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# Exploration of digital technology for landscape architecture workflow based on AIGC

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## Abstract

In the digital age, AI technology has become a focal point in the field of land-scape architecture, with research primarily focusing on machine learning and neural networks. This study, grounded in the development of generative models and digital landscape technology, employs design thinking to explore the image generation pathways of generative AI models in landscape architecture. The findings indicate that the workflow proposed by general-purpose AI algorithms has certain limitations. By leveraging landscape architecture expertise for data augmentation and model fine-tuning, the speed and efficiency of AI-assisted landscape architecture image generation systems can be significantly enhanced.

## Keywords

landscape architecture; AIGC; generative artificial intelligence; machine learning; thinking model

## 1. Introduction

With the explosive growth of artificial intelligence technology over the past two years, generative AI has become widely adopted in the design field. In today's landscape architecture sector, the market is transitioning from an era of growth to one of consolidation. The proportion of' upgrading' projects, such as urban renewal and rural revitalization, is rapidly increasing. Market shrinkage has intensified competition within the industry, making cost reduction and efficiency enhancement essential for survival in the design sector. In recent years, researchers have conducted experiments using deep learning, neural networks, and other algorithms, training large language models (LLMs)and achieving significant advancements in natural language processing and computer vision . As generative AI continues to evolve in the landscape architecture field, mastering AI technology has become a crucial tool for enhancing work efficiency. This article explores the application of AIGC technology at various stages of practical landscape architecture work, aiming to provide effective pathways for landscape architects to explore new design approaches in the modern era.

## 2. The development of digital tools

### 2.1. The classical garden design period

During the classical garden design era, gardens were primarily found in royal and noble estates, private residences, religious sites, and specialized functional areas, such as vegetable and fruit gardens. The garden designers of this period were renowned artists and craftsmen, often passed down through generations. They relied on their craftsmanship to create gardens, a practice known as 'garden-making.' Traditional garden designers used basic drawing tools and an understanding of natural topography, materials, and botany when designing gardens.

### 2.2. The era of computer aided design

In the 20th century, urbanization accelerated, leading to the expansion of traditional garden design from private to public spaces. Traditional garden designers were replaced by more commercial design firms. From the 1980s to the 1990s, advancements in computer technology, particularly in 3D modeling, graphics, and data processing, led to the development of Computer-Aided Design (CAD). This technology was widely used for terrain analysis, plant placement, and water feature design, standardizing the workflow in landscape design.

### 2.3. The era of computer aided design

At the end of the 20th century, with the advent of the digital age and the booming market in landscape architecture, the boundaries of the landscape design industry have continuously expanded. The trend towards digital landscape design has become increasingly prominent. The emergence of parametric design tools such as GIS, BIM, and LIM has integrated various subtle aspects of landscape design, including wind, heat, light, and sound, into the design process. This has freed landscape design from the limitations of designers' personal experiences and aesthetic preferences.

### 2.4. The era of AI collaborative design

In 2017, the Google team published a paper titled "Attention is All You Need," which introduced the Transformer architecture . This marked a significant shift in the direction of AI development in both language and image processing. Building on the Transformer architecture, adaptive attention mechanisms led to the creation of renowned models such as GPT and BERT. These models' exceptional capabilities in semantic and image understanding ushered in a new era of large pre-trained models, significantly advancing technological progress in these fields and driving the current rapid development of AI technology.

Currently, the digital age has entered a critical phase, with major AI models like Chat GPT, Deep Seek, and Stable Diffusion emerging one after another. These tools not only excel in language and image processing but also offer extremely fast response

times, making it easier for the general public to interact with their environment intuitively. As a result, every aspect of landscape design is becoming more controllable, turning the dream of automated landscape design into a reality.

**Table 1.** The Development History of Digital Technology in Landscape Architecture.

| stage | A rough start time | Main design tools | Designer positioning | Design approach |
|---|---|---|---|---|
| The classical garden design period | Before 1950 | Hand-drawn tools | Designer's subjective design | handicraft art |
| The era of computer aided design | Around 1980 | CAD, PS, SU, etc | CAD | Digital mapping, analog design, etc |
| The era of digital collaborative design | Around 1990 | BIM, LIM, GIS, etc | Digital aided design | Data visualization, etc |
| The AI-driven design era | Around 2020 | Chat GPT, SD, etc | AI aided design | Machine learning, neural networks, etc |

## 3. Elated Concepts And Theories

### 3.1. Conceptual Framework

#### 3.1.1. Machine Learning And Deep Learning

Machine learning is a branch of artificial intelligence. As a key technology for the ongoing evolution of AI, it enables computers to learn and improve autonomously through algorithms without relying on human programming instructions, thereby making predictions and decisions. Machine learning typically includes: 1) supervised learning; 2) unsupervised learning; 3) reinforcement learning, among others.

Deep learning, a subfield of machine learning, is called 'deep' because it employs neural network structures with multiple layers that can learn and extract abstract features at various levels of data. Deep learning and neural networks are crucial advancements in the field of machine learning, enabling the handling of more complex models and larger datasets, thus addressing some limitations of traditional machine learning methods in areas such as image recognition, speech recognition, and natural language processing. A notable deep learning algorithm, the Generative Adversarial Network (GAN), can be used for generating, enhancing, and repairing images.

#### 3.1.2. Generative AI

The application of models derived from deep learning algorithms is known as generative AI or AIGC, such as large language models (LLMS) like Chat GPT. These models typically require extensive data training to capture the patterns in data distribution and focus on developing technologies that can autonomously generate new content. Unlike traditional discriminative AI, which performs tasks such as classification and prediction, generative AI has strong multimodal capabilities. Its primary goal is creation. Generative AI models learn from various types of data, including text, images, audio, video, and code, to generate original content that meets specific

needs across different modalities.

### 3.2. Correlation Theory

In landscape architecture, text and images are crucial design elements. Therefore, professionals in this field should prioritize the effectiveness of artificial intelligence (AI) in natural language processing and computer vision. For instance, during the initial stages of the design process, designers often use these technologies to develop design sketches and preliminary concepts. Designers provide AI with basic design ideas, such as textual descriptions or sketches, and after setting specific constraints, AI can generate images from text (text-to-image generation) or convert images into text (image-to-text generation). Additionally, it is important to recognize the continuous learning capabilities of AI. Machine learning is a key capability that enables AI to adapt from general domains to the specialized field of landscape architecture. This means that AI is not just a rigid output; it can evolve continuously as training improves, ensuring that downstream applications better align with the work patterns and output styles of the landscape architecture field.

#### 3.2.1. Natural language processing

Natural language processing (NLP) is a crucial area in artificial intelligence, enabling computers to understand, interpret, and generate human language. This technology, through deep learning, produces large language models (LLMs), which are trained to comprehend and generate natural language.In the field of landscape architecture, these models can understand and produce texts in multiple languages, including writing, dialogue, translation, and summaries. In this domain, LLMs are commonly used for information organization, data collection, promotional slogans, and requirement documents. The most popular downstream application of large language models today is Chat GPT, which, by accessing knowledge bases and autonomously learning about planning and design backgrounds, enables designers to complete ten-thousand-word planning and design texts within hours, addressing the text requirements at various stages of the design workflow.

#### 3.2.2. Computer vision

Computer vision is another crucial area of artificial intelligence, enabling computers to understand the content in images or videos. In landscape architecture, images serve as the most direct means for designers to convey their ideas. The large text-to-image pre-trained model Stable Diffusion is a culmination of technology, integrating technologies such as Control Net and Lora. Its applications in landscape architecture include: 1) image transformation, such as converting summer landscapes into winter scenes or horses into zebras; 2) image generation, creating high-resolution images like faces and landscapes; 3) style transfer, applying one image style to another, such as transforming ordinary photos into the style of Van

Gogh or Picasso; 4) text-to-image generation, generating images based on textual descriptions. These features are practical tools that can be effectively utilized in landscape design.

## 4. Research on collaborative application technology of landscape architecture and AI

### 4.1. Research on the thinking process of AI intervention in landscape architecture design

Landscape design thinking emphasizes that design is an iterative process. Drawing inspiration from the traditional "Double Diamond" design thinking model,AI-assisted designers generate designs, with AI serving as the third key player alongside the client and the designer. Currently, AI-assisted design can be viewed in two stages: 1) using artificial intelligence to create a large number of rough designs quickly, resulting in numerous design templates. 2) Designers refine these templates based on AI-generated designs, making fine adjustments to finalize the design and deliver the final product.

In the traditional design process, designers typically gather user feedback and then conduct the initial brainstorming phase. With the introduction of artificial intelligence, this process has undergone a significant transformation. In the first stage, users lead the process, with designers assisting, using AI to generate a wide range of design ideas based on their needs. Thanks to its high efficiency, AI can produce a large number of design blueprints, though these may not be of the highest quality. In the second stage, designers refine and focus the design direction by selecting and processing the blueprints based on the specific conditions of the project site. This process is repeated multiple times, ultimately leading to the final output that meets the design requirements.

### 4.2. Research on AI intervention workflow

In order to realize the adaptive research of artificial intelligence from general field to landscape architecture field, it is necessary to put forward a variety of control strategies in different stages according to the characteristics of landscape architecture scheme design work, so as to ensure that the output quality meets the design requirements.

In practical applications, based on the input and output modalities of landscape architecture projects at different stages, AI models serve as an intermediary to divide the landscape architecture design process into four stages: the research stage, the conceptualization stage, the layout development stage, and the effect expression stage. Each stage corresponds to the specific fine-tuning control modes required during the landscape architecture work involving AI intervention.

#### 4.2.1. Project research stage

In the process of landscape architecture design, the discovery phase primarily involves researching various project backgrounds, site conditions, ecological environments, and historical and cultural aspects. The use of AI serves to refine the research and ensure that only accurate and usable data is processed. Designers need to gather and analyze a large amount of information to better understand the issues and requirements. During this phase, AI assists designers in producing the following: 1) Text: AI uses existing information to form initial planning texts and research forms, write design briefs, and collect clear legal documents; 2) Images: Based on neural networks and sparse sampling for 3D modeling, and image segmentation analysis of site aerial photographs to analyze the layout of landscape elements .

#### 4.2.2. Concept conception stage

In landscape architecture design, the definition phase is a process of clarifying project goals, design concepts, and functional layouts. Conceptual design requires divergent thinking, and during this stage, AI-assisted designers must clearly define design issues and objectives, guiding the direction for subsequent design tasks. The primary methods used by AI-assisted designers in this phase include: 1) text: text-to-image generation, expanding and refining initial concepts; 2) images: ControlNet line drawing to generate concept sketches, color block derivation to create concept images, and concept image presentations with white model materials.

#### 4.2.3. Lay out the deduction stage

The main focus of the development phase is the formation and optimization of the design layout. During this stage, designers must apply creative thinking to the already divergent conceptual goals, using comparative, analytical, and evaluative methods to identify the most viable design solutions. In the control and deduction phase, AI assists designers in narrowing their focus, anticipating various potential outcomes after the project's completion, and gradually concentrating on the design. The primary methods include: 1) text-to-image generation; 2) image-to-image generation, partial modifications of Control Net, self-supervised inference of architectural forms with genetic algorithm-defined red lines , and landscape element layout inference based on image segmentation.

#### 4.2.4. The stage of expression of effect

In landscape architecture design, the goal of the delivery phase is to select the optimal expression. This involves putting the design plan into practice, including rendering, construction drawings, and spatial concept realization. The delivery phase also emphasizes transforming the design plan into practical outcomes, ensuring its correct implementation and smooth execution. During this phase, AI-assisted designers primarily produce through: 1) text: modifying on-site photos with prompts and generating stylized renderings, formulating construction

plans and post-construction maintenance measures; 2) images: converting blurry images into precise ones, quickly switching between stylized scene materials, simulating seasonal effects throughout the lifecycle, and deducing building facade layouts.

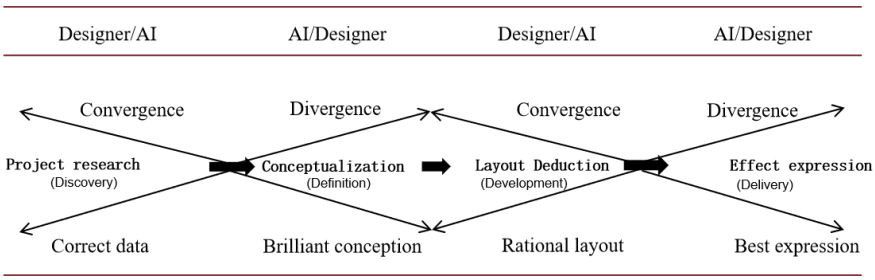


**Figure 1.** Flow chart of AI intervention in landscape architecture design thinking

**Table 2.** AI means and technologies in various stages of landscape architecture

| stage | flow path | technology | living example |
|---|---|---|---|
| Data research | Current image collection and screening<br>Collect geographical and cultural features and clarify laws and regulations<br>Size estimates | image analysis<br>The thinking chain<br>Search, enhance, generate, etc |  |
| Conceptualization | overall conceptual design<br>conceptual design<br>Material and plant analysis<br>Concept review | Text to image<br>Figure generation, etc |  |
| Lay out the deduction | sectorization<br>architectural composition<br>Road layout<br>Plant layout<br>Water system layout | image segmentation,<br>Line drawing of the original,<br>Local redrawing, etc |  |
| Effect expression | Overall effect<br>A partial rendering detail design<br>Construction supervision<br>Later maintenance | Secondary pre-training fine-tuning<br>Local redrawing, etc |  |

a. All charts in this article have been drawn by the author.

## 5. Shortcomings and prospects

### 5.1. Technical level

#### 5.1.1. Fabricating facts

By observing the AI-generated landscape images from models like DeepSeek and StableDiffusion, it is evident that large language models based on deep learning are trained using vast amounts of text, modeled after human behavior. This makes AI adept at mimicking human actions. The content generated by AI is based on

prompts and previous outputs, processed in units (tokens) to continuously predict and generate results. AI composites and reproduces existing data; for areas where the model lacks knowledge, it may produce incorrect outputs due to its lack of understanding. Therefore, strategies such as thinking chains and retrieval-enhanced generation can effectively address these issues.

#### 5.1.2. The calculation is not accurate

In the process of AI-generated content, the algorithm outputs the content. However, for complex numerical problems, large language models like GPT may not genuinely assist in computation; instead, they might just guess the next most likely token to respond with. As a result, they might give incorrect answers to complex mathematical questions. For complex tasks, program-assisted computation is an effective solution.

#### 5.1.3. The data is outdated

Large language models based on LLMS may provide incorrect answers to questions about the latest time. The responses from LLMS are often time-sensitive, and this issue is particularly common when the database is not updated in a timely manner. Especially in fields where databases change rapidly, even data from several months or a year ago can become outdated and potentially misleading. Currently, most large language models have integrated online search capabilities, which effectively assist in their operations.

### 5.2. Social aspect

#### 5.2.1. Aesthetic bias

The output of artificial intelligence often mirrors human capabilities. The ability to design will lead to changes in societal aesthetics, making it increasingly difficult to define whether personal or professional aesthetics are superior. AI, based on a general database of garden designs, will produce more uniform designs. In the future, there may be more similar landscape element models, leading to an increasing number of uniform design forms, which could result in discrimination against AI-generated content.

#### 5.2.2. Order and patents

The trend of AI gradually becoming involved in design is inevitable. The integration of AI into landscape design will inevitably clash with traditional methods. While AI brings convenience, it also lowers the entry barrier for design. Given that AI-generated content is based on prediction and imitation, and its widespread adoption, we may see an increasing number of AI-generated works, such as articles, images, music, and even landscapes. For the general public and users, distinguishing between genuine and AI-generated content will become increasingly difficult, posing

a significant challenge to legal and regulatory frameworks.

### 5.3. look into the distance

The rise of artificial intelligence has brought unprecedented opportunities, but it also comes with numerous challenges. In the design field, AI can facilitate a leap in design thinking and innovation. Professionals who have a basic aesthetic sense, relevant skills, and an understanding of AI can explore broader development opportunities in the new technological landscape. While technology brings convenience, it can also be a double-edged sword, leading to issues such as loss of control over technology, outdated data, job losses, social aesthetic biases, order and patent issues, and increased economic inequality.

In the practical future application of landscape architecture, the intervention of AI technology needs to fully consider the characteristics and requirements of landscape architecture projects. AI technology is always a foreign force, and the professional level of landscape architects should be fully utilized to avoid losing control as far as possible.

## 6. Epilogue

The scope of the landscape architecture and planning major is broad, ranging from the ecological protection of wetlands and national protected areas to the maintenance of rural landscapes and streets. It encompasses a variety of landscape elements, including mountains, water, forests, fields, lakes, grasslands, and deserts. AI technology, as an auxiliary tool, trains the professional knowledge of landscape architects into AI databases, ensuring the true emergence of an automated design system.

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