

Research on the Human-machine Collaborative Path of Interior Design based on AIGC Generative Artificial Intelligence

Bin Zhou

Liaoning Communication University, Shenyang, Liaoning 110136, China

Abstract

With the rapid iteration of large models and AIGC (Generative Artificial Intelligence) technology, the interior design industry undergoing a paradigm shift from experience-driven design to algorithm-assisted human-machine collaborative design. Traditional interior design processes face practical dilemmas: long project iteration cycles, low in creative conceptualization, and high costs for personalized implementation. Based on the cutting-edge practices of AI-assisted interior design, this paper explores the application models generative AI throughout the entire workflow, covering stages such as requirement analysis, scheme generation, floor plan optimization, rendering, and design modification; it analyzes existing limitations, including spatial distortion, lack of emotional expression, copyright and ethical risks, and insufficient feasibility of implementation. The paper proposes a human-machine collaborative workflow with "the designer as leader and AI as the auxiliary tool," and discusses implementation strategies for the deep integration of AI and interior design. Research shows that AI does not replace designers but serves as creative tool to unleash their creative potential, driving interior design towards a more efficient, personalized, and ecological direction, providing theoretical references and practical guidance for the industry's transformation.

Keywords

Generative artificial intelligence, spatial generation, digital design, AIGC, interior design, Human-AI Collaboration.

1. Introduction

Digital technology continuously expands the boundaries of cultural creation, architecture, and environmental design. Generative artificial intelligence technology based on diffusion models and multimodal large models new tools and work paradigms to interior design. A traditional, complete interior design workflow includes client interviews, conceptualization, spatial planning, rendering production, iterative design revisions and construction drawing preparation. In commercial projects, designers spend a significant amount of time on repetitive drafting and constant design adjustments, which compresses the time available for refining creative concepts exploring users' emotional needs. Faced with the diverse and personalized demands of contemporary consumers, traditional design methods struggle to quickly produce multiple alternative solutions, leading to an efficiency between supply and demand.

In recent years, a large number of indoor design AI tools have emerged, ranging from general image generation models like Midjourney and Stable Diffusion vertical industry platforms such as Kujiale and Zhuxiaobang. After uploading a floor plan, the system can generate multiple interior design schemes within minutes, significantly the workload of rendering. However, significant flaws still exist in actual design work: while AI-generated images are visually appealing, errors frequently occur in wall, door, and structures, and furniture dimensions often violate ergonomic standards, making the schemes impossible to implement directly[1]. The

models tend to produce homogenized popular styles, making it difficult to deeply reflect emotions and regional cultural characteristics[2]. Meanwhile, copyright and ethical issues surrounding AI-generated works are receiving increasing attention[3].

Many scholars have carried out relevant discussions on the application of artificial intelligence in the field of interior design[4]. Most existing academic literature focuses on the technical introduction of AI tools, making it urgent to conduct research to construct mature human-AI collaborative work models and the technical shortcomings of artificial intelligence[5]. Starting from the complete workflow of interior design, this paper analyzes the advantages and limitations of generative AI, constructs a human-AI framework in the field of interior design, and explores the transformation of designers' capabilities and the future development direction of the industry in the AI era.

2. Technical Foundations and Application Scenarios of Generative Artificial Intelligence in Interior Design

2.1. Technical Foundation

Generative AI applied to interior design relies on three core technologies: multimodal large language models, diffusion image generation models, and spatial control networks. Multimodal large models undertake the task of requirement analysis, utilizing natural language processing to transform clients' verbal home renovation requests into standardized design tasks; diffusion models generate interior renderings on text prompts; spatial control networks (ControlNet, IDCN) constrain the positions of walls, doors, and windows, mitigating the spatial hallucination problem of AI systems and ensuring that the generated images match the real floor plan parameters.

Unlike pure art creation, interior design belongs to a highly constrained design discipline. In addition to aesthetic requirements, a design solution must also satisfy wall, ergonomic dimensions, fire safety regulations, lighting and ventilation conditions, as well as budget constraints, which is the fundamental difference between AI-assisted interior design and ordinary AI generation.

2.2. Requirement Analysis and Conceptual Idea Generation

Requirement interviews are the starting point of interior design projects. In the traditional model, designers collect information on family composition, lifestyle habits, style preferences, budgets, and special renovation requirements through interviews, relying heavily on their communication experience. Large language models can assist in information processing: AI analyzes chat logs and voice--text transcripts, extracts key design conditions, generates design briefs, and filters keywords for subsequent design creation.

In the past, designers had to browse through vast image libraries to find inspiration; generative AI can quickly produce a large number of diverse conceptual based on short text descriptions to explore different design directions. For example, by inputting prompts such as "small living room, new Chinese style, wooden material, large capacity, soft natural light," dozens of reference images with different layouts and color schemes can be generated in a short time. This expands the designer's creative vision and conventional aesthetic patterns. AI serves only as a creative generator, and the output is for reference only; the final conceptual direction is evaluated, selected, and determined by designer.

2.3. Spatial Planning and Optimization

Floor plans are the core of interior design and largely determine the functionality of a space. Vertical AI tools import drawing files and automatically generate functional zoning, paths, and furniture layouts based on an ergonomics database, outputting multiple alternative layout

options. The algorithm simultaneously considers space utilization, lighting, circulation paths, and furniture, demonstrating outstanding advantages in optimizing small and irregular floor plans.

However, AI-generated floor plans have obvious shortcomings: algorithms operate based on existing datasets, making it difficult to capture users' implicit daily living habits. Details such as age-friendly accessibility, child safety requirements, and special storage needs cannot be fully covered by the algorithm. Therefore, AI-generated floor plans must be and modified by designers to correct logical flaws at the practical usage level.

2.4. Rendering Generation and Scheme Iteration and Modification

Renderings are an important medium for communicating design schemes. Traditional rendering using 3ds Max and SketchUp is time-consuming, and modifying single rendering often takes hours[6]. With the help of generative AI, combining floor plan base images with style prompts can quickly produce realistic renderings; the local inpainting feature can wall finishes, furniture, and lighting scenes, significantly shortening the iteration cycle.

In actual projects, clients often propose numerous revisions, requiring designers to repeatedly redraw renderings and consume a significant amount of man-hours. AI localpainting can quickly respond to modification requests, freeing designers from mechanical rendering tasks to focus on the core logic of the design itself.

2.5. Material Selection Assistance, Budget Planning and Other Extended Applications

AI recommends corresponding building materials and furniture products based on the design scheme and outputs a preliminary budget estimate; under the smart home framework, it simulates smart and shading scenes, quickly generating renderings from different perspectives and at different times of the day, facilitating communication with clients.

3. Existing Problems of Generative Artificial Intelligence Applied in Interior Design

3.1. Spatial Illusion and Poor Feasibility of the Solution

This is the most prominent issue in current interior design AI. Even when using ControlNet to constrain the floor plan, errors such as mis walls, incorrect door and window placements, furniture dimensions violating ergonomics, and physically impossible components still occur. AI-generated images prioritize visual aesthetics and do not fully comply with interior design standards; many renderings look exquisite but cannot be directly converted into construction drawings. Novice designers who blindly copy AI outputs will produce unfeasible schemes. AI excels at visual expression but cannot replace the drafting of construction and detail drawings.

3.2. Lack of Humanistic Emotion and Cultural Depth, Homogenized Solutions

Indoor spaces carry the memories and emotions of residents, embodying regional culture and daily life narratives, and belong to subjective tacit knowledge. AI training is derived massive online design cases, most of which imitate popular templates, making it difficult to capture users' deep emotional needs and easily leading to a monotonous "Internet celebrity template." When dealing with intangible cultural heritage and regional traditional elements, AI often mechanically piles up symbols, failing to understand the underlying cultural connotations.

3.3. Copyright and Ethical Risks

AI model training datasets contain a large number of publicly available interior design works online, with unclear ownership of the original copyrights. Currently, there is lack of clear

regulations and industry standards to define the copyright of AI-generated works and to distinguish the contributions of humans and machines in the creative process. Directly using-generated outputs for commercial projects poses a risk of copyright disputes. Meanwhile, over-reliance on AI tools will weaken fundamental abilities such as hand-drawing and spatial thinking posing new challenges to the training of design.

3.4. Limited Ability to Uncover Real User Needs

Many clients express their needs vaguely and with emotional undertones, such as wanting a "warm and healing indoor space." AI can only replicate the on a visual level, failing to empathize with the resident's inner feelings. Life experiences, family relationships, and psychological states are difficult to fully translate into text.

4. Innovative Human-machine Collaboration Model for Interior Design

Combining the advantages and disadvantages of AI, the future of the industry is not AI replacing designers, but human-machine collaboration: designers take the, with AI serving as an auxiliary tool. Human creative empathy and value judgment are combined with AI's high-speed computational and generative capabilities. This article proposes a fivestage human-machine collaborative workflow:

Phase 1: Deeply mining user needs (human-led, AI-assisted)

Designers communicate face-to-face with clients recording lifestyle habits, emotional needs, and cultural preferences, and conducting on-site measurements of the floor plan; AI assists in organizing interview records and generating standardized design briefs. key decisions in this phase are made by the designer, and AI cannot replace face-to-face client interviews.

Phase 2: Conceptual Ideation (Human-AI Collaboration)

The designer establishes the core design concept and uses AI to generate a large number of images to expand creative ideas; the designer screens and evaluates the AI outputs, eliminating unreasonable or homogenized solutions, and determines 2-3 main design directions.

Phase 3: Floor Plan Generation (Human-led, AI-generated alternatives)

The designer completes the initial floor plan; the AI generates layout alternatives based on the floor plan data; the designer compares the schemes based on life experience and industry standards, corrects the logical flaws in the AI-generated plans and determines the final floor plan[7].

Phase 4: Rendering Iteration (AI handles repetitive rendering tasks)

AI generates renderings based on the floor plan confirmed by the designer; local in is used to quickly respond to client modification requests; the designer verifies furniture dimensions and door/window positions, correcting spatial hallucinations generated by the AI.

Phase5:Construction Drawing Preparation and Verification

AI cannot output construction drawings that comply with standards. Based on finalized concept, designers draw construction drawings, details, and material lists, verify compliance with national interior design standards, and complete the technical preparation for project implementation.

model achieves a clear division of labor: designers are responsible for user empathy, value judgment, cultural creation, and implementation feasibility verification; AI is responsible for batch generation, rendering, and repetitive information processing, with the two complementing each other.

5. Development Strategies for the Interior Design Industry in the Era of Generative AI

5.1. Transformation of Designer Compet

In the era of widespread AI adoption, a designer's core competitiveness is no longer just about drawing and rendering speed. Three capabilities are becoming increasingly: first, proficiency in using AI tools, mastering prompt engineering and model parameter tuning; second, critical verification skills to identify errors and spatial hallucinations in AI-generated solutions; the ability to uncover user needs and build cultural depth into design solutions, which is a capability AI struggles to achieve. Fundamental knowledge such as hand drawing, ergonomics, and codes remains irreplaceable; only a solid professional foundation can enable one to recognize errors in AI outputs.

5.2. Improve Industry Standards and Copyright Mechanisms

The industry should establish copyright norms and commercial usage rules for AI-generated design works, distinguishing the creative contributions of humans and machines. Designers must directly use unmodified AI images as commercial deliverables; they should fully document the entire design process, differentiate between AI-assisted materials and final original design outputs, and mitigate copyright risks.

5.3. Optimize Talent Cultivation and Establish an Objective Understanding of AI

Higher education in interior design needs to update its curriculum and add courses related to generative AI design. Students should learn to use AI as a collaborative while recognizing its limitations, and directly copying AI outputs is strictly prohibited[1]. Teaching should establish a complete chain of thought: concept establishment → AI-assisted creative generation → revision → practical refinement. Talent cultivation in the intelligent era cannot abandon traditional foundational skills such as spatial thinking, hand drawing, and construction drawing.

5.4. Vertical Model Optimization with Enhanced Spatial Constraints

At the technical level, vertical AI models for interior design need to embed building codes and ergonomic knowledge bases to improve floor plan accuracy and suppress spatial. Expanding training materials related to regional culture and traditional residential architecture will reduce design homogenization, enhance the feasibility of schemes, and narrow the gap between AI-generated effects and-world construction.

6. Conclusion

Generative AI brings an efficiency revolution to interior design, offering outstanding advantages in creative brainstorming, rendering iteration, and information processing, thereby compensating for shortcomings of traditional workflows. However, at the current stage, the technology still faces issues such as spatial hallucinations, insufficient depth in emotion and culture, and copyright ethics, and AI independently complete a complete interior design project. Interior design is a human-centric design discipline that integrates function, aesthetics, emotion, and culture. Human life experience, empathy, and critical thinking are values that artificial intelligence can hardly match. The future is not about machines replacing humans, but a human-machine collaborative system led by designers. AI takes over repetitive tasks, liberating designers to focus on higher-value work: user communication, cultural creation, and project implementation. Interior design practitioners should actively embrace new technologies while maintaining objective and judgment, driving the industry towards a more efficient, human-centric, and diverse future.

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