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Facilitation or inhibition: The influence of generative artificial intelligence on design reasoning for modular structures

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Abstract

Artificial intelligence (AI) has given rise to AI-driven design systems that are widely used in various design phases. Despite the considerable research on developing AI systems for specialized design tasks in structural design, the impact of generative AI on human designers is often disregarded. However, there is growing concern about the impact of AI on the creative design process, which human designers once dominated. Our research believes AI research should go beyond the fixed mindset of "developing assistive tools for design tasks" towards developing a collaborative intelligence research framework involving human designers, AI systems, and design solutions, contributing to the structural design process. This research focuses on the impact of generative AI on the design reasoning process of modular structures, which aims to enhance the collaboration between human designers and AI systems. Utilizing the deep learning model, our study developed a fine-tuning diffusion model called *Modularstructure*, which generates synthetic images of modular structures with specific features. The research analyzes the influence of text-to-image generation on design cognition, perceived workload, and the confidence index of human designers. It offers a new perspective and method for promoting collaboration between human designers and generative AI in structural design and creativity.

Keywords: Generative Artificial Intelligence, Text-to-image Generation, Modular Structures, Design Reasoning, Design Cognition.

1. Introduction

With the progression of AI theories and technology, AI-driven design approaches have gained prominence within domains such as architecture, engineering, and product design [1]. The influence of AI on the inventive design process, traditionally dominated by human designers, has emerged as a significant concern within the design discipline. The emergence of AI-powered design practices is poised to revolutionize architectural design approaches and principles [2], [3]. AI research in structural design encompasses various design stages, including but not limited to concept generation, performance evaluation, prototyping and manufacturing. Recent research indicates that well-trained AI systems can perform specialized design tasks, surpassing the performance of human designers [4], [5].

Currently, AI research in structural design focuses on developing AI systems in specialized design scenarios [6], [7]. Utilizing machine learning, AI imitates the design reasoning capability of human designers to solve specific design problems. Recent studies have shown that human designers can derive novel inspirations through collaboration with AI systems. Notably, AI has demonstrated the capacity to generate unexpected ideas from human designers [8], implying a shift from being a mere assistive tool to assuming a collaborative role. Despite the considerable research on developing AI systems for specialized design tasks in structural design, the influence of generative AI on human designers is often disregarded. Our research advocates for a departure from the conventional mindset of exclusively constructing assistive tools for design tasks, urging instead the establishment of a collaborative intelligence research framework encompassing human designers, AI systems, and design solutions. Exploring the development of AI-driven design systems through a collaborative design lens can engender a more systematic and speculative comprehension of this burgeoning design paradigm.

This research focuses on the impact of generative AI on the design reasoning process of modular structures, aiming to optimize the synergy between human designers and AI systems. Modular structures are widely used in multiple spatial scenarios and serve as art installations, temporary buildings, or urban furniture [9], [10], [11]. These structures possess distinct visual attributes characterized by repeatability, discreteness, and similarity, enabling designers to articulate unique design intentions through a symbolic graphic language and concurrently customize configurations to address specific situational demands.

Like all art and design activities, the design reasoning of modular structures is a unique and non-linear process closely related to individual designers' cognition and design behaviours [12]. Essential tools designers employ in this process include freehand sketching, 3D modelling, and prototyping, all of which enrich the visual reasoning process [13]. These mediums support visual cognition and function as external representations of the designer's cognitive processes, continually undergoing refinement throughout the reasoning phase [14]. Visual reasoning encompasses a cyclical progression of observation, imagination, and depiction. By observing design behaviour and analyzing the think-aloud protocol [15], the researchers can understand the designer's cognition development in design reasoning.

Our research develops a generative AI system, a fine-tuning diffusion model, for image generation of modular structures and explores its influence on the design reasoning phase. In the AI era, this study offers a new perspective and method for promoting collaboration between human designers and AI systems in structural design and creativity.

2. Methodology

Our research endeavours to develop the *Modularstructure*, a text-to-image generation, for synthetic images of modular structures based on prompts provided by human designers. A research framework founded on a controlled experiment is proposed to explore the impact of generative AI on the design reasoning process. Considering the results of the think-aloud protocol, the NASA Task Index [16] Questionnaire and the Confidence Level Questionnaire, our study analyses the influence of generative AI on design reasoning regarding designer and design solution dimensions.

2.1. Generative AI towards modular structures

Our research utilizes the DreamBooth [17] method on Stable Diffusion [18] to develop a fine-tuning model for image synthesis of modular structures based on the AARG model [19] as a pre-trained model. Creating the *Modularstructure* fine-tuning diffusion model involves preparing the image dataset, setting training parameters, observing training logs, and conducting the usability test (Figure 1).

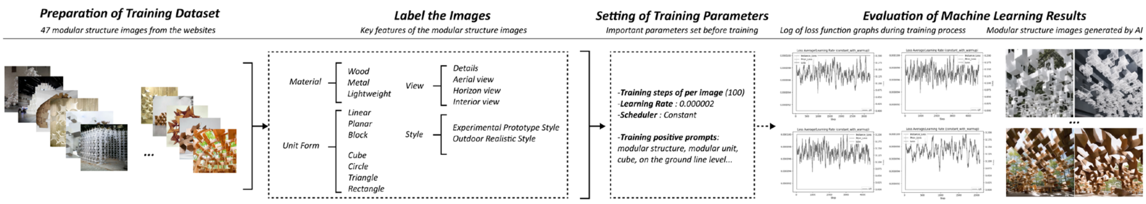

Figure 1: Creation of the *Modularstructure* Fine-tuning Diffusion Model.

Firstly, the researcher selects 47 high-quality images with typical structural features from a large pool of modular structure images as the training dataset. Each image was labelled based on four dimensions: material, a form of unit, viewpoint, and style. The fine-tuning diffusion model training is initiated after configuring the DreamBooth training parameters on the Stable Diffusion WebUI. The loss function logs provided insights into the training results for each episode. In addition, the researcher evaluated the usability of the *Modularstructure* fine-tuning diffusion model for image generation.

Our research has developed the *Modularstructure* fine-tuning diffusion model, effectively generating modular structure images that align with specific prompts. This generative AI system will be leveraged in subsequent research on modular structure design reasoning.

2.2. Research framework for design reasoning of modular structures

Our research conducted a controlled experiment to investigate the influence of generative AI on the design reasoning process. All participants engaged in design reasoning using freehand sketching, 3D modelling, and prototyping. However, only the experimental group had access to the *Modularstructure* fine-tuning diffusion model. Both groups were given the same architectural design task, which included specific spatial scenario information and architectural dimension requirements.

The experiment consists of 2 sessions, including Design Reasoning and Review of the Design Process (Figure 2). Preceding the design task, the experimental group received an additional 10 minutes to acquire the skill of generating preferred modular structure images utilizing the *Modularstructure* model. In the initial session, the participants were encouraged to propose as rich and detailed design solutions as possible within the time frame. The subsequent session consisted of the Think-aloud protocol and questionnaire surveys to comprehend the design cognitions and emotions of the participants during design reasoning.

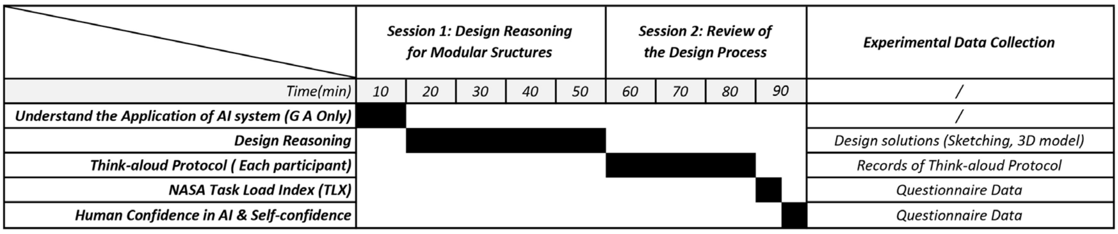

Figure 2: Time Allocation of Design Reasoning Experiment.

Based on the observation of design behaviours and the think-aloud protocol analysis, this study concludes the influence of the generative AI system on the design cognition process of individual designers. According to the participants' feedback from the questionnaire survey, this study discusses its impact on their perceived workload and confidence level, respectively.

2.3. Analytical dimensions

In the collaborative design lens between the human designer and the generative AI system, our research investigates the impact of generative AI on human designers, including design cognition, perceived workload, confidence level, and design solutions, including quantity and quality. The design solutions exhibiting high imaginative scores will be translated into 1:25 scale architectural prototypes, serving as tangible demonstrations of the potential of generative AI systems in enriching structural design reasoning.

3. Experiment

3.1. Participants and Design Task

In this experiment, 12 designers specializing in architectural and structural design were selected and randomly divided into two groups. The design task required participants to propose modular architectural design solutions within a specific spatial scenario. Participants were encouraged to develop imaginative structural design solutions with specific characteristics such as shelter, interactivity, stability, and sustainability. This open-ended setting allowed the designers to explore the potential application scenario of modular structures.

3.2. Tutorial for image generation utilizing the *Modularstructure* fine-tuning model

Our team provided a tutorial to Experimental Group A on how to use the *Modularstructure* fine-tuning model within the Stable Diffusion WebUI for generating modular structure images. It mainly encompassed instructions on providing the Positive and Negative Prompts, setting the Sampler, Iteration Steps, and Image Size. It demonstrated using specific prompts to generate images with stylistic structural features (Figure 3). Before posting the design task, it was ascertained that each participant in A can customize prompts to generate modular structure images per their individualized design intent (Figure 4).

Positive prompts*: (masterpiece),(best quality),on the groundline level,white,block,low,repeating units,modular structure, Memphis style,art installation,colorful and vivid,fashion,interlocking,plants,*
Negative prompts*: error,low-quality,no wood,no-line,*

Sampler: *DDIM*
Steps: *20*
Seed: *1378633924*

Positive prompts*: (masterpiece),(best quality),on the groundline level,wooden,block,high,repeating units,modular structure, interlocking,plants,*
Negative prompts*: error,low-quality,no wood,no-line,*

Sampler: *DDIM*
Steps: *20*
Seed: *1414656602*

Figure 3: Images generated by the *Modularstructure* fine-tuning model in the tutorial demo.

Figure 4: Image samples generated in testing phrase.

3.3. Session 2: Review of the design process

3.3.1. Analysis of Think-aloud Protocols

During the thinking-aloud process, participants were tasked with articulating their cognitive processes as they viewed visual recordings of the initial session. Our research encoded each participant's design reasoning trajectory. Combining the creative process model proposed by Howards [20] and the visual reasoning model proposed by Schon [21], this study encodes the design reasoning process of modular structures into five phases, including analysis of the design task (A), ideation and concept generation (G1), generative AI-driven ideation and concept generation (G2), creation of external representations (D), and evaluation (E). The encoding criteria and examples of the protocol are shown below (Figure 5).

(1) ***Analysis of the Design Task (A)***: Analyzing the information and requirements provided or transferring the design task to a more specific design problem.

(2) ***Ideation and Concept Generation (G1)***: Generating the creative factors or the preliminary idea description for a design problem based on the individual's previous design experience or sudden inspiration. (Differentiated from the imagery triggered by images generated by the AI.)

(3) ***Generative AI-driven Ideation and Concept Generation (G2)***: Generating the creative factors or the preliminary idea description for a design problem triggered by synthetic images.

(4) ***Creation of External Representations (D)***: Transfer of thoughts into freehand sketches, 3D models, and prototypes.

(5) ***Evaluation (E)***: Reflecting on the design idea or reviewing the design solution.

Code	***Description***	***Example***
A	*Analyze design task*	*- In the case of large modular structures, stability is important...* *- The dimensions of the outdoor site are clearly defined...*
G1	*Ideation &* *Design concept generation*	*-I wanna design a modular structure that can be used as a pavilion...* *-Then, I think lightweight materials are more suitable...*
G2	*Ideation triggered by generative AI systems*	*-I was inspired by the interlocking structures in this set of AI-generated images.* *-The spatial scene in this image reminds me of...*
D	*Free-hand sketching, 3D modeling, prototyping*	*/*
E	*Assessment the design solution*	*-The structure looks loose to me...* *-This set of images generated by AI looks unstable...*

Figure 5: Encoding Criterion and Examples of the Protocol.

Our study annotated the verbalized modular structure design reasoning process from 12 participants based on the described encoding criterion. The visualization of the design reasoning trajectories per participant demonstrated the distribution of the five phases in the design process (Figure 6). Additionally, the duration per participant in each type of stage throughout the process is shown as follows (Figure 7).

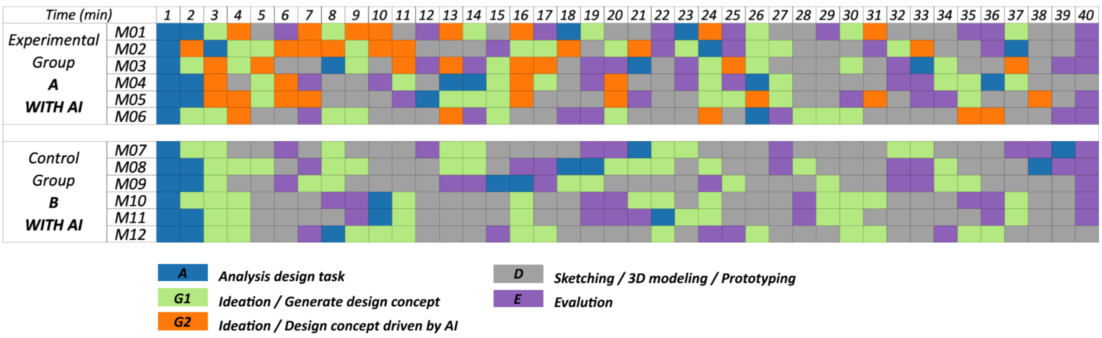

Figure 6: Visualization of design reasoning trajectories per participant based on the encoding criterion.

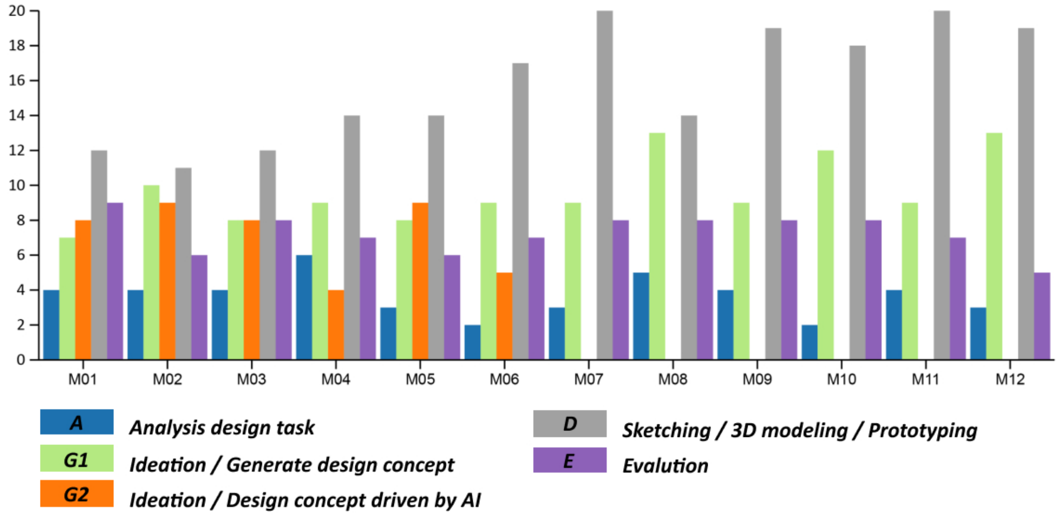

Figure 7: Duration of each phase in the 40-minute modular structure design reasoning per participant.

The study obtained the following insights by observing each participant's phrase distribution in visualizing design reasoning trajectories (Figure 6). The design trajectories of participants in Experimental Group A revealed that generative AI-driven ideation and concept generation (G2) occurred intensively within the initial 20 minutes of the experiment. In comparing Control Group B and Experimental Group A, it was noted that the analysis of design tasks (A) appeared more frequently throughout the design reasoning process of the latter. According to Howard's creative design model theory, the transition from ideation (G1/G2) to evaluation (E) represents an independent thinking period for proposing a creative solution — from idea generation to evaluation. Compared to Control Group B, the discreteness of G-E block distributions in the visualization is higher in Experimental Group A. It indicates that within the equivalent time frame, participants in A, under the intervention of generative AI, put forward more ideations during the thinking period, which either involve iterative refinement of existing ideations or the generation of novel solutions. Upon assessing the design schemes, it was observed that participants in A proposed more differentiated design ideas. However, many technical realization details of structural design schemes must be more specific or better thought through.

Figure 7 indicates that participants with generative AI showed significantly decreased time allocated to freehand sketching, creating 3D models, and prototyping (D) compared to Control Group B (Figure 7). Furthermore, the duration of ideation (G1) based on the individual's previous design experience or sudden inspiration decreased while the duration of design task analysis (A) demonstrated an increase. Based on the findings above, the research indicates that generative AI inhibits human designers from creating external representations of thinking within a constrained timeframe and diminishes the motivation to generate design concepts actively. Designers increasingly rely on generative AI for ideation and design concepts. Based on the descriptions provided by participants, the study characterizes the interaction process with text-to-image generation systems as one of collaborative visual reasoning, encompassing observation, imagination, and generation. This process facilitates the ideation stage (G1/G2) while supplanting the creation of external representations of ideas (D). Additionally, the heightened duration and frequency of task analysis (A) point to the possibility that collaboration with generative AI may result in distractions or a loss of focus for human designers within the design reasoning process.

3.3.2. Perceived workload of participants

Upon completing the experiment, participants were asked to complete a workload perception questionnaire related to the six indicators of the NASA Task Load Index (TLX): Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration. Each dimension is evaluated on a scale from 0 to 100. The team recorded the feedback from each participant and subsequently computed the average score for each indicator within the respective groups for comparative analysis (Figure 8).

NASA TLX	Experimental Group A	Control Group B
Mental Demand	86	76
Physical Demand	67	85
Temporal Demand	89	78
Performance	86	80
Effort	68	79
Frustration	60	70

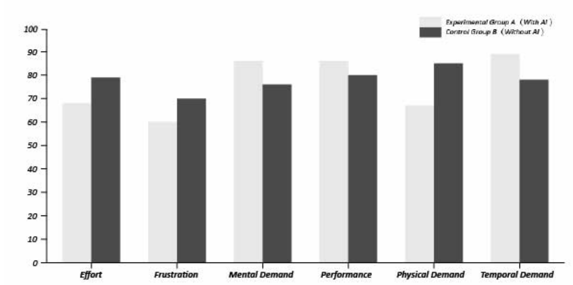

Figure 8: The Result of the NASA Task Load Index (TLX) Questionnaire.

The findings indicate that participants in Experimental Group A exhibited significantly heightened Mental Demand scores while registering lower Effort and Frustration scores in contrast to those in Control Group B. In post-study interviews, it was suggested that integrating generative AI in structural design reasoning processes augments the participants' psychological preparedness to assimilate and apply novel skills. Employing generative AI to create images can shift some of the design workload to the AI, consequently diminishing the exertion and frustration encountered by human designers. The decline in Physical Demand aligns with the reduced duration participants allocate to creating external representations of their concepts.

3.3.3. Human confidence in AI and self-confidence

In this section, participants were presented with the following questions in a questionnaire: "If AI generated 100 images based on prompts provided, what is the estimated number of images that would facilitate ideation or concept generation?" to assess human designers' confidence in AI. Furthermore, participants were requested to rate their confidence level in developing satisfactory modular structure design schemes on a scale of 0 to 100.

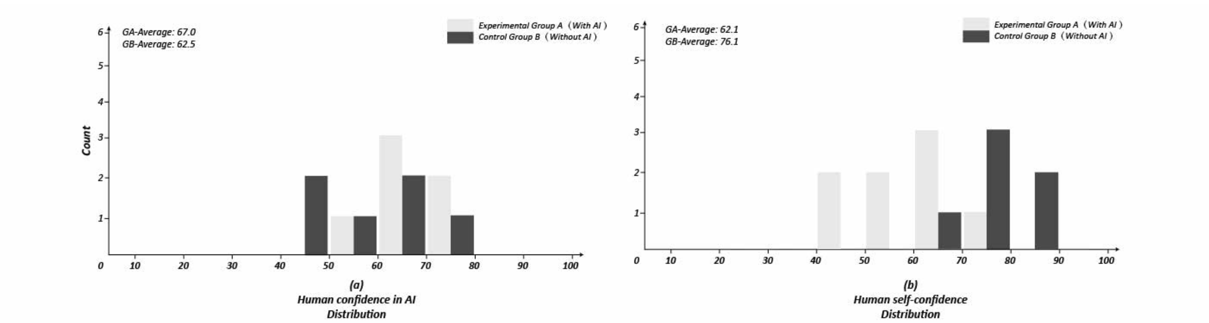

Figure 9: The Results of Human Confidence in AI and Self-confidence Questionnaire.

The chart indicates that human confidence in generative AI scored a relatively lower value. However, human self-confidence ratings exhibit a distribution that is concentrated at a relatively high level (figure 9).

3.4. Structural prototype: Imaginative modular structures

Our research has developed prototypes at a 1:25 scale for design concepts with high imaginative scores, demonstrating the structural creativity and potential spatial application of modular structures.

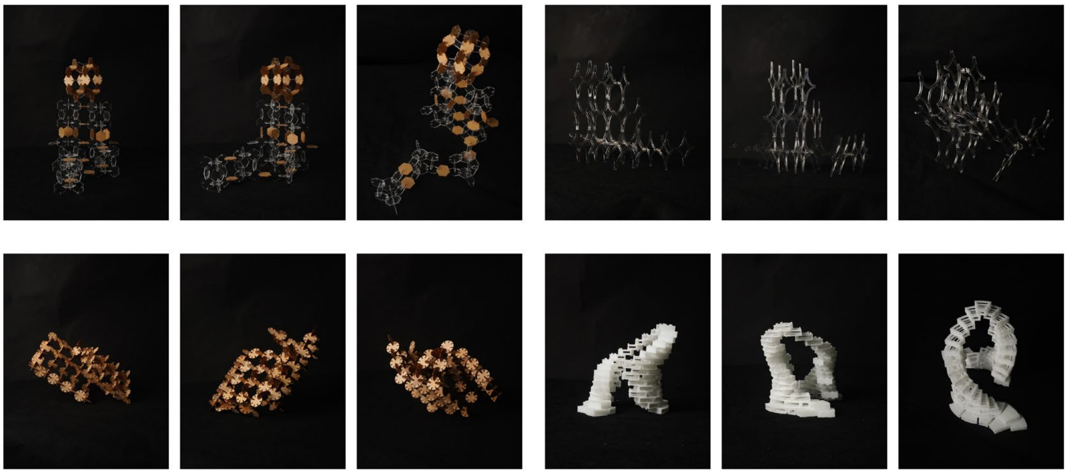

Figure 10: Structural Prototype: Imaginative Modular Structures.

4. Discussion

4.1. Facilitation or inhibition

Based on the findings in the experiment section, it is evident that generative AI has the potential to facilitate the generation of ideation and design solutions, thereby accelerating the iterative process from ideation to evaluation. Within the constrained time frame, collaborating with generative AI led to the proposal of more diversified ideations and design solutions. Nevertheless, some design solutions require more technical realization and further refinement. Collaborating with generative AI enables human designers to enhance their divergent thinking. However, the accuracy of the AI system in recognizing prompts determines the level of detailed solutions. Furthermore, the synthetic images triggered the human designer's imagination, as evidenced by the metaphorical prompts provided by the participants during the test.

Generative AI inhibits the creation of external representations of the thought process, drastically reducing the time spent on free-hand sketching, 3D modelling, and prototyping. Interacting with text-to-image generation can be considered a collaborative creation process of external representations involving iteration of observation – imagination - generation. Thus, it partially replaces the previous visual reasoning approach. The study argues that designers' increasing reliance on generative AI should be viewed critically. While this trend has the potential to accelerate collaborative intelligent design methods and advanced AI systems, it also concurrently diminishes human designers' motivation to generate ideation or design solutions proactively.

4.2. Co-intelligent design towards structural design

Based on the impact of generative AI on design reasoning towards modular structures, this research argues that the collaborative intelligent design approach towards modular structure should articulate the unique capabilities of human designers with the computational advantages of generative AI. Participants involuntarily employed metaphor and analogy prompts when engaging with AI systems, such as they described surfaces as the ebb and flow of waves. It is crucial to note that human designers' imagination, intuition, and thought processes are unique and cannot be ignored or replaced in the co-intelligent design process. The Modularstructure fine-tuning diffusion model generates images that help designers create concrete and rich associations about spatial scenarios. A well-trained generative AI can participate in the human designer's visual reasoning and accelerate the iteration.

Further research in human-computer interaction is essential in structural design to facilitate the collaborative design process between AI and human designers. Enhancing the interaction mechanism and performance of the AI system is imperative to achieving a preferable collaborative process.

5. Conclusion

Structural design is known for its unwavering dedication to rationality and precision. However, upon studying the remarkable and intricate structural designs that have emerged throughout history, it is evident that the imagination and creativity of designers have played an indispensable role in their creation. This study explores the impact of generative AI on the design reasoning of modular structures to promote collaborative structural design. It contributes to understanding AI's potential role in structural design.

Our research believes AI research should go beyond the fixed mindset of "developing assistive tools for design tasks" towards developing a collaborative intelligence research framework involving human designers, AI systems, and design solutions, contributing to the structural design process. Taking a systemic perspective on the entire design context and exploring the interaction between human designers and AI systems is imperative, contributing to a more systematic and speculative understanding of such emerging design phenomena driven by AI.

Generative AI facilitates generating structural design ideation and solutions during the design reasoning phase while accelerating the iterative process from conception to evaluation. However, it inhibits the creation of external representations of the thinking process, or rather, the process of interacting with the AI can be viewed as the collaborative visual reasoning process replacing the previous ones. The reliance of human designers on AI warrants critical consideration, as it diminishes their motivation to generate ideation or structure design solutions proactively.

This research argues that the collaborative intelligent design approach towards modular structures should articulate the human designers' unique capabilities with the computational advantages of artificial intelligence. It is crucial to note that human designers' imagination, intuition, and thought processes are unique and cannot be ignored or replaced in the co-intelligent design process. The well-trained generative AI is incorporated into the human designer's visual reasoning process to enhance the design reasoning process and develop structural design schemes. Based on the collaborative intelligent research framework, further study on human-computer interaction in structural design is necessary. This study provides a new perspective and research method to facilitate the collaboration between human designer and generative AI towards creative structural design in the AI era.

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References

[1] R. K. Pallavi and Y. H. Sudeep, 'Applications and Potential of Artificial Intelligence in Structural Engineering', *ISJEM*, vol. 02, no. 04, Apr. 2023, doi: 10.55041/ISJEM00353.

[2] H. Salehi and R. Burgueño, 'Emerging artificial intelligence methods in structural engineering', *Engineering Structures*, vol. 171, pp. 170–189, Sep. 2018, doi: 10.1016/j.engstruct.2018.05.084.

[3] M. Sun, P. Buš, J. Chen, and K. Sun, 'CO-INTELLIGENT DESIGN TOWARD MODULAR STRUCTURES', in *CAADRIA 2024*, Singapore University of Technology and Design, Singapore.

[4] A. Raina, C. McComb, and J. Cagan, 'Learning to Design From Humans: Imitating Human Designers Through Deep Learning', *Journal of Mechanical Design*, vol. 141, no. 11, p. 111102, Nov. 2019, doi: 10.1115/1.4044256.

[5] A. Raina, J. Cagan, and C. McComb, 'Transferring Design Strategies From Human to Computer and Across Design Problems', *Journal of Mechanical Design*, vol. 141, no. 11, p. 114501, Nov. 2019, doi: 10.1115/1.4044258.

[6] M. Pan, Y. Yang, Z. Zheng, and W. Pan, 'Artificial Intelligence and Robotics for Prefabricated and Modular Construction: A Systematic Literature Review', *J. Constr. Eng. Manage.*, vol. 148, no. 9, p. 03122004, Sep. 2022, doi: 10.1061/(ASCE)CO.1943-7862.0002324.

[7] 'Artificial intelligence and the future of modular and pre-fab construction', Daily Commercial News. Accessed: Apr. 09, 2024. [Online]. Available: https://canada.constructconnect.com/dcn/news/technology/2023/07/artificial-intelligence-and-the-future-of-modular-and-pre-fab-construction

[8] L. Chen *et al.*, 'An artificial intelligence based data-driven approach for design ideation', *Journal of Visual Communication and Image Representation*, vol. 61, pp. 10–22, May 2019, doi: 10.1016/j.jvcir.2019.02.009.

[9] J. V. Ruiz, H. Toshiki, and T. Hirayama, 'Kodama', Kengo Kuma and Associates. Accessed: Dec. 02, 2023. [Online]. Available: https://kkaa.co.jp/en/project/kodama/

[10] J. Taylor, 'Populous Creates Eames-Inspired Installation for World Architecture Festival London', ArchDaily. Accessed: Dec. 02, 2023. [Online]. Available: https://www.archdaily.com/769325/populous-creates-eames-inspired-installation-for-world-architecture-festival-london

[11] Arup Associates, 'Temporary Permanence Installation', Temporary Permanence Installation / Arup Associates. Accessed: Dec. 02, 2023. [Online]. Available: https://www.archdaily.com/786564/urban-public-spatial-installation-arup-associates?ad_medium=gallery

[12] G. Goldschmidt and M. Weil, 'Contents and Structure in Design Reasoning', *Design Issues*, vol. 14, no. 3, p. 85, 1998, doi: 10.2307/1511899.

[13] J. A. Park, Y. S. Kim, and J. Y. Cho, 'Visual Reasoning as a critical attribute in design creativity', presented at the Proceedings of International Design Research Symposium, 2006, 2006.

[14] R. Oxman, 'Digital Media and Design Didactics in Visual Cognition', presented at the eCAADe 2001: Architectural information management, 2001. doi: 10.52842/conf.ecaade.2001.186.

[15] L. Hay, A. H. B. Duffy, C. McTeague, L. M. Pidgeon, T. Vuletic, and M. Grealy, 'A systematic review of protocol studies on conceptual design cognition: Design as search and exploration', *Des. Sci.*, vol. 3, p. e10, 2017, doi: 10.1017/dsj.2017.11.

[16] S. G. Hart and L. E. Staveland, 'Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research', in *Advances in Psychology*, vol. 52, Elsevier, 1988, pp. 139–183. doi: 10.1016/S0166-4115(08)62386-9.

[17] N. Ruiz, Y. Li, V. Jampani, Y. Pritch, M. Rubinstein, and K. Aberman, 'DreamBooth: Fine Tuning Text-to-Image Diffusion Models for Subject-Driven Generation', in *2023 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, Vancouver, BC, Canada: IEEE, Jun. 2023, pp. 22500–22510. doi: 10.1109/CVPR52729.2023.02155.

[18] 'Stable Diffusion 3', Stability AI. Accessed: Jun. 04, 2024. [Online]. Available: https://stability.ai/news/stable-diffusion-3

[19] 'AARG-Architecture-Res-v1.0'. Accessed: Apr. 09, 2024. [Online]. Available: https://civitai.com/models/24236/aarg-architecture-res

[20] T. J. Howard, S. J. Culley, and E. Dekoninck, 'Describing the creative design process by the integration of engineering design and cognitive psychology literature', *Design Studies*, vol. 29, no. 2, pp. 160–180, Mar. 2008, doi: 10.1016/j.destud.2008.01.001.

[21] D. A. Schon and G. Wiggins, 'Kinds of seeing and their functions in designing', *Design Studies*, vol. 13, no. 2, pp. 135–156, Apr. 1992, doi: 10.1016/0142-694X(92)90268-F.

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