

Research on Digital Transformation and System Reconstruction of AIGC-Enabled Landscape Architecture

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Abstract: Landscape architecture is a huge and complex discipline with strong cross-fertilization, which needs to be supported by massive resource databases and strong Analysis and processing capabilities. The traditional design methods need help. The digital landscape has become an important method of landscape architecture, and the development of Artificial Intelligence Generated Content (AIGC) provides new opportunities for the digitalization process. Through the introduction of related concepts, the article takes the dilemma faced by traditional landscape architecture as the main entry point, explores the application form of AIGC in landscape architecture workflow from three aspects: information analysis, design assistance, and innovation demand, and identifies that AIGC-enabled development is the road to the future of landscape architecture. Finally, it discusses the possible misconceptions of the process, aiming to provide new ideas for landscape architecture digital transformation and system restructuring.

Keywords: AIGC; Landscape Architecture; Digital Transformation; Design System Research.

1. Introduction

With the rapid development of science and technology, digital technology has profoundly changed how people live and work. In this digital era, all industries are actively exploring how to use digital technology to achieve transformation and upgrading, and the landscape architecture industry is no exception. 2023, the first year of AIGC, when the accumulation and integration of GAN, CLIP, Transformer, Diffusion, pre-trained models, multimodal technology, generative algorithms, and other technologies, the Artificial Intelligence Generated Content (AIGC) strong out of the Circle. The iterative innovation of algorithms, the formation of pre-learning models, and the application of multimodality make AIGC more polygonal, with more fluent, simulated, scientific content generation capabilities and human-computer interaction capabilities.[1] AIGC brings digitization to a new level and shines in various industries.

The application of the new generation of artificial intelligence technology makes AIGC show great innovation and potential in landscape architecture, promoting the development of landscape architecture in the direction of digitization, realism, interactivity, and scientificity. However, the current research on AIGC, especially in landscape architecture, still needs to be improved, mostly focusing on external expressions and single-point applications, needing more systematicity and popularity. Thus, it is urgently necessary to study the empowering value of AIGC deeply and provide a reference for the digital transformation and system optimization of landscape architecture. This study will enable more designers to recognize A.I.'s potential and development opportunities, bravely attempt to use AIGC as an important aid for landscape architecture, and promote the industry's flourishing in the digital revolution.

2. Background and Significance of the Study

2.1. Background of AIGC-assisted Landscape Architecture

2.1.1. Policy Background

Since 2015, the State Council, the National Development and Reform Commission, the Ministry of Science and Technology, and other departments have continued to issue policies on the A.I. industry. AIGC has received national support in the "New Generation of Artificial Intelligence Development Plan" and "Three-Year Action Plan for Promoting the Development of the New Generation of Artificial Intelligence Industry (2018-2020)", which has facilitated the advancement of China's A.I. technology and the landing of its applications. 2022 In September, the promulgation of "White Paper on Artificial Intelligence Generated Content (AIGC)" clarified the value of AIGC applications and raised potential pitfalls, providing directional references for the industry's future development. 2023 In July, "the Interim Measures for the Administration of Generative Artificial Intelligence Services" was issued by the State Office of Internet Information Technology, the Development and Reform Commission, and seven other departments, which standardized the development of AIGC and promoted it in a safer and more rational direction step forward. As one of the cultural industries that the country focuses on developing, landscape architecture also actively responds to national policies and realizes transformation and upgrading with the help of digital technology.

2.1.2. Industry Background

In the whole cycle of landscape architecture, AIGC plays a significant enabling role in integrating multiple data capture, efficient content translation, optimization of scheme comparison, virtual scene creation, green and sustainable development, etc. There is a lot of space for landscape digital

applications to rise. Horizontal Analysis, compared with foreign countries, domestic research on landscape digital is less concerned, and relevant, high-quality academic papers are mainly in English. With "digital landscape" as the keyword, there is a significant difference between the number

of articles on China Knowledge Network and Web of Science.[2] In the past five years, vertical Analysis has increased the heat of the digital landscape in China, and digital technology has gradually been implemented in design projects.

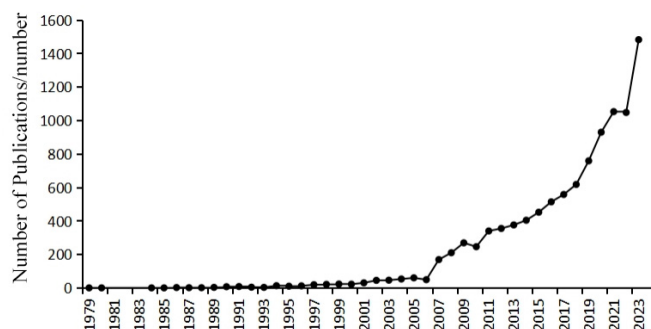


Fig 1. Statistics on the number of published papers in Chinese on the digital landscape

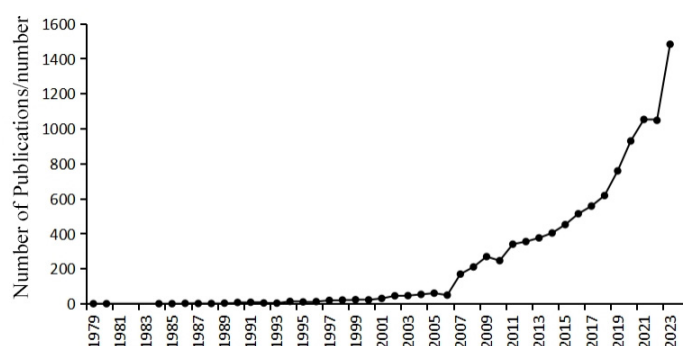


Fig 2. Statistics on the number of published papers in foreign languages on the digital landscape

For example, in Zhang Tang's Chengdu Luh Cloud Paradise, digital design has become an important part of the experimental board. Here, we take Glacier Canyon and Water Drop Theater, two typical landscape structures designed and processed digitally, as examples. Glacier Canyon is a two-side mirrored music wall. The designer intends to use concave and convex folded plates to project images and enhance the light and shadow effect, while the size and position of the folded plates are difficult to control; modeled by Rhino and Grasshopper parametric design software, all the folded plates' maximum side lengths and heights are measured by computer-assisted estimation, which is used for controlling the size of the finished panels. The complex structure of the Water Drop Theater consists of 34 layers of transverse ring keels, with 715 pieces of the structural support of varying sizes added between the layers, which is a huge amount of work and prone to deviation by manual drawing alone, and digital design demonstrates its advantages. With the huge amount of work and a high degree of technical pressure, the human limit has been very difficult to meet, and it is easy to cause material, manpower, and capital waste. The participation of digital technology is conducive to the rapid extraction of site information, optimization of design, cost control, shorten the construction period, which provides great convenience for landscape architecture. The digital landscape development is unstoppable.

2.2. Significance of AIGC-assisted Landscape Architecture

2.2.1. Scientific Analysis to Improve the Efficiency and Inclusiveness of Landscape Architecture

Unlike traditional methods influenced by human thinking stereotypes and constrained by the upper limit of human ability, AIGC has an advanced professional theoretical reserve and a huge database, which makes up for human beings' limited knowledge reserve and creative ability. Using machine deep learning and big data analysis, AIGC brings more possibilities for landscape architecture to achieve efficient development, scientific progress, and diversified intermingling.

2.2.2. Well-established System to Assist in the Digital Transformation of Landscape Architecture

Landscape digital transformation is a systematic project that requires interdisciplinary knowledge and technical support; AIGC breaks down the boundaries between multiple information and generates content with stable quality by its pre-learning advantage and multimodal integration, forming a complete knowledge system architecture, promoting the construction and optimization of landscape architecture system, and accelerating the digitalization process.

3. Definition of Relevant Concepts

3.1. The Concept of AIGC

AIGC (Artificial Intelligence Generated Content) is a new

production method in which A.I. autonomously generates text, images, voice, video, and 3D models based on machine learning technology according to manual instructions to create higher-quality content faster.[3] As an important upgrade of digital content creation, AIGC is developing into a horizontal combination of deep integration with various industries against the increasing prosperity of digital content and the general trend of digital-real integration.

3.2. Digital Transformation of Landscape Architecture

The concept and understanding of digital landscape or landscape digitization have yet to reach a consensus among various industries. According to the current research results, many scholars at home and abroad maintain a positive attitude towards developing a "digital landscape," believing that digital technology can maximize the interactive innovation of landscape art.[4] Zhang Yamin believes that landscape digitalization is a way for artificial Intelligence to use morphogenesis and digital research theories to expand the knowledge of landscape morphology, stimulate the innovation of design methods, and build a logical system of Landscape architecture based on program algorithms.[5] Comprehensive views of many scholars, this paper defines landscape digitization as the whole process of landscape architecture workflow, including data collection, pre-analysis, creative conception, strategy suggestion, drawing performance, and virtual modeling with the assistance of artificial Intelligence. It is a technological change that relies on big data and high-tech algorithms and integrates knowledge and practice of landscape.

4. The Dilemma of Developing Traditional Landscape Architecture

In the face of increasingly complex and changing, high-standard, scientific landscape development, the traditional design relying on the designer's knowledge, experience, and aesthetic ability makes it difficult to keep pace with the times, which is highlighted by the inefficient use of resources, insufficient ecological, environmental protection and difficulty in meeting the market demand at three levels. Improving the Intelligence, conscientization, efficiency, and humanization of landscape architecture so that the design ability can keep up with the speed of development should become the focus of the current landscape industry.

4.1. Design Level: Serious Homogenization of Design Scheme

With the development of the design market, some landscape architecture works cater too much to the market demand and customer preference but lack in-depth excavation of the site characteristics, natural environment, or cultural connotations, resulting in homogenization. This is mainly reflected in the design approach and presentation of templates, as well as the lack of innovation and personalization. For example, landscape modeling, color matching, light and shadow effects, and other aspects have similar design patterns and routines, making the works lack novelty and surprise.

4.2. Resource Utilization Level: Inefficient Use of Resources

From creative conception, sketching, strategy adjustment,

program revision, and design expression to final production, traditional landscape architecture usually consumes a long time and a large number of resources, is repetitively labor-intensive, and has low productivity. Especially when facing complex and large-scale projects, backward design tools are difficult to undertake, and designers can hardly tolerate prolonged high-pressure operation, which is prone to cause serious resource loss, leading to higher costs. In addition, the designer's style will also increase the cost of communication.

4.3. Ecological Level: Insufficient Ecological Sustainability

At present, the logic of the traditional design strategy mostly relies on the designer's experience and subjective judgment, which is often based on qualitative Analysis; the scientific rationality of the program is yet to be verified.[6] Insufficiently thorough site analysis can easily lead to conflict between the designed landscape and the environmental ecology. Since some landscape architecture projects lack enough consideration for protecting the natural environment during the planning and construction, ecological damage and biodiversity loss happen. The over-development of wetlands, destruction of forests, and destruction of mountainous landscapes have caused serious impacts on the ecosystem. Furthermore, insufficient understanding of the plants, animals, and microorganisms intended to be included will not only lead to the horror of the regional landscape but also threaten the surrounding ecological balance and damage biodiversity. This is particularly evident in urban landscape architecture, which pays much attention to decorativeness and ornamental features that neglect the protection and restoration of ecosystems.

5. Forms of Digital Application of AIGC In Landscape Architecture Workflows

As a new empowering approach, AIGC is infiltrating all aspects of landscape architecture, from pre-analysis, logical construction, and design expression to the whole innovative application process. With the help of deep learning and model optimization technology, the design efficiency and quality have been substantially improved. It actively promotes the efficiency of cross-modal interaction and conceptual design on generation. AIGC has brought profound innovations and new vitality to the landscape architecture industry, promoting the sector towards digitalization.

5.1. Information Analysis Level: Catering to Open and Shared Cross-modal Interactions

Landscape data covers complicated contents and diverse forms involving multiple systems and departments' data, equipment, and technology. The data constraints and influences on each other constitute an intricate mesh relationship, which makes it difficult to organize and analyze. AIGC technology relies on the Landscape Information Model (LIM), uses massive cloud data and experimental data as the training material to carry out data preprocessing, and then integrates a cross-modal resource library based on ChatGPT and Stable Diffusion, injects a deep learning-based Transformer model to complete the construction of a knowledge graph in turn, finally conducts

information translation after completing the evaluation.

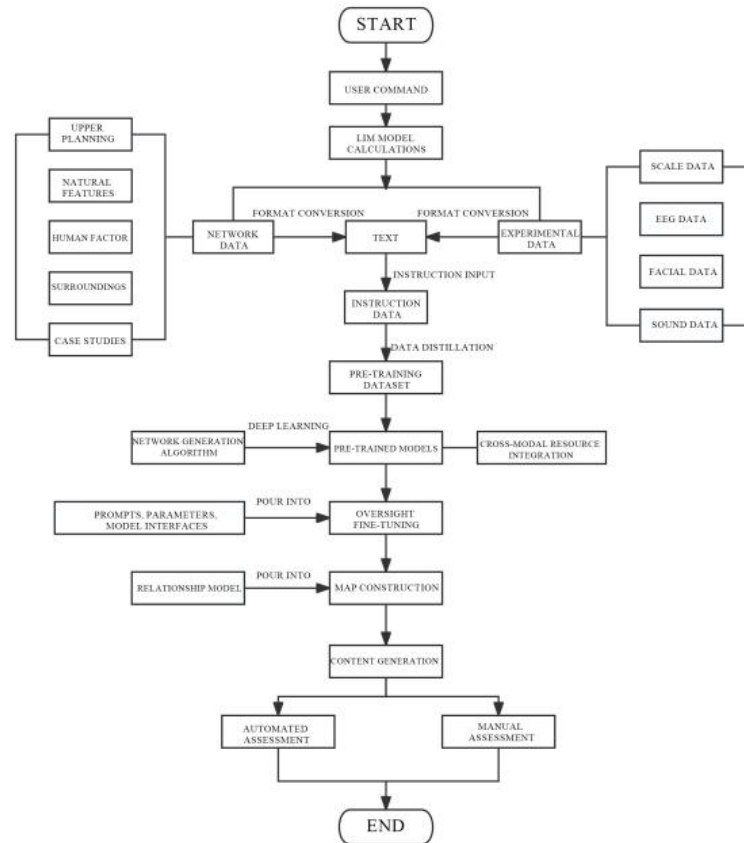


Fig 3. AIGC-assisted pre-analysis flowchart

5.1.1. Site Status Analysis

In the pre-landscape Analysis, the factors affecting landscape design can be broadly categorized into intrinsic and extrinsic factors: intrinsic factors include functional systems, transportation systems, landscape node systems, plant systems, etc., and extrinsic factors include geographic environments, humanistic environments, climatic conditions, and users' functional requirements for the landscape. The coverage is wide, while the traditional collection methods are limited.

With the help of computers, geographic information technology, the Internet of Things, a global positioning system, and other technical means and methods, AIGC can complete the complex process from the massive collection of commonalities to the individuality of the feature extraction without manually extracting the rule information. It not only reduces the cost of time and resources but also improves the efficiency of production, promoting the diversification of the content of the landscape resources and providing a solid foundation for the later data collation, Analysis, design, and innovation, which lays a solid foundation for later data organization and Analysis, design, and innovation, and wins a time advantage.

5.1.2. Cross-modal Resource Integration

As early as the 1960s, McHarg mentioned the "lasagna" model in his book "Designing with Nature," arguing that comprehensive landscape architecture requires independent Analysis of multiple influencing elements and comprehensive superposition. It shows that landscape architecture is a cross-cutting, thorough, and high degree of freedom discipline that requires open sharing and inter-modal Analysis.

Landscape architecture itself is a discipline focusing on the creation of outdoor landscapes, and the questionnaire survey method, live-action photography method, field survey method, dialogue interview method, and outdoor experimental method are common research methods in the subject, which is an important basis for the humanization of landscape architecture. Compared with interior design, architectural design, and planning design, the complexity of the content involved in the life cycle of landscape architecture, the diversity of presentation methods, the diversity of subjects, and the high-frequency contact add difficulties to the collection, organization, Analysis, and presentation of the resource data. However, due to the huge database and powerful computing power, algorithms, and modeling support, AIGC dissolves human's unconscious tendency to think visibly. Its multimodal approach breaks the information boundaries, making the generated content complete, diverse, technologically integrated, and stable. It lays a solid technical foundation for creating landscape architecture of higher social value.

5.2. Design Assistance Level: Assisting the Practice of Efficient and Innovative Conceptual Design

Landscape architecture is both artistic and scientific. Artistic design focuses on emotional expression, cultural significance, and aesthetic value, while scientific design requires landscape architecture to be functional, environmentally friendly, and sustainable. Traditionally, the two are complementary and mutually restrictive, and many experts and scholars strive to balance art and science. Although AIGC does not have human perception and emotion,

it can carry out the design of art style fusion and the combination of innovative elements, which broadens the form of artistic expression; its parametric design protects the scientific nature of the landscape.

5.2.1. Attempts at Creative Expression

From the point of view of creative freedom, AIGC provides unlimited creative space, providing abundant positive feedback for the designers who are "in it." When the traditional thinking inertia and realistic limitations are broken, designers are often willing to make more free creative attempts, which is extremely friendly to stimulate the creative inspiration of the designer and can maximize the designer's color, highlighting the distinctive charm. From the perspective of creative professionalism, AIGC has more than professional creative ability in art creation. From the point of view of creative tolerance, AIGC provides more possibilities for integrating various Landscape architecture elements.

5.2.2. Design Ideas Experiment

AIGC incorporates experimental design creation to help transform imagination into productivity, allowing some space experiments that dare not be tested or are difficult to accomplish to be verified, and it can verify the feasibility of design solutions on the ground with basically no consumption of resources. In the previously mentioned Zhang Tang Cloud Paradise project, the idea of the structure seems to be out of the blue; the team used digital technology to conduct a series of experiments such as virtual modeling, material simulation, spatial perception, and so on, to turn the seemingly unattainable design ideas into reality. The action ensures the safety and rationality of the function of the structure but also protects its artistic value. In addition to structural issues, the choice of materials in landscape architecture is also quite delicate; the participation of intelligent technology allows more opportunities for trial and error in the choice of materials and is the continuous optimization of the synthesis of ideas, providing more possibilities for the selection of the most suitable solutions. AIGC relies on strong logical empowerment, from visual privilege to the formation of the process, to build a bridge between the concept and the material, as well as the virtual and the physical.



Fig 4. AIGC-assisted design diagram Image credit: Author's drawing

5.3. Innovation Demand Level: Building a Virtual Space Combining Design and Humanities

The diverse needs of the crowd for culture determine that there should be new changes in how cultural values are presented in landscape architecture. In recent years, more and more scholars have focused on the study of the digital immersive experience of the landscape, both powerful spatial rendering and simple perception of digital art, not only to provide visitors with visual, auditory, olfactory, gustatory, tactile, and other multi-sensory experience but also the use of non-linear interactive means to enable the viewer to immerse in the logic of the cultural story, triggering resonance.[9] From a single-layer structure, AIGC automatically generates story clues and routes by learning the cultural, ecological, economic, and social data of the site; from a parallel structure and a comprehensive narrative structure, based on the timeline, geographical differences or data types, AIGC integrates other elements to add more freedom to the spatial sequence arrangement. [10] Intelligent technology greatly improves participation and interaction between the public and landscape architecture projects. While melting the boundaries between design and humanities, it also draws the distance between landscape and human beings, the virtual and the real.

6. Conclusion

In the rapid development of technology and Intelligence, while AIGC offers great potential for landscape design, the possible risks should be addressed. Controversies around fairness, liability, and security are growing in society, such as unclear copyright ownership, ethical bias, vulnerability to abuse, environmental risks, etc. Not only does AIGC create immeasurable production value for humans, but it also brings trouble, particularly in the humanities and the arts. With its deep traditional cultural and historical heritage, the intervention of intelligent technology often makes old-fashioned people feel embarrassed, and its scientific and artistic value goes beyond words. Landscape architecture is deeply rooted in cultural soil, and people's understanding and evaluation of landscape may differ in various cultural backgrounds, which is prone to bias in human-computer interaction. When we focus on AIGC helping landscape architecture to a more efficient, scientific, and rational level, we must also remember that subjective human initiative can never be ignored. The social and humanistic spirit of emotion can not be a massive amount of information and simple interpretation of a few models; human emotions need to grasp the balance of art and science. Artificial Intelligence in landscape architecture needs to have artistic innovation and local cultural items compatible with the ideology so that further in-depth collaboration with human beings to create a rooted in the land lets the people be satisfied with the landscape.

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