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Research on Environmental Architectural Design Methods Based on the AIGC Creation Method

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Abstract. Significant advancements in Natural Processing Language (NLP) technology have facilitated the swift progress of artificial intelligence-generated content (AIGC). This has resulted in the emergence of a novel avenue for environmental design creation, specifically the utilization of multimodal large models for "text-to-image" generation. The emerging paradigm in the field of environmental design creation The advent of technological advancements has precipitated a paradigm shift in the conventional way of production, wherein the process of creation will transition from individual inspiration to generative creativity facilitated by artificial intelligence. Researchers in this study use questionnaires, semi-structured interviews, and experiments to look into how generative artificial intelligence (AI) affects the growth of environmental architects in new ways of making things. It also investigates how these novel design methods can effectively cater to a wide range of user preferences, thereby enhancing the efficiency and quality of environmental architect creation.

Keywords. artificial intelligence-generated content (AIGC), environmental architectural design,AIGC creation method

1. Introduction

The iterative process of deep neural networks within the learning paradigm and network structure significantly enhances the learning capacity of AI algorithms. The fundamental capabilities of deep learning algorithms, such as perception, cognition, imitation, and generation, play a crucial role in determining the productivity of AIGC technology in generating batches of outputs. The utilization of AIGC for environmental design offers several advantages, including the ability to expedite the design process, automate tasks, optimize outcomes, conserve resources, and streamline the intricate and laborious stages involved in traditional environmental architectural design. These stages typically encompass preliminary research, conceptual sketching, preliminary design, iterative refinement, bidding, and ultimately culminating in the creation of a final draft. By employing a data-driven approach, AIGC facilitates these processes in a more efficient manner. Enhancing design efficiency and quality is facilitated by this approach. This study investigates the topic of human-computer collaborative creativity specifically within the context of environmental architectural design degrees, targeting

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both teachers and students. The objective of this study is to examine the primary factors that contribute to enhancing the efficiency of environmental architecture designers within the context of the new creation mode of AIGC. This will be achieved through the use of AI prompts, design creation that takes into account the diverse preferences of users, and iterative refinement of the algorithm. This study primarily utilizes professors and students specializing in environmental architectural design as research participants. It aims to compare the effectiveness of traditional and innovative design methods, analyze the strengths and weaknesses of the latter, and investigate potential future directions for development.

2. Literature Review

2.1. Definition and background of AIGC

AIGC, also known as Artificial Intelligence Generated Content, encompasses the integration of artificial intelligence techniques and generative computing methodologies to facilitate automated, intelligent, and creative computation, design, and generating processes [1]. This method represents a novel approach to content processing, following the established paradigms of professionally produced content (PGC) and user-created content (UGC). In a comprehensive manner, the concept of AIGC encompasses a wide range of fields, serving as a manifestation of inventive thinking and originality. It involves the amalgamation of artificial intelligence techniques with generative computing methodologies. The concept not only demonstrates the interconnected and mutually supportive relationship between the two disciplines but also seeks to leverage computer programs, models, and algorithms for the purpose of autonomously producing imaginative and groundbreaking content that fosters advancement and novelty across several domains.

2.2. Technological evolution of AIGC-assisted creation of environmental architectural designs

The emergence of AIGC has facilitated the acquisition of design skills and rendered the field of design more accessible. In the realm of environmental architecture, an increasing number of designers have embraced the practice of human-computer cooperation as a means to foster inclusivity in the process of design generation.Reviewing the historical milestones of environmental architectural design, the author believes that designers use computers to create environmental architectural design as shown in Figure 1 and Figure 2, which can be basically divided into the following stages:

The origins of computer-aided design (CAD) can be attributed to the exploration period of computer-generated design in the 1950s and 1960s. Notably, in 1957, Dr. Patrick Hanratty played a pivotal role in the development and production of the initial commercially accessible computer numerical control programming system [2]. The Sketchpad drawing software, invented by Ivan Suzelain in 1963, facilitated graphical interaction between designers and computer systems.

Design that utilizes computer graphics The 1.0 era, which spanned from the 1980s to the 1990s, Since its inception in 1982, Adobe has demonstrated a steadfast commitment to the exploration and advancement of digital design. In the year 1990, the

Knoll brothers, namely Homas and John, effectively launched and developed Photoshop [3], a software application designed for vector graphics with Bezier curves. The advent of AutoCAD in the aforementioned year marked the commencement of the 3D epoch .

The design approach utilizes data and machine learning techniques. During the 2.0 period, which commenced in the early 21st century, and after 2006, the emergence of deep learning algorithms and advancements in graphics processing unit (GPU) computational capabilities led to the development of intelligent assisted design tools [4]. These tools have the capability to undergo training using a substantial volume of data in order to enhance the efficiency of the design.

The direct generative design age, known as the 3.0 era, which is based on AIGC, has initiated a period of significant advancements in the twenty-first century. In the year 2019, NVIDIA introduced styleGAN, a style-based generative adversarial network, with the aim of enhancing the visual fidelity of generated images. In the year 2021, OpenAI introduced ChatGPT, a deep learning model that encompasses 175 billion parameters, thereby significantly altering the landscape of AI development and utilization by humans in contemporary times. In July of the aforementioned year, Stable Diffusion, which is founded on the Latent Diffusion Model and the Diffusion Model , enhanced the precision of artificial intelligence mapping to a level comparable to that of artistic creations. This accomplishment was achieved through iterative algorithmic processes and resulted in heightened productivity at an advanced level. Furthermore, the threshold for the necessary equipment to engage in such creative endeavors was lowered to a more accessible mass level.

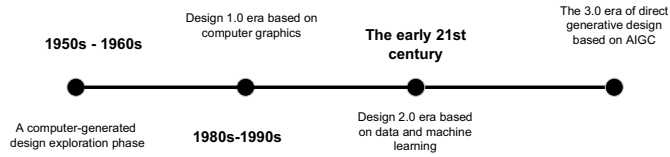

Figure 1. Four stages in the development of AIGC-assisted environmental building design.

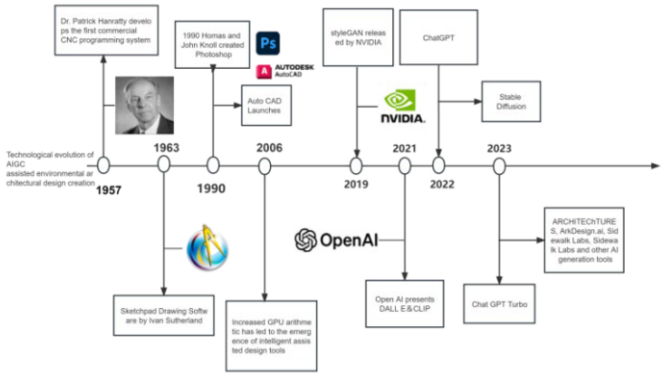

Figure 2. Technological evolution of AIGC-assisted creation of environmental architectural designs.

3. Methodology

3.1. Shortcomings and obstacles of the traditional design process

The growth of society has resulted in a heightened need within the contemporary design market. However, the conventional methods of design education, which have led to the creation of isolated data repositories, struggle to adequately address the varied demands of design. Hence, it is imperative for design students, educators, and practitioners to enhance their proficiency and aptitude in design, thereby optimizing design efficiency. A survey was conducted among 100 students and teachers in the design class, utilizing a questionnaire format. The results indicated that a significant majority of these individuals, who possess extensive experience in design education, continue to adhere to conventional design methodologies, as depicted in Figure 3. During the design process, a significant majority of students (88%) prioritize utilizing the Internet for information gathering and fieldwork to thoroughly investigate and analyze the design's background. This preliminary stage typically spans a duration of approximately 3-4 days. Subsequently, when creating the initial design draft, the time required varies depending on individual design proficiencies. However, a substantial majority (94%) of design students indicated that this phase necessitates at least one day. When revising the initial draft, conventional design practices involve employing specialized software tools such as PhotoShop and C4D, as depicted in Figure 4. Nevertheless, despite the utilization of advanced tools, a significant majority of design students (61%) still required approximately one week to complete their tasks. During the process of refining and finalizing the design, students invest a significant amount of time and work. This implies that the completion of a comprehensive set of designs requires a minimum of one week or longer, even for a proficient design student possessing a solid software background.

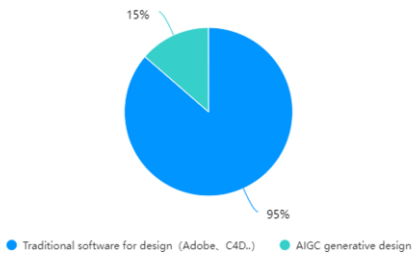

Figure 3. The way design students create on a daily basis.

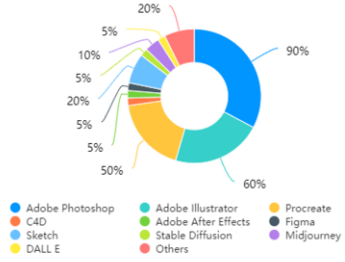

Figure 4. Commonly used software for students.

3.2. research problem

In light of the findings from the questionnaire, we have formulated the following research inquiries to gain a deeper understanding of the influence of AIGC's innovative approach on the creative efficacy of educators and students in the field of environmental architectural design. To address these specific aspects of the questionnaire, we have conducted semi-structured interviews.

- The design process of creating in the traditional way of creating
- Respondent AIGC Awareness Collection
- What it's like to create designs with AIGC

3.3. research target

A total of 40 participants, consisting of students and teachers specializing in environmental architectural design from various universities in China, were selected for semi-structured interviews. All participants had a minimum of 4 years of professional study and held a master's degree or higher. They possessed significant practical expertise in this field, demonstrated proficiency in relevant software applications, and had achieved notable success in national competitions.

3.4. Research Methodology and Significance

The study consists of three primary steps, as depicted in Figure 5.

Step 1:Pre-creation (questionnaire survey): A questionnaire survey was employed to gather information on conventional creative techniques from a sample of 100 students and teachers affiliated with the School of Design.

Step 2:Mid-composition (semi-structured interviews):A total of 40 participants, consisting of students and professors specializing in environmental architecture and design, were engaged in semi-structured interviews. The purpose of these interviews was to inquire about the process of AIGC production and gather their preliminary perspectives on the methodology employed.

Step 3:Post-creation (survey tracking): The purpose of this study is to monitor and analyze the genuine emotions and challenges experienced by participants while they engage in the creative process using the AIGC creation model, subsequent to their initial interview.

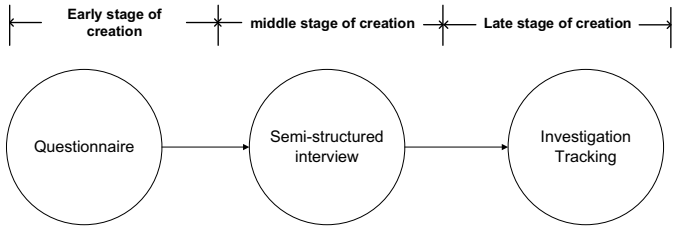

Figure 5. The three phases of the study.

The present study employed a questionnaire collection method to gain insights into the challenges faced by design students and teachers who adhere to traditional creation methods. Additionally, semi-structured interviews were conducted to ascertain the level of acceptance and understanding of AIGC among teachers and students at the College of Architecture and Design. To further explore the practical experience of using AIGC in the creative process, hands-on approaches were employed. Subsequently, a two-month tracking survey was conducted to gather the thoughts and reflections of the interviewees regarding the new creation method utilizing AIGC.

3.5. Research Instruments and Procedures

This study presents a comprehensive analysis of the design process involved in a new authorship technique based on AIGC. The analysis is based on the authoring experiences of 40 respondents, as depicted in Figure 6.

Step 1:Use the text class generation tool chatGPT for pre-design background research and prompt text generation.

The emergence of Large Language Modeling (LLM) has given rise to a novel discipline known as ChatGPT Prompt Word Engineering [5]. In order to get the intended outcome using LLM, it is imperative to input instructions that adhere to the prescribed criteria and possess clarity. Through the modification of prompts for the purpose of generating iterative loops, the LLM is capable of consistently comprehending and acquiring knowledge to produce content that aligns with predetermined criteria, hence enhancing the quality of the prompts.

Step 2:Use Midjourney to provide relevant design inspiration for conceptualization and the selection of suitable solutions.

The utilization of cue word engineering in the context of image generation, namely in the field of text-to-image conversion, has gained significant traction and is currently prevalent in several generative tools. During the course of the voyage, the inclusion of a high-performance 10W GPU, functional page operation, and impressive out-of-the-picture effects contribute to the appeal of this designer inspiration, offering a compelling option.

Step 3:Download the CKPT model and the Lora model from Civitai and load the model in Stable Diffusion. Put the generated prompt into Stable Diffusion for preliminary design generation.

Stable Diffusion is an end-to-end model comprising three primary core components: the self-splitting Variational Autoencoder (VAE), the Image Segmentation Full Convolutional Neural Network-U-Net, and the text encoder of Contrastive Language-Image Pre-Training (CLIP).The encoder within the VAE model transforms the input image into latent features of reduced dimensionality. These latent features serve as inputs to the U-Net architecture. Subsequently, the decoder component of the model reconstructs the original image at the pixel level by processing the low-dimensional latent features.The ability of a VAE to capture the distinguishing characteristics of various artists or art styles is achieved by the acquisition of latent representations from a substantial collection of artworks. Additionally, it has the capability to produce artistic creations that incorporate a blend of styles. This is achieved by identifying two distinct points within the latent space, each representing a different style, and then interpolating between these points [6]. The U-Net model plays a pivotal role in ensuring robust diffusion and is tasked with making predictions on noise residuals.The technique of stable diffusion can be employed to make a gradual image by iteratively invoking U-Net. In each iteration, U-Net is utilized to eliminate noise and produce gradually denoised images. The text encoder utilized in CLIP has the ability to encode the given text prompt into a text embedding. This text embedding enables a level of control and direction over the content of the resulting image, hence facilitating a diverse and highly manageable image-generating capability.

Step 4:Use the ControlNet plug-in in Stable Diffusion for fine tuning.

The pre-training process is regulated by ControlNet, which incorporates supplementary inputs to enable the AI system to produce the desired final image outcome with greater control. This is achieved by modifying the pre-processor

parameters.The Modified Line Segment Detector algorithm is well-suited for the identification and detection of straight line segments within images or designs. The algorithm is capable of accurately determining the position and orientation of straight line segments in complex images with higher efficiency when dealing with interior and architectural design applications.

Step 5:Make manual adjustments in Photoshop and finish finalizing.

Manual adjustments are implemented to address the imperfections arising from AI algorithms. These changes are paired with the utilization of Photoshop software to carry out the final processing of effects, ultimately attaining the intended outcome.

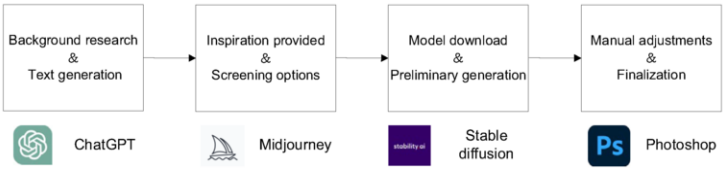

Figure 6. Design steps for the AIGC creation method.

4. Results and Discussion

4.1. Comparison of traditional creation methods and AIGC creation methods

This study involved the selection of 40 students from the College of Environmental Architecture and Design who were instructed to engage in a task that required the utilization of both traditional and AIGC production methods. The duration of time allocated to each of the two distinct approaches was carefully watched and documented. Additionally, a collection of works produced under each method was gathered for the purpose of conducting a comprehensive study and facilitating a thorough comparison.

Table 1 clearly illustrates that, in the context of a shared theme, the design outputs generated through two distinct creative processes exhibit discernible variations in terms of creation duration, complexity, and quality.

- At the level of length of creation

By monitoring the duration allocated to both creation techniques, it becomes evident that the AIGC creation method requires significantly less time compared to the old creation approach. The text generation tool known as ChatGPT is designed to efficiently condense and structure research findings, enabling designers to obtain prompt answers to their inquiries. The utilization of picture production tools such as midjourney and stable diffusion enables the rapid generation of a diverse array of options within a matter of minutes.

- On the level of complexity of the work

By examining the output of the two techniques of creation, it becomes evident that, regardless of the mode employed, the resulting representation effectively aligns with the topic of creation. Furthermore, the image exhibits a notable level of coherence and harmony. Although the AIGC mode exhibits slightly superior visual effects and

complexity compared to the traditional creation mode, the meticulous examination of the works reveals the necessity for designers to engage in post-adjustment and thoughtful consideration to ensure the reasonability and feasibility of the design.

- On the level of the quality of the work

As the level of intricacy in the task increases, there will be a matching enhancement in the caliber of the output. The utilization of cross-entropy in information theory is a prevalent practice for assessing the performance of deep learning neural networks in the context of sample evaluation. Cross-entropy is a mathematical metric used to quantify the discrepancy between the probability distributions of two distinct events. A decrease in cross-entropy indicates a higher degree of alignment between the model's output and the actual occurrence. The calculation of cross entropy can be performed using the formula as Eq. (1).

$$H(p,q) = -\sum_{i=1}^{n} p(x)\log(q(x)) \quad (1)$$

where it denotes two events ***p,q***. In the context of this research, these events correspond to the conventional design approach and the AIGC design approach. In the realm of reality, individuals tend to possess consistent expectations regarding the quality of creative endeavors. As the standards for quality increase, the intricacy of the task also intensifies, leading to heightened levels of uncertainty and a larger cross-entropy. When the artistic work reaches a more elevated state of humanistic ideological elements, the intricacy of semantics imposes some constraints on the comprehension of AIGC. The content generated by the designer's personal accumulation of humanity and injecton of personal emotions possesses profound significance.

Sample	Categories	Topics	Traditional Creative Mode& time consuming	AIGC Creation Mode & time consuming
1	Landscape Design	Nanjing Forestry University PurpleLake Creek renderings	1440 hours	1hour
2	Green space landscape design	Child-friendly urbanzoral park design	336 hours	0.5 hour
3	Architectural design	Hubei University of Technology campus cafe renovation project	720 hours	0.3 hour

4	Interior decoration design	High-end modern living room	48 hours	0.2 hour

Table 1. Comparison between traditional methods and AIGC methods under the same proposition.

4.2. Diversity generation based on user preferences

The issue of accommodating the diverse tastes of users in the realm of environmental architectural design arises from the presence of some variances in user preferences. This study aims to assess the preferences of users with respect to the generation of architectural diversity and the fusion of architectural shapes. The process of architectural diversity generation involves the creation of several architectural styles that are related yet distinct, all within a predetermined framework. The concept of architectural shape preference involves the integration of several architectural shapes in order to modify the original building's geometry and achieve the desired user preference. Figures 7 and 8 depict the production of architectural diversity through line drawings, specifically focusing on buildings characterized by curved and square designs. The preservation and diversification of the original qualities of the line drawings are seen in this manner. To advance the examination of architectural shape fusion, Figure 9 employs a combination of square and curved buildings. Through an iterative process facilitated by an AI tool, novel fusion outcomes are obtained. This approach yields a diverse array of sketches that align with the user's preferences within a matter of seconds. Following the production of the sketches, it is feasible to generate a diverse range of rendering styles tailored to the user's own tastes.

Figure 7. Architectural diversity generating line drawings and modernist style renderings (curved buildings)

Figure 8. Architectural diversity generating line drawings and functionalist style rendering (square building)

Figure 9. Architectural diversity generating line drawings and renderings in postmodernist style (curved square hybrid building)

5. Conclusions

The advent of AI-generative design has brought about significant advancements in the realm of environmental architectural design. To shed light on the challenges currently encountered by traditional design approaches, this study commenced with a questionnaire survey administered to 100 design students, focusing on conventional creation methods. Subsequently, semi-structured interview was administered to a cohort of 40 students specializing in environmental architecture design. The interview encompassed inquiries pertaining to three key dimensions: the intricacies of design generation through conventional creative techniques, the level of comprehension regarding AIGC, and the subjective experiences associated with design creation facilitated by AIGC. The responses provided by the interviewees were meticulously documented for analysis and interpretation. During the interview process, a uniform proposition was presented to the respondents, requiring them to employ both the old creation method and the new creation method. Subsequently, the resulting works were assessed and compared in terms of time, complexity, and quality. The present study provides a summary of a set of design processes derived from the recently developed AIGC production method. Additionally, a novel approach for generating line drawings is proposed that takes into account the diverse preferences of users. The research revealed that the utilization of AIGC can significantly enhance the creative productivity of environmental designers and offer them novel insights and concepts. However, there remains a notable deficiency in comprehending the subjective and humanistic aspects of thought. As the complexity of the intended meaning in a design effort increases, the limits of AI in expressing such meaning become more apparent.

The ongoing advancement of models in the realm of environmental architectural design offers artists an array of boundless creative opportunities. Through the utilization of a substantial design model, designers engage in iterative processes that enhance the caliber of their work, thereby enabling a greater emphasis on the development of innovative concepts. In the foreseeable future, it is anticipated that AIGC tools will progressively integrate into the entirety of the design process, assuming a crucial role as an integral component of production.

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