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STUDY ON TYPES OF PARAMETRIC GRAPHIC GENERATION ALGORITHMS

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This study discusses the general types and characteristics of parametric graphics, as well as the classification of relevant algorithms into general, specific, mesh-based, simulation-based, and iterative generation algorithms. The *potential of integrating artificial intelligence (AI) together with parametric design in the creation of graphic generation* is analysed.

Key words: *parametric design, generation, graphic, pattern, algorithm, types.*

INTRODUCTION

Graphics, as an important subject in the realm of visual communication, encompass geometric shapes, patterns, images, lines, and symbols formed in planes or spaces. With the advancement of computer-aided design (CAD) technology, designers began utilizing drawing software for graphic creation on computers. From the perspective of design tools and media, compared to traditional drawing tools, using CAD software enables more flexible, precise, and free graphic creation. Nonetheless, in terms of conceptualizing designs, the transition to CAD hasn't fundamentally altered the essence, as it still relies on the designer's artistic capacity to manifest innovative and compelling visual ideas.

With the great development of computer-aided design (CAD) technology and artificial intelligence (AI), digital generative design has increasingly permeated into the realm of design, introducing new tools and revolutionizing design patterns. Parametric design emerges as a significant digital design paradigm wherein design problems are transformed into parameters. Using computer programming languages, parametric design establishes logical algorithmic rules

Parametric design is widely applied in various design fields such as architectural design, product design, graphic design, and fashion design. It generates different types of graphics through various generative algorithms, paving the way for new innovative directions in graphic design.

PURPOSE

As a significant technical means in generative design, parametric design utilizes parameters and logical rules to construct generation algorithms, enabling the generation of a large number of complex, exquisite, ordered, and random patterns and graphics which is a crucial aspect of research in graphic design.

Parametric design provides an innovative approach for the generation of graphics in graphic design.

This technology utilizes various algorithms to generate different types of graphics. However, in specific design practices, designers lack theoretical and methodological guidance in selecting algorithms. This paper conducts research and analysis on a certain number of generative design cases to explore different types of algorithms in parametric graphic generation. The aim is to enable designers to judge and select suitable algorithm types for generative design based on design needs.

RESULTS AND DISCUSSION

Parametric design is a crucial digital design tool that integrates algorithms into design innovation, essential for achieving digitalization and intelligence. Parametrization is vital for this, especially in graphic design where parametric design can generate diverse graphic results with unique characteristics compared to traditional designs, indicating the direction of graphic generation design development.

1. Parametric Graphic Generation Design Tools

Graphic generation design requires implementation through scripting and programming. Currently, popular design tools include Processing, Grasshopper, etc. Processing is an open-source programming language and integrated development environment (IDE) used for creative programming and visual arts. Grasshopper is a powerful parametric design software integrated within Rhino software and also a graphical programming tool used for visualizing algorithms.

2. Types and Characteristics of Parametric Graphic

Parametric design enables the generation of a wide range of graphics and patterns, categorized into geometric (like grids and arrangements), organic (mimicking nature), abstract (non-representational), artistic (incorporating painting styles), and composite (combining various elements) patterns. This diversity and flexibility make parametric design a powerful tool for creating visually captivating and stylistically diverse pattern designs in graphic design. Parametrically generated graphics often exhibit a high level of complexity, presenting visually striking effects that surpass human cognitive limits.

3. Types of Algorithms for Parametric Graphic Generation

Parametric design is essentially using various parameters to construct generating algorithms, enabling the creation of patterns and graphics. Through analysis and categorization of a considerable number of parametrically generated graphics, and exploring their algorithmic logic, it is found that designers can embark on parametric graphic generation using the following types of algorithms.

(1) General Generative Algorithms

This type of algorithm is suitable for scenarios where the generation logic is relatively simple and explicit, involving fewer parameters. It involves building straightforward algorithms to generate graphics and achieving basic transformations of the graphics through parameter adjustments. Algorithms aid designers in breaking free from mechanical repetition and expressing graphics in an algorithmic manner, particularly suitable for defining and transforming simple geometric shapes.

(2) Specific Graphic Generation Algorithms

Designers can directly utilize specific graphic generation algorithms for design and generation. Examples include algorithms such as Voronoi diagrams, Delaunay triangulation, etc. These algorithms, formulated mathematically, have been organized into simple and easy-to-use algorithmic modules, integrated into corresponding software. Graphics generated using these specific algorithms exhibit distinctive shape characteristics. While there is variability with parameter adjustments, the visual expressions remain relatively singular and constrained.

(3) Grid-Based Generation Algorithms

This type of algorithm is suitable for generating complex patterns and textures. Patterns and textures are often intricate, exhibiting regular variations based on similarities. Designers find it challenging to achieve complex yet natural variations using conventional design software and tools. For this type of algorithm, a grid system is established first, such as rectangular grids, triangular grids, hexagonal grids, etc. Within each unit of the system, parameters are extracted and transformed.

(4) Simulation-Based Generation Algorithms

Simulation algorithms refer to algorithms that can simulate objective phenomena and principles in fields such as physics and biology in the natural world. Examples include elasticity simulation algorithms, wind field simulation algorithms, magnetic field simulation algorithms, electric field simulation algorithms, fluid simulation algorithms, cell growth simulation algorithms, swarm movement simulation algorithms, etc. These algorithms are often existing and mature. By using these algorithms, unique and visually striking graphics can be generated, showcasing significant visual novelty and complexity.

(5) Iterative Generation Algorithms

Simple graphic logic, through multiple cycles of iteration, can also generate complex and exquisite graphics. Fractal patterns are the product of these algorithms. Fractal patterns are geometric patterns with self-similarity, characterized by similarities in local parts and overall morphology at different scales.

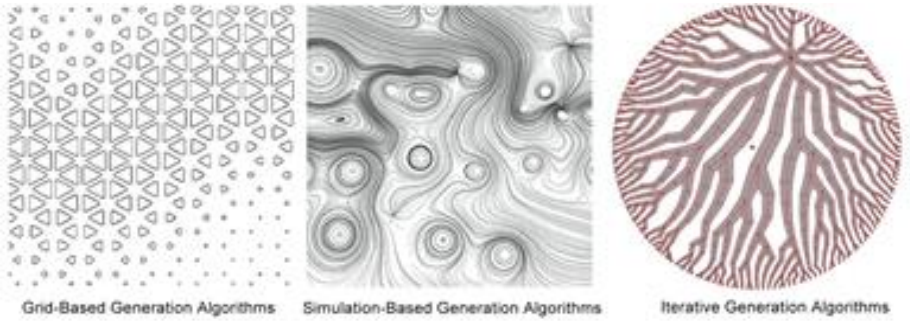

Fig. 1. Graphics generated by 3 types of the above algorithms with the Grasshopper generator by the authors

These patterns are generated by repeatedly applying certain rules or patterns, showcasing complex, rich, and aesthetically pleasing geometric structures. Designers can achieve higher levels of complexity and aesthetic depth in graphic design by increasing the number of iterative iterations.

(6) Integration of Parametric Design and AI

AI technology has made significant strides in generating innovative and imaginative graphic designs. However, a challenge arises as designers often find it difficult to make precise adjustments to the generated results. Parametric design, on the other hand, provides the advantage of using parameters and clear algorithms to structure graphics, allowing for precise control and customization.

CONCLUSIONS

Parametric design, which uses algorithms and logic in the creative design process, has now come to play a significant role in creating complex and visually appealing graphics, which is essential for the digital development of graphic design. Currently, there are a large number of algorithms and programs used to create parametric graphics. In this article, we classify the relevant algorithms into five types: General generation algorithms, Specific graphics generation algorithms, Mesh-based, Simulation-based, and Iterative generation algorithms, which will help designers to effectively choose appropriate algorithms for graphics generation. In addition, the integration of AI with parametric design allows for additional benefits in graphic creation, which will inevitably have a significant impact on the future of graphic design.

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ДОСЛІДЖЕННЯ ТИПІВ АЛГОРИТМІВ ГЕНЕРАЦІЇ ПАРАМЕТРИЧНОЇ ГРАФІКИ

У цьому дослідженні обговорюються загальні типи та характеристики параметричної графіки, а також класифікація відповідних алгоритмів на загальні, специфічні, алгоритми генерації на основі сітки, на основі моделювання та ітеративні алгоритми генерації. Аналізується *потенціал інтеграції штучного інтелекту (ШІ) разом із параметричним дизайном, у створення графічної генерації.*

Ключові слова: *параметричний дизайн, генерація, графіка, патерн, алгоритм, типи.*