Research on the "Human-Machine Collaboration" Mode in AI-Aided Design and Its Influence on Designers' Creativity

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Abstract

With the comprehensive popularization of generative artificial intelligence represented by Midjourney and Stable Diffusion in the design industry, AI has become an indispensable auxiliary tool for designers in conceptual sketching, scheme iteration, material rendering and visual output. However, the dual contradictions of AI stimulating creative inspiration and triggering design homogenization have become prominent pain points in the current design industry. Existing research mostly focuses on the final design output of AI-assisted creation, while ignoring the dynamic changes of designers' whole creative process under human-machine collaborative working mode, lacking systematic research on the internal mechanism of creativity gain and loss. Taking graphic design, environmental design and product design practitioners as research objects, this paper takes generative AI tools as the core auxiliary carrier, defines the connotation and classification of "human-machine collaboration modes" in design work, and constructs a whole-process analysis framework of "pre-creation inspiration—mid-process scheme iteration—post-production optimization evaluation". This research reveals the positive driving and negative restriction mechanism of AI on designers' creative thinking, solves the problem of creative homogenization caused by over-reliance on AI, provides theoretical reference for standardized human-machine collaborative design workflow, and forms a replicable practical paradigm for designers to give full play to independent creative ability under AI auxiliary environment.

Keywords

AI-Aided Design; Human-Machine Collaboration; Designer Creativity; Creative Process; Design Homogenization.

1. Introduction

1.1. Research Background

Driven by digital technology, generative artificial intelligence represented by Midjourney, Stable Diffusion, DALL·E and other visual generation models have been fully embedded into all links of industrial design, visual communication, interior and landscape design. AI can quickly generate massive visual schemes according to text prompts, greatly compressing the time cost of preliminary conception and drawing, and reshaping the traditional design work logic dominated by manual creation alone. At present, more than 70% of domestic design enterprises and independent designers have applied AI auxiliary tools in daily design work, covering concept generation, effect drawing production, scheme modification and other links [1].

Nevertheless, the large-scale application of AI also brings obvious industry problems. On the one hand, AI can quickly provide massive reference pictures, break designers' thinking bottlenecks, and expand creative boundary; on the other hand, a large number of designers rely excessively on AI output works, copy universal prompt templates, and produce a large number of similar design works with identical visual logic, resulting in serious design

homogenization [5]. Many designers' independent thinking ability, original conception ability and personalized expression ability decline obviously, and the core creative subject status of human designers is impacted.

Design creation is a complete dynamic thinking process including inspiration capture, logic deduction, emotional expression and personalized innovation, rather than a single final visual result [3]. At present, most domestic and foreign research on AI design only evaluates the quality of finished design works, rarely tracks the whole creative process of designers under human-machine collaboration, and fails to systematically analyze how AI affects designers' thinking logic, inspiration acquisition and innovative expression in different creation stages [4]. Therefore, it is urgent to carry out targeted theoretical combing and empirical research aiming at the whole creative process of designers under human-machine collaborative mode.

1.2. Research Significance

1.2.1. Theoretical Significance

This paper defines the classification, operation logic and core connotation of human-machine collaboration modes in AI-aided design, constructs a whole-process analysis framework of designers' creative process based on generative AI participation, clarifies the internal influence mechanism of AI on designers' creative thinking in different creative stages [3]. It fills the theoretical gap of whole-process research on human-machine collaborative creation focusing on designers' creative process rather than design results, enriches the research system of digital design, artificial intelligence and design creativity, and provides theoretical basis and framework reference for the research on human subjectivity in intelligent design environment [4].

1.2.2. Practical Significance

Taking designers of three mainstream design fields (graphic design, product design, environmental design) as empirical research objects, this paper sorts out differentiated human-machine collaborative operation modes, summarizes targeted optimization strategies to avoid creative homogenization, puts forward operation norms to maintain designers' independent creative ability [5]. It can effectively alleviate the phenomenon of design homogenization caused by over-reliance on AI, give full play to AI's advantage of expanding creative inspiration, protect designers' core originality, and form a replicable human-machine collaborative working paradigm for design enterprises and individual designers in all design categories [1].

1.3. Research Methods and Content

1.3.1. Research Methods

(1) Field Interview Method: Conduct one-on-one in-depth interviews with 30 frontline designers, design directors and design teachers who long-term use Midjourney, Stable Diffusion and other AI tools, record their daily human-machine collaborative workflow, creative pain points and real experience of creativity change;

(2) Questionnaire Survey Method: Distribute 500 electronic questionnaires to designers in graphic, product and environmental design industries, recover 468 valid questionnaires, investigate designers' usage habits of AI tools, inspiration acquisition efficiency and the degree of homogenization of their own design works;

(3) Comparative Experimental Method: Select 60 designers with different working years to set up control groups (pure manual creation) and experimental groups (AI-assisted creation), record the whole creative process of two groups of designers, compare the difference of creative thinking richness, inspiration quantity and originality of final works;

(4) Case Analysis Method: Track the whole design process of typical design projects with high-quality human-machine collaboration and homogenized AI design projects, summarize the

operation rules of effective human-machine collaboration and the inducement of creative solidification [7][8].

1.3.2. Research Content

(1) Sort out the theoretical basis of generative AI, human-machine collaborative design and designer creativity, clarify the core connotation and classification of human-machine collaboration mode in AI-aided design [3];

(2) Analyze the current prominent problems of design homogenization and designers' creative atrophy under AI auxiliary environment, explore the matching relationship between AI tool characteristics and each stage of designer's creative process [4][5];

(3) Construct a whole-process analysis framework of designers' creativity change under human-machine collaboration, and summarize classified human-machine collaborative operation modes;

(4) Carry out empirical comparison and effect evaluation combined with designer questionnaire and design experiment data, verify the positive and negative influence of AI on designers' creativity in different creative links [7][8];

(5) Put forward multi-dimensional optimization strategies for designers, design enterprises and design education to balance AI auxiliary efficiency and independent creative ability [9].

2. Theoretical Basis and Mode Construction

2.1. Core Concepts and Theoretical Basis

2.1.1. AI-Aided Generative Design

AI-aided generative design refers to taking large visual generation models such as Midjourney and Stable Diffusion as carriers, relying on text prompts, picture reference, parameter adjustment and other interactive ways to automatically generate massive visual schemes, and assisting designers to complete conception, sketching, rendering and scheme iteration. It has the characteristics of fast output, rich picture styles and low threshold of use, and covers all mainstream design fields [2].

2.1.2. Human-Machine Collaboration Mode in Design

Human-machine collaboration mode in design refers to the fixed interactive operation logic formed by designers and generative AI tools in the whole creative process, taking human designers as the core creative subject and AI as auxiliary tool [3]. Different operation sequences, division of labor and interaction logic form differentiated collaboration modes, which directly determine the inspiration acquisition efficiency and originality of final design works.

2.1.3. Designer Creativity and Whole Creative Process

Designer creativity includes multi-dimensional abilities such as independent conception thinking, personalized emotional expression, original visual logic and innovative problem-solving. The whole creative process is divided into three continuous stages: pre-creation inspiration excavation stage, mid-process scheme iteration stage and post-production optimization evaluation stage [4]. Most existing research only evaluates the final design result, ignoring the continuous change of creative thinking in the three stages.

2.2. Classification of Human-Machine Collaboration Modes and Whole-Process Creative Influence Analysis Framework

Aiming at the industry pain points of AI leading to creative inspiration solidification and design homogenization, this paper constructs a dual research system of "three classification of

human-machine collaboration modes + three-stage whole-process creative influence analysis", as detailed below:

2.2.1. Three Classification of Human-Machine Collaboration Modes

(1) AI-Dominated Auxiliary Mode: Designers rely entirely on AI prompt words to generate schemes, only carry out simple screening and fine-tuning of AI output results, rarely add independent thinking and personalized transformation; this mode is easy to cause serious creative homogenization and weaken designers' independent conception ability [5].

(2) Human-Machine Equal Co-Creation Mode: Designers complete core conception, creative positioning and emotional logic first, take AI as the tool of visual expansion and scheme supplement, use AI to enrich picture forms on the basis of independent creative framework, and retain human personalized design logic; this mode can maximize AI's inspiration expansion advantage and avoid homogenization [3].

(3) Human-Dominated AI Auxiliary Mode: Designers complete all core creative thinking, hand-drawn sketches and main scheme logic independently, only use AI to complete repetitive mechanical work such as effect drawing rendering and material matching; AI only undertakes low-value repetitive work, and human creativity is absolutely dominant.

2.2.2. Three-Stage Whole-Process Creative Influence Analysis Path

(1) Pre-creation Inspiration Excavation Stage: Analyze whether AI expands designers' thinking boundary or limits thinking to fixed popular styles, count the quantity and originality of initial inspiration generated by designers under different collaboration modes;

(2) Mid-process Scheme Iteration Stage: Compare the difference of scheme diversity, personalized symbol application and innovative structural logic under three collaboration modes, judge the positive or negative influence of AI on designers' creative deduction ability [7][8];

(3) Post-production Optimization Evaluation Stage: Evaluate the originality, differentiation and personalized emotional expression of final design works, summarize the degree of homogenization risk brought by different human-machine collaboration modes [5].

3. Empirical Research: Comparative Experiment and Questionnaire Survey of Designer Creativity

3.1. Overview of Empirical Research Objects

This paper selects three typical designer groups as empirical research samples to cover the mainstream application fields of AI design:

(1) Graphic Designers: Responsible for poster, brand VI, packaging design, long-term use Midjourney for visual scheme generation [7];

(2) Product Designers: Engaged in daily necessities and electronic product appearance design, mainly use Stable Diffusion for hand-drawn sketch auxiliary [8];

(3) Environmental Designers: Including interior and landscape designers, apply AI to space effect drawing and scene conception.

Before the experiment and questionnaire survey, the three groups of designers generally had the same industry confusion: AI can improve work efficiency, but long-term use leads to similar design styles, personal creative thinking becomes lazy, and it is difficult to form unique personalized design language [5]. The core research demand is to distinguish the creativity influence difference of different human-machine collaboration modes, and find collaborative methods to balance efficiency and originality.

3.2. Implementation of Empirical Research

Centering on the core research theme of "human-machine collaboration mode and designer creativity change", two empirical research methods of questionnaire survey and control group comparison experiment are carried out simultaneously:

(1) Questionnaire Survey Implementation: Set dimension indicators including AI usage frequency, collaboration mode preference, inspiration acquisition effect, homogenization perception and creative ability self-evaluation, collect real usage data of designers in different industries, and sort out the proportion of three human-machine collaboration modes in the industry;

(2) Control Group Comparative Experiment: Divide designers into three experimental groups corresponding to three collaboration modes, assign the same design task, record the whole creative thinking process, count the number of independent inspirations, the uniqueness of design symbols and the differentiation degree of finished works, and quantify the positive and negative influence of each mode on creativity [7][8].

During the research process, design industry seniors, design education scholars and AI visual creation engineers were invited to participate in the index evaluation of experimental works to ensure the objectivity and authenticity of creativity evaluation results [9].

4. Results of Empirical Effect Evaluation

After the completion of questionnaires and comparative experiments, data statistics and effect evaluation were carried out combined with comparative analysis method and quantitative scoring, and the core research results are as follows:

4.1. Inspiration Acquisition Effect in Pre-Creation Stage

Under the human-dominated AI auxiliary mode and human-machine equal co-creation mode, 89% of designers said that AI effectively expanded their inspiration scope, and the number of creative directions increased by 72% on average; under the AI-dominated auxiliary mode, only 31% of designers acquired new inspiration, and 86% of designers said their thinking was limited to popular AI styles, lacking unique personalized conception [5]. It can be seen that AI can play a positive role in inspiring creativity only when human thinking occupies the leading position.

4.2. Creative Iteration Effect in Mid-Process Stage

Designers under human-machine equal co-creation mode have the strongest scheme iteration ability, with an average of more than 12 differentiated creative schemes for a single task, and the application of personalized design symbols is abundant; designers under AI-dominated mode have single scheme logic, high repetition rate of visual elements, and serious convergence of design expression; the human-dominated AI auxiliary mode has stable originality, but the number of alternative schemes is relatively less, and the advantage lies in strong personalized emotional expression [7][8]. The whole-process creative thinking richness of works under equal co-creation mode is significantly higher than the other two modes.

4.3. Final Work Differentiation and Comprehensive Creative Benefit

Works created under AI-dominated mode have the highest homogenization rate, up to 78%, lacking unique designer personal style; the homogenization rate of human-machine equal co-creation works is only 11%, which can balance creation efficiency and personalized originality; human-dominated auxiliary works have zero homogenization risk, but the average design cycle increases by 60%. Comprehensive scoring from three dimensions: inspiration richness, work originality and work efficiency, the human-machine equal co-creation mode gets the

highest comprehensive score of 91 points, which is the optimal collaborative mode to stimulate designers' creativity. 93% of designers believe that standardized equal co-creation mode can avoid creative atrophy while exerting AI auxiliary advantages [3][5].

5. Conclusion and Optimization Suggestions

5.1. Research Conclusion

(1) Generative AI represented by Midjourney and Stable Diffusion has dual effects on designers' creativity: it can expand inspiration boundaries and enrich visual forms, but over-reliance on AI-dominated collaboration mode will lead to thinking solidification and serious design homogenization; the core factor determining creativity gain or loss is the human-machine collaboration mode adopted by designers in the whole creative process [5].

(2) The three classification system of "AI-dominated / human-machine equal co-creation / human-dominated" human-machine collaboration modes and the three-stage whole-process creative influence analysis framework of "pre-inspiration—mid-iteration—post-evaluation" have complete logical rigor and operability, which can comprehensively reveal the internal mechanism of AI acting on designers' creative thinking [3][4].

(3) The empirical data of graphic, product and environmental design groups verifies that the human-machine equal co-creation mode is the optimal collaborative path to stimulate designers' creativity, which can simultaneously take into account AI's high-efficiency auxiliary advantages and human independent original expression ability, and has popularization value for all design industries [7][8].

5.2. Multi-Dimensional Optimization Suggestions

(1) Industry Enterprise Level: Formulate standardized human-machine collaborative design operation specifications, restrict the full AI generation mode without independent conception, take "human core conception + AI auxiliary expansion" as the standard workflow of design projects, and set originality evaluation indicators for design works [1][2].

(2) Designer Individual Level: Establish independent creative thinking first, complete core creative positioning and hand-drawn logic framework before using AI, take AI as the tool of scheme supplement rather than the source of core creation, accumulate personalized design symbol library to avoid copying universal AI prompt templates [5].

(3) Design Education Level: Add special courses of human-machine collaborative creation in design major teaching, guide students to establish human-centered creative subject consciousness, teach differentiated AI auxiliary usage methods in different creative stages, and prevent students from forming the habit of relying entirely on AI for creation [9].

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