of AI-based spatial design tools. Compared with LayoutGPT, where the need for human intervention remains immediately evident, IDS attempts to move closer to the structure of professional reasoning by integrating revision within the same process. The system still lacks critical judgment, cultural intention, and responsibility of choice, which remain essential aspects of design practice. Nevertheless, it shows that research is moving toward frameworks capable of receiving increasingly complex requests and producing spatial configurations that are progressively more coherent and reliable. In this sense, IDS should not be read as a complete replacement for the designer, but as an indication of the direction in which these technologies are developing: from tools that assist layout generation toward systems that attempt to participate in the reasoning process that precedes spatial form.

A Framework for Theatrical Scenography

Beyond systems dedicated to the configuration of space, such as the frameworks examined in relation to interior architecture, research broadens its perspective: it does not seek merely to organize inhabitable space, but to create environments capable of translating moods, dramaturgical intentions, and scenic perceptions. Within this context, the scientific article *StageDesigner: Artistic Stage Generation for Scenography via Theater Scripts* (Gan et al. 2025) presents an AI-based framework for generating artistic scenographies from theatrical scripts. StageDesigner does not focus solely on the geometric arrangement of objects, but rather attempts to transform a theatrical text into a scenic space that is visually, narratively, and atmospherically coherent. The framework is organized into four main phases: script analysis, foreground generation, foreground projection, and background generation (Gan et al. 2025, 3–4; see Figure 3).

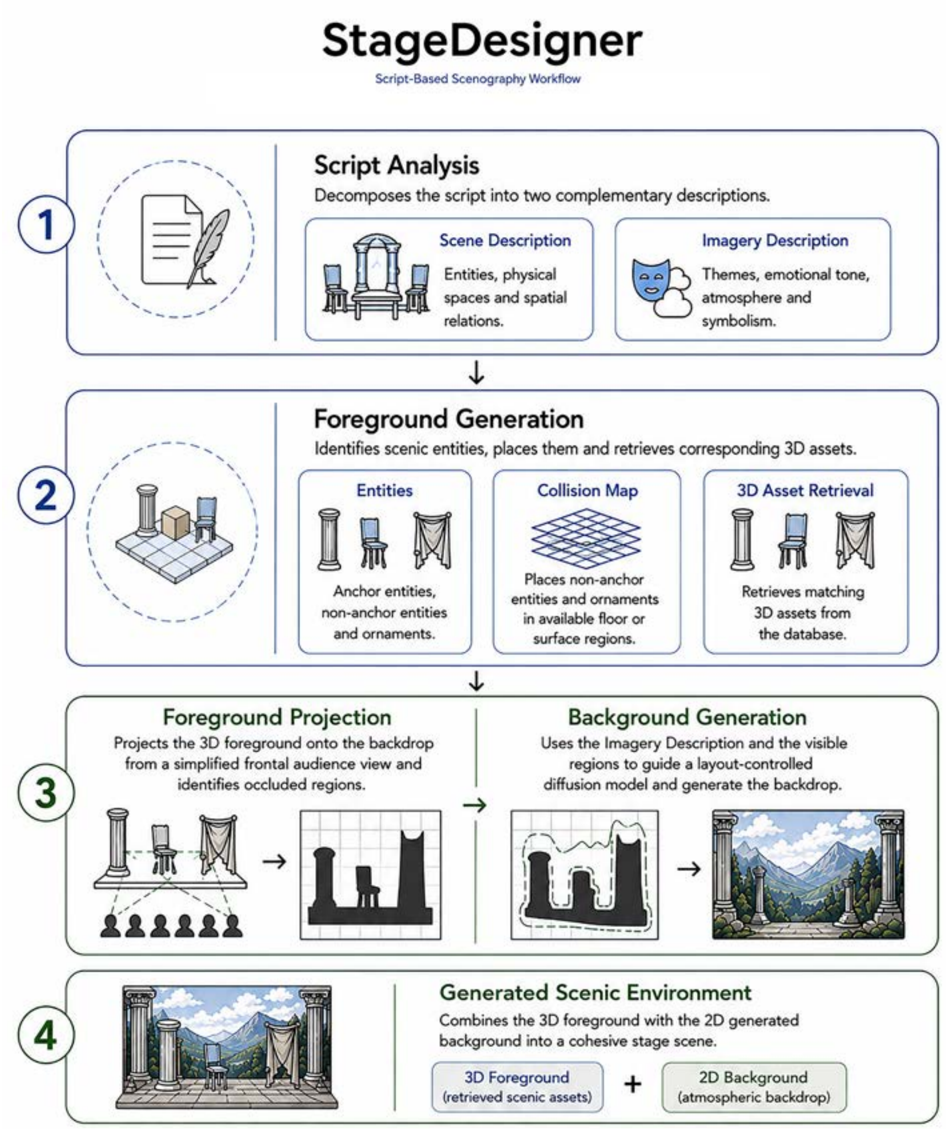

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Diagram by the author, based on Gan et al. (2025). Simplified representation of the StageDesigner workflow. Content and graphic layout by the author; final aesthetic rendering produced with the assistance of OpenAI

To understand the system, it is necessary to begin with StagePro-V1, a dataset created for AI-assisted scenographic generation and for the evaluation of results. Developed in collaboration with professional scenographers, the dataset addresses the scarcity of data specifically dedicated to theatrical staging. Compared with datasets for 3D environments, which are often focused on domestic interiors, StagePro-V1 describes not only spatial arrangement but also the narrative, symbolic, and atmospheric dimensions of scenic space. It includes 276 productions from the 1940s to the 2020s, combining theatrical scripts and script-based scene descriptions with frontal and top-down images, annotated layouts, and information on style, principal objects, and spatial relationships (Gan et al. 2025, 5–6).

The process begins with script analysis. The LLM interprets the theatrical script and extracts scenic entities, spatial relationships, and thematic information, organizing them into a Scene Description and an Imagery Description. The Foreground Generation Module, a hybrid module that combines AI with explicit computational procedures, organizes the three-dimensional elements, avoids overlaps, and respects the boundaries of the stage. The Foreground Projection Module then projects these elements from the audience's viewpoint to identify the areas of the backdrop that would be obscured. Finally, the Background Generation Module uses this visibility information together with a layout-controlled DM to produce a two-dimensional background coherent with the narrative atmosphere and to place key elements within the regions that remain visible (Gan et al. 2025, 3–5). During the Foreground Generation phase, the elements of the scene are divided into three categories: anchor entities, the principal objects derived from the script; non-anchor entities, elements associated with them; and ornaments, additional components introduced to enrich the scene even when they are not explicitly mentioned in the text. To place non-anchor entities and ornaments without overlaps, the system uses a Multi-level Collision Map: an algorithmic grid applied to the stage floor and to the surfaces of scenic elements, in which each cell can be either free or occupied. The control therefore concerns not only the floor, but also front, lateral, and upper surfaces (Gan et al. 2025, 4–5). The Multi-level Collision Map reveals a crucial aspect of generative design: spatial intelligence does not reside in the language model alone. Even within an advanced AI framework, the organization of space depends on explicit computational procedures capable of checking occupation and boundaries. The system is therefore hybrid rather than autonomous: AI interprets the script and identifies scenic relationships, while non-generative algorithms position elements in space and control collisions and available surfaces without interpreting their dramaturgical meaning.

At this point, the meaning of the "return to the stage" proposed in this article becomes clearer. Historically, scenography has often adopted tools developed for other design fields, especially architecture, adapting them to its own expressive and operational needs. StageDesigner marks a potential discontinuity in this process: scenography is no longer merely an application field for general spatial technologies, but becomes the direct object of computational research. The framework is conceived around theatrical conditions such as atmosphere, audience perspective, visibility, and dramaturgical meaning. Its relevance therefore lies in the possibility that scenography may no longer need to rely exclusively on tools conceived for adjacent disciplines, opening instead toward computational systems designed from the outset around its own processes.

The designer and the machine

The trajectory from LayoutGPT to IDS and StageDesigner clearly shows how the application of technology to the design of space is changing (see Figure 4).

4
Comparative analysis of layout generation approaches, with particular emphasis on the role of LLMs and geometric control

Aspect	LayoutGPT	Iterated Design System (IDS)	StageDesigner
Domain	2D and 3D spatial layout generation	Conceptual spatial design, demonstrated mainly through interior scenarios	Theatrical scenography
Input	Text prompt and scene or room specifications	Design intention expressed in natural language	Theater script
Main objective	Plan spatial arrangements before visual generation	Support hierarchical and iterative conceptual design	Generate coherent stage environments from scripts
Role of the LLM	Visual planning and spatial organization	Semantic analysis and iterative revision	Script analysis and extraction of scenic and atmospheric information
Geometric mechanism	CSS-like structured spatial representation	DSL-based geometric formalization and MIQP optimization	Multi-level Collision Map and visibility-aware projection
Output	Structured 2D layouts or 3D scene layouts	Hierarchical semantic-geometric scene graph and feasible spatial configuration	3D foreground and visibility-aware 2D backdrop
Evaluation	Object counting and spatial-relation accuracy	Design experiments and ablation studies	Geometric, semantic, and user evaluation

In light of these developments, it appears inaccurate to claim that such frameworks are currently capable of fully replacing the professional. They still represent only a portion of design work and require careful supervision by the scenographer, architect or designer. AI, in the current state of research, is not truly autonomous: it requires interpretation, control, and correction. The results generated may be rapid and visually convincing, but they are not automatically correct, nor necessarily coherent with the deeper intentions of the project.

However, reducing these systems to simple support tools would be equally limiting. The studies examined in this article show a progressive shift of digital tools toward increasingly internal phases of the creative process. Whereas in the past technology intervened primarily in the technical representation of the project, today it is beginning to participate in its conception, its narrative organization, and its spatial verification. The central issue, therefore, is not the immediate replacement of the professional, but the progressive delegation of portions of the design process to computational systems capable of interpreting requests, processing relationships, correcting configurations, and proposing solutions.

At least two considerations arise from this. The first concerns the future possibility of progressively integrated design software, capable of accompanying the professional through every phase of the work: from textual analysis to the generation of spatial hypotheses, from the verification of geometric constraints to the selection of objects and finally to the production of images, three-dimensional models and visual atmospheres. It cannot be ruled out that processes currently distributed across distinct frameworks may converge into a single working system.

The second consideration concerns the emergence of a new professional competence: the ability to converse with the machine. In this scenario, prompting cannot be understood as the simple writing of commands, but rather as a design practice. To formulate a prompt means to translate an idea into a clear, coherent, and strategic description; it means indicating functions, moods, materials, spatial relationships, narrative intentions, and technical constraints. The quality of the result produced by the framework depends to a large extent on the quality of the information provided by the user. Consequently, language assumes a central role in the design process: not only as a critical or descriptive tool, but as an operational medium capable of directly orienting the generation of space.

The professional does not disappear, but is shifted toward a different position: one less tied to the manual production of every single step and gradually oriented toward directing the project. Architects and scenographers become professionals capable of governing complex processes in which human intuition and computational calculation collaborate. It is precisely within this collaboration that one of the most delicate questions emerges: if the system becomes even more capable of organizing space, correcting errors, optimizing configurations, and interpreting narrative atmospheres, to what extent does design competence remain exclusively human? And where, in the future, will the boundary lie between ideation, control and the automation of the creative process?

This boundary may become increasingly fluid. Research on so-called *Spatial Intelligence* aims to develop models capable of understanding and reasoning about physical space through three-dimensional data, simulations, robotics, and immersive experiences (Fu et al. 2025). The current difficulties of generative systems in truly understanding space should therefore not be considered definitive limitations, but rather transitional phases within a broader evolution. AI seems destined to become not only a tool of representation, but an increasingly sophisticated design interlocutor.

The future challenge will consist neither in excluding automation from design nor in entrusting design entirely to the machine. Rather, it will consist in understanding how to critically integrate these tools into professional practice, without relinquishing the cultural, aesthetic, and historical responsibility of the designer. For architecture and scenography – disciplines that construct space as experience and relationship – AI does not simply represent a new technology, but a profound transformation in the way design is produced.

In this scenario, the value of the professional will not reside only in the ability to produce a form, but in the ability to guide the process through which that form becomes meaningful space. The difference between human and machine will be defined at the moment when the human being consciously assumes their own position: when they use design not merely to produce a solution, but to take a stance toward the world.

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