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GENERAL LAYOUT PLANNING MODEL OF LANDSCAPE CERAMIC SCULPTURE BASED ON NSGA - II ALGORITHM

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Abstract. The current overall layout planning model matrix of landscape ceramic sculpture is generally unidirectional, and the planning efficiency is low, resulting in a decline in the layout optimization ratio of the model. Therefore, the design and verification analysis of landscape ceramic sculpture's overall layout planning model based on the Nondominated Sorting Genetic Algorithm (NSGA - II) algorithm is proposed. According to the actual planning needs and standards, first set the basic layout points, establish a cross-planning matrix in a multi-level manner, and improve the efficiency of the overall layout planning of the sculpture. The NSGA - II calculation landscape ceramic sculpture layout planning structure is constructed on this basis, and the model design is realized by level conversion. This novel NSGA-II with level conversion performs better layout planning when compared with other conventional models. The final test results show that through three stages of layout optimization processing, compared with the initial planning layout, the optimal layout optimization ratio for the setting of the plaza sculpture can reach more than 60%, indicating that with the help of this method, the layout planning of sculpture has been further improved, the space has been expanded, and has practical application value.

Key words: NSGA - II algorithm; Landscape ceramics; Ceramic sculpture; General layout; Planning model; Layout planning;

1. Introduction. Most of the landscape ceramic sculptures are large urban sculptures, which are generally set in a more prominent urban public environment and are symbols of the city or a particular area, such as large squares, public green spaces, public buildings and other areas [13]. Landscape ceramic sculpture is usually large in scale and system, so there are many factors to consider in planning and design [22]. The outdoor landscape ceramic sculpture is also an essential part of modern cities to some extent and needs to be integrated with the town when planning [11]. The styles of landscape ceramic sculptures are different and varied. Generally, they are directly related to their location. They can be roughly divided into the following categories: memorial, thematic, decorative, entertaining, and religious [6]. There are also significant differences in the overall layout planning of the built-in design of different landscape ceramic sculptures. As a public environment art, the comprehensive layout and overall planning directly affect the design effect in the later period [17]. To strengthen the artistry of sculpture, relevant staff usually design in advance through the overall layout planning model before manufacturing landscape ceramic sculpture and deal with the details of sculpture [2]. However, most of the traditional sculpture general layout planning models are one-way. Although they can achieve the expected planning tasks and goals, they lack pertinence and stability. Sculptures are also prone to problems in the production process, such as inconsistency with the surrounding environment and planning chaos [9]. Therefore, the design and verification analysis of landscape ceramic sculpture's overall layout planning model based on the NSGA - II algorithm is proposed. The so-called NSGA - II algorithm is one of the multi-objective genetic algorithms. It has a strong pertinence in calculation. In application, it uses diversified methods to reduce the circularity and complexity of the non-inferior sorting genetic algorithm, further strengthens the actual running speed to a certain extent, and has the characteristics of good convergence, which is convenient for later calculation of solution set [16]. Integrating this algorithm with the design of the overall layout planning model of landscape ceramic sculpture can better expand the actual planning scope, strengthen the applicability of the model, gradually build a more stable and diversified layout planning model, promote the design of the model to further integrate with the urban space environment and humanistic environment, and highlight the

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urban characteristic culture [12]. In addition, the application of the NSGA - II algorithm can also minimize the errors in the design process of landscape ceramic sculpture, improve the overall application performance of the planning model, facilitate the hierarchical control of urban design, form a scientific planning guidance, have important value in the visual landscape environment design, and lay a solid foundation for the innovation and maintenance of subsequent landscape ceramic sculpture [21].

This research finds the solution for following question,

1. How the problem in Automated layout planning is formalized?
2. Layout planning requires multi objective algorithm, how the algorithm achieves the efficiency?

2. Design the overall layout of landscape ceramic sculpture NSGA - II calculation planning model.

2.1. Basic layout point setting. In general, the layout planning of landscape ceramic sculpture needs to consider the surrounding environment and fusion background and try to increase the combination degree of sculpture and environment, showing a sense of hierarchy [4]. Therefore, before designing the overall layout planning model of landscape ceramic sculpture, it is necessary to set the specific space size, layout scale, and planning location of the sculpture and calibrate the basic layout point [14]. First, measure and calculate the space proportion of the sculpture and generally control it within one-tenth of the one-way control range [8]. Subsequently, the setting of planning layout points must be integrated with the urban functional structure to form an orderly spatial sequence and reasonably control the spacing of issues, as shown in Formula 2.1 below:

$$G = \frac{\pi \times \Re}{f - \sum_{r=1} \pi r + \chi^2} - \Re(\aleph + r)^2 \tag{2.1}$$

In Formula 2.1 G represents the spacing between points,$f$represents a conversion sequence, π indicates the unit control value, r represents the number of points, χ indicates the sensing range, $\Re$ indicates the remaining space. According to the above settings, the calculation of the spacing between the points is completed. Next, the spacing value obtained from the comprehensive measurement is used to adjust the position of the initial points and reasonably expand the layout space of the sculpture [19]. Then, based on this, the area and scope set by the sculpture, combined with the characteristics of the surrounding environment, set nodes, portals, and demarcated specific fields, further highlighting the landmark perception of the sculpture from multiple aspects [23].

In addition, the layout planning and point setting of landscape ceramic sculpture also need to build a highly coordinated landscape axis and green channel, which can balance the layout of the entire sculpture, increase the surrounding adjustable space, and facilitate viewing [7]. However, it should be noted that the setting of the sculpture layout points must be coordinated with their positions and kept on the same level. To some extent, it is also conducive to the transformation of space or layout and the close integration of life [1].

2.2. Establish multi-level cross-planning matrix. After setting the essential layout points, the next step is integrating the NSGA - II algorithm to establish a multi-level cross-planning matrix. Different from the traditional layout planning matrix, the multi-level cross matrix designed this time covers a relatively large area and is more targeted. In the practical application process, it has a certain degree of assistance for the overall layout planning of sculpture [3]. First of all, the actual setting area of the sculpture is integrated for hierarchical control, and the public space is also divided into primary and secondary. Therefore, the model matrix needs to follow this principle in the construction process, design a cross hierarchical control structure, set a core or planning key position in the model matrix, and take this as the axis to extend to both sides, form two controllable two-way balance spaces [5]. The layout is divided and controlled at a hierarchical level, and the weight coefficient of cross-planning is calculated, as shown in Formula 2.2:

$$D = \sum_{w=1} \lambda w + \xi(b - c)^2 \tag{2.2}$$

In Equation 2.2 D represents the weight coefficient of cross planning, λ indicates the reserved one-way distance,$w$indicates the number of crossings, ξ represents the displacement distance of the point, b is the

Table 2.1: Classification of sculpture layout levels

Sculpture layout level	*Definition*	*Matrix Planning Location*
Sculpture Core Area	Main setting area of sculpture within 1 meter	Sculpture base and core points
Sculpture layout corridor	Transition corridor	Corridor length and location
Sculpture landscape area	Visiting points and surrounding areas	Landscape extension area

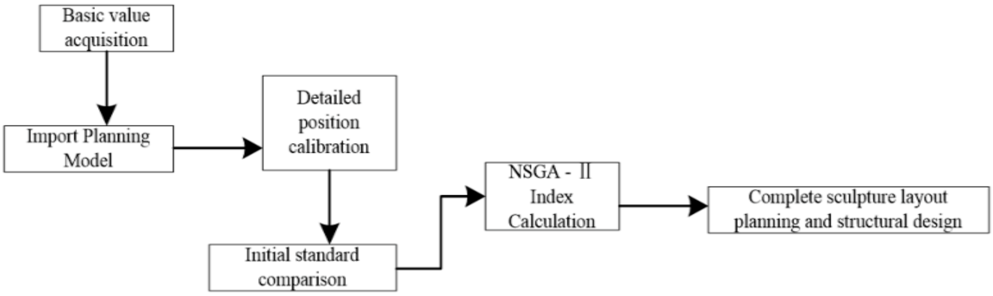

Fig. 2.1: NSGA - II Calculation Landscape Ceramic Sculpture Layout Planning Structure Diagram

scale volume ratio, c indicates the deviation of the drawing. According to the above measurement, the weight coefficient of cross-planning is calculated. This value is then set in the matrix to form a circular layout planning structure, and the directional limit standard [15] is correspondingly configured. At this time, using the design matrix, it is necessary to divide the key control areas at the location of the sculpture layout and, at the same time, mark out the corresponding levels. The specific location is the sculpture core area, layout corridor, and sculpture landscape area [24]. The specific definition and matrix planning location are shown in Table 2.1.

According to Table 2.1, complete the division of sculpture layout levels. On this basis, adjust the planning structure of the matrix to form a more flexible and changeable layout planning framework, make directional planning for the layout of sculptures from multiple aspects, and strengthen the application ability of the matrix [17].

2.3. Construct NSGA - II to calculate the layout planning structure of landscape ceramic sculpture. The multi-level cross-planning matrix of the above design is imported into the layout planning structure of landscape ceramic sculpture to control and guide the sculpture construction. After completing the basic planning, the next step is to integrate the pressure setting requirements of sculpture and the collected data information [18]. Measure the scale of the single sculpture, and calculate the volume value of the sculpture using the NSGA - II algorithm, as shown in Formula 2.3:

$$Q = \int (x - z)^2 \times \omega + \frac{\sqrt{j-1}}{z\omega^2} \tag{2.3}$$

In Formula 2.3, Q represents the mass value of the sculpture,$x$represents the conversion ratio of the matrix, z indicates the degree ratio, ω indicates the seating range of the sculpture, j indicates the overlap range. According to the above settings, the calculation of the sculpture mass value is completed. This value is set inside the model as the layout solidification limit standard value of the model [20]. Next, import the initial data and information of landscape ceramic sculpture into the automatic layout planning program, and design an inferior model planning structure based on this, as shown in Figure 2.1.

According to Figure 2.1, complete the design and application analysis of NSGA - II measuring landscape ceramic sculpture layout planning structure. At the same time, using the planning matrix of the design, we

Table 2.2: Setting Table of Level Conversion Values

Conversion indicators	*Initial level*	*Transition level*
Spatial sequence	Single sequence	Bidirectional sequence
Sculpture position deviation	1.05	3.05
Local area delimitation	unify	multiple target

can re-calculate the indicators, compare the standards of the delicate areas of the sculpture layout, and obtain a scientific planning scheme to facilitate the layout planning work [10].

Here is a step-by-step approach for implementing the NSGA-II algorithm:

1. Initialize the population: Create an initial population of candidate solutions.
2. Evaluate the population: Evaluate the objective values for each individual.
3. Perform non-dominated sorting to classify the solutions into different fronts or levels based on their dominance relationships.
4. Calculate the crowding distance for each individual within each front.
5. Select parents: Select parents for the next generation using a combination of non-dominated sorting and crowding distance.
6. Reproduction: Apply genetic operators such as crossover and mutation to create offspring from the selected parents. These genetic operators introduce variation in the population and help explore different regions of the search space.
7. Create the next generation: Combine the parents and offspring to create the next generation of the population.
8. Repeat the evaluation steps 2-7, non-dominated sorting, crowding distance calculation, parent selection, reproduction, and generation creation steps for a certain number of generations or until a termination condition is met.
9. Terminate the algorithm if the condition is met.
10. Select the final Pareto front.

2.4. Hierarchical transformation implementation model design. The so-called hierarchical transformation mainly refers to the overall layout planning model of sculpture, it is often re-planned due to the change of sculpture points and the adjustment of hierarchical control processing standards, but this form will reduce the planning efficiency. Therefore, the hierarchical transformation method is adopted to increase the transformation ability of the model and complete the layout planning task faster. Set the hierarchy and conversion indicators, as shown in Table 2.2.

Set the value of cascade conversion according to Table 2.2. According to the planning requirements of the sculpture layout and the specific refining standards, the index parameters are converted one by one at each level, and the general situation of the sculpture setting is reasonably adjusted through the model to ensure that the optimal layout planning scheme is obtained.

3. Experiment. This time is mainly to analyze and verify the application effect of landscape ceramic sculpture's overall layout planning model based on the NSGA - II algorithm. Considering the authenticity and reliability of the final test results, the analysis is carried out by comparison, and the square sculpture project in urban area D is selected as the main target of the test. Use professional equipment and devices to collect primary data on landscape ceramic sculpture and information and summarize and integrate them for future use. According to the overall design requirements and standard changes of the landscape ceramic sculpture planning model, the final test results are compared and studied. Next, integrate the NSGA - II algorithm to build and correlate the test environment.

3.1. Experiment preparation. Based on the NSGA - II algorithm, the actual test and analysis environment of the square sculpture project in urban area D was verified and studied. City D is located in southwest China, with a total area of 9655 square kilometers. The urban environment is good, there are many squares, and the layout is complicated. It needs multi-dimensional planning. The sculpture designed this time is the

Table 3.1: Setting Table of Phased Layout Conditions for Sculpture in Urban Square D

Sculpture design stage	*Layout conditions*	*Proportion of controllable completion space*
Positioning stage	The structure matches the spatial sequence, forming a layered sense of sculpture space	3.2
Design phase	Set main nodes and key points to highlight carving Ability to perceive landmarks in sculpture works	4.1
Manufacturing phase	Closely integrate with public space and integrate with civil life	5.5

theme sculpture of a square. The geographical location of the square is superior. It is located in the center of the city, with convenient transportation. It is planned to form a three-dimensional transportation network. In such an environment, the selection of square sculpture needs to be atmospheric, simple, and with urban characteristics. When designing, the surrounding environment and basic settings of the square should also be considered to ensure the spatial basis of the planning of the ceramic sculpture system. According to the actual planning needs and standards, first design the design phase of the comprehensive sculpture, and then make unconditional settings, as shown in Table 3.1.

According to Table 3.1, complete the setting of phased layout conditions for sculptures in urban square D, and convert the above information into data packages or instructions into sculpture planning models for future use. In this background environment, according to the space of the square, use the sculpture planning model to calculate the floor area of the sculpture, and at the same time, mark the corresponding falling point at the setting point, so as to facilitate the setting of later sculptures. Then, on this basis, the NSGA - II algorithm is integrated to calculate the initial scale value of the sculpture, as shown in Formula 3.1:

$$H = (1 - m) \times \sum_{u=1} nu + v^2 \times \frac{1}{m+n} \tag{3.1}$$

In Formula 3.1 H represents the initial scale value of the sculpture, m represents the setting space of the sculpture, n represents the controllable coverage area of the scheduling, u represents the number of landing positions of sculptures, v represents a single value conversion distance. According to the above settings, the construction and correlation of the basic test environment are completed. Next, the NSGA - II algorithm is integrated to carry out a specific measurement and analysis of the sculpture planning model of the square in D urban area.

3.2. Experimental process and result analysis. In the above-built test environment, the NSGA - II algorithm is integrated to carry out specific verification and analysis on the sculpture planning model of D City Square. The model designed this time is a multi-level composite landscape ceramic sculpture with strong urban cultural characteristics. First of all, the phased layout conditions and construction standards of the square sculpture set above are introduced into the model. Considering the changes and adjustments of the surrounding environment of the square, the specific floor space and area of landscape ceramic sculpture are determined first. Then, the layout planning of the sculptures will be carried out. Generally, in order to highlight the characteristics of sculptures, sculptures will be set between squares. The specific planning is shown in Figure 3.1.

According to Figure 3.1, complete the design and analysis of the initial planning structure of the sculpture in the square of urban area D. Next, synthesize the designed sculpture planning model, determine the weight proportion of the sculpture at this time, and apply the analytic hierarchy process and progressive analysis method to set the overall layout of the cloth sculpture at this time. Adjust the basic index parameters of the model at this time by constructing a judgment matrix and model, And reset some values, as shown in Table 3.2.

Set the initial index parameters of the sculpture planning model according to Table 3.2. Next, according to the above model setting conditions and sculpture manufacturing processing, complete the sculpture setting.

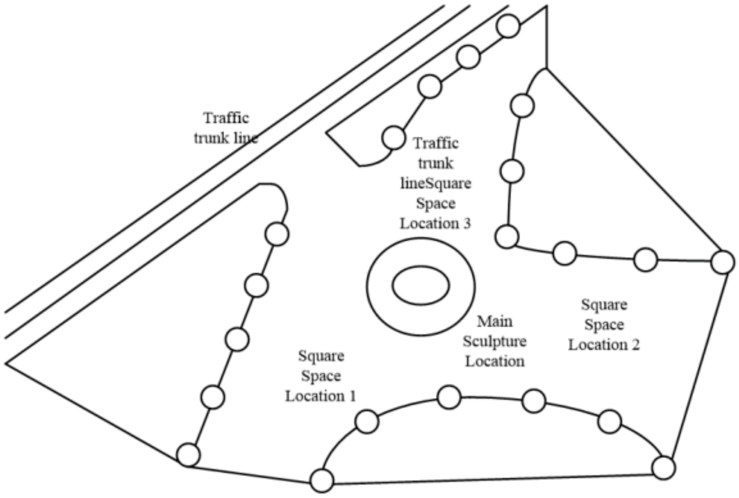

Fig. 3.1: Diagram of Initial Planning Structure of Sculpture in City Square of D

Table 3.2: Initial Index Parameter Setting of Sculpture Planning Model

Initial indicators of sculpture planning model	*Initial setting of index parameter values*	*Measured index parameter value standard*
Landing point setting	Set double landing points, but not stable	Set multiple landing points, with strong stability and safety
Space percentage	3.2	4.1
Preset model planning deviation	1.03	1.01
Model layout settings	18.61	16.05
Local definition of sculpture layout planning	Local layout planning is stable and balanced, with controllable spatial adjustment	The local layout must have a strong sense of hierarchy, echoing and integrating with the surrounding environment

Five local locations of the sculpture are selected for measurement. According to the initial layout standard, the overall layout planning model of the sculpture and the NSGA - II algorithm is integrated to calculate the layout optimization ratio, as shown in Formula 3.2:

$$M = O^2 \times \Im + (\nu + \sum_{y=1} \Im y - 1)^2 \tag{3.2}$$

In Formula 3.2 M represents the layout optimization ratio, O represents the total area of the square, $\Im$ indicates directional coverage, ν represents the conversion distance, y indicates the measurement frequency of the model. According to the above determination, complete the analysis of the test results, as shown in Figure 3.2.

According to Figure 3.2, the comparative analysis of the test results is completed: through three stages of layout optimization processing, compared with the initial planning layout, the optimal layout optimization ratio for the setting of the square sculpture can reach more than 60%, which shows that with the help of this method, the layout planning of sculpture has been further improved, the space has been expanded, and has practical application value.

4. Conclusion. The research presented in this paper focuses on the design and application analysis of the overall layout planning model of landscape ceramic sculpture using the NSGA-II algorithm. The developed

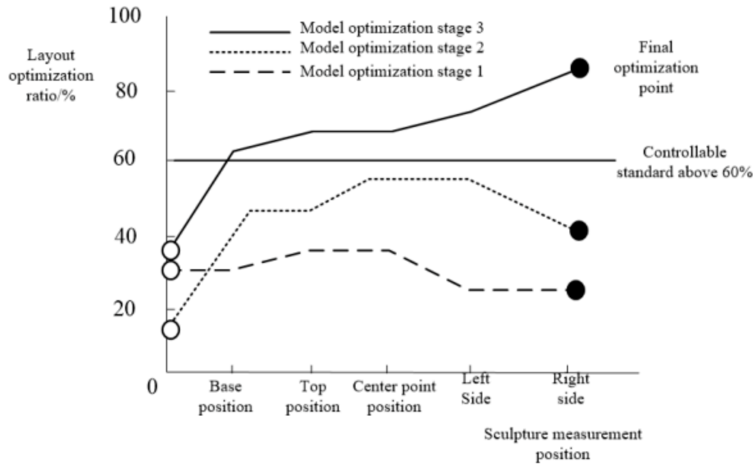

Fig. 3.2: Comparison and Analysis of Test Results

model demonstrates enhanced pertinence and stability compared to the original layout planning model, offering significant potential for expanding the space dedicated to urban sculpture. By employing a multi-level approach to planning control and considering local conditions, the model guides the characteristics, culture, and even the setting environment of the city to design specific planning schemes. Furthermore, it emphasizes the meticulous multi-dimensional processing of details and incorporates hierarchical control, placing a strong emphasis on the key features of sculpture. Through this comprehensive design approach, the research achieves multi-dimensional planning and control of space, effectively integrating multiple objectives into the landscape ceramic sculpture design process. Looking ahead, this work opens avenues for further innovation and development of the overall layout planning model for sculptures, taking it to new heights of creativity and effectiveness. Future research can explore additional optimization techniques, incorporate advanced technologies, and consider evolving urban design principles to continue refining the field of landscape ceramic sculpture planning.

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