Research on landscape Spatial Structure Optimization of Garden sculpture based on improved Particle Swarm Optimization algorithm

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Abstract: Traditional methods in landscape sculpture landscape spatial structure optimization, did not consider the harmony between sculpture landscape and garden, there is a problem of long optimization processing time. Therefore, this paper designs a new optimization method of landscape sculpture spatial structure by improving particle swarm optimization algorithm. This paper analyzes the influence of garden sculpture on the whole space of the garden, and establishes the landscape space structure optimization model of garden sculpture. The spatial optimization index of garden sculpture landscape was established through analysis, and the spatial optimization constraints were set. The improved particle swarm optimization algorithm was used to solve the optimization model, and the optimization of the sculpture landscape spatial structure was completed. Compared with the optimization method based on genetic algorithm, the experiment shows that the optimization method based on improved particle algorithm has short processing time, and the optimized vegetation area, harmony between sculpture and garden are significantly improved, with better application effect.

1. Introduction
The composition forms of modern gardens are constantly enriched, and the combination relations between each component element and the environment of the garden are constantly changing. Sculpture intervenes in the garden space, and the main sculpture penetrates with the environment space, forming a relatively independent landscape space. However, in the process of garden design, the spatial structure of the sculpture landscape is separated from the whole garden. When the sculpture is placed into the garden environment to form the landscape together, it also changes the original spatial structure of the garden, affecting the effect of the garden landscape and the rationality and harmony of the spatial structure. In the application of the traditional method of spatial structure optimization of garden sculpture landscape based on genetic algorithm, although it can improve the rationality of spatial structure compared with before optimization, in fact, it cannot fully display the artistic beauty of sculpture, and the harmony of spatial structure is poor[1-3].

Reasonable and good spatial structure is the basis for garden sculpture landscape to play its role. Therefore, in order to improve the rationality of spatial structure layout of garden landscape, this paper will study the spatial structure optimization method of garden sculpture landscape based on improved particle swarm optimization based on the above analysis.
2. A method for landscape spatial structure optimization of garden sculpture based on improved particle swarm optimization algorithm

2.1. The model of landscape space structure optimization of garden sculpture is established

When the spatial structure of garden sculpture landscape is optimized, the objective function of the optimization model is that the spatial structure is the embodiment of the optimization direction[4-5]. From the perspective of landscape browsing, economy and ecology, the objective function of the spatial structure optimization model of garden sculpture landscape is established as shown in the following formula.

\[
\begin{align*}
  f(z) &= \max \left( \sum_{k=1}^{K} c_k z_k \right) \\
  g(z) &= \sum_{k=1}^{K} a_k z_k \\
  h(z) &= \max \left( \alpha_1 \sum_{k=1}^{K} v_k z_k + \alpha_2 \sum_{k=1}^{K} v'_k z_k \right)
\end{align*}
\]

In formula (1), \( f(z) \) is the total economic output value of landscape architecture, whose unit is ten thousand yuan; \( c_k \) is the output value coefficient of the \( k \)-th class landscape including sculptures, vegetation and other ornaments; \( z_k \) refers to the area occupied by the \( k \)-th class landscape in the garden; \( K \) is the number of landscape types in the garden; \( g(z) \) is the sum of the ecological security index of each landscape in the garden; \( a_k \) is the ecological security index per unit area of the \( k \)-th type landscape; \( h(z) \) is the comprehensive benefits of each landscape in the garden area to the garden visitors; \( \alpha_1 \) and \( \alpha_2 \) are the index weights of the objective function of garden economic benefit and ecological protection degree; \( v_k \) is the output value coefficient of the \( k \)-th class landscape in the garden after standardized treatment; \( v'_k \) is the ecological security index per unit area of the \( k \)-th landscape in the garden after standardized treatment. After the objective function of the spatial structure optimization model is established, the constraints of the model are designed by determining the spatial optimization index of the landscape sculpture.

2.2. Landscape space optimization index of garden sculpture is determined

The index of landscape plate aggregation refers to the degree of aggregation between different landscape plates in a garden, and its calculation formula is as follows:

\[
C = c_{\text{max}} + \sum_{i=1}^{K} \sum_{j=1}^{K} P_{ij} \ln \left( P_{ij} \right)
\]

In formula (2), \( c_{\text{max}} \) is the maximum aggregation index between different landscape plates in the garden; \( P_{ij} \) is the probability that type \( i \) landscape and type \( j \) landscape are adjacent to each other in the landscape plate. \( C \) is the aggregation index of landscape plates, and its value range is \((0,100]\). The fractal dimension of the landscape plate represents the relationship between the shape of the plate and its area[6-9]. The greater the fractal dimension is, the greater the deviation between the sculpture landscape and the whole garden. According to the indexes determined above, the following constraints of spatial structure are set:
In formula (3), \( A \) is the total area of the garden; \( A_d \) represents the minimum demand sculpture total area in the garden; \( z_{dk} \) is the area of different sculpture landscape in the garden; \( z_{uk} \) is the area of green vegetation in gardens; \( A_l \) is the minimum required area of vegetation in landscape planning; \( F \) is the fractal dimension of the landscape plate in optimization; \( F_{min} \) is the fractal dimension of the theoretical minimum landscape plate[10]. The above process completes the establishment of the spatial structure optimization model points for garden sculpture landscape, and the improved particle swarm optimization algorithm is used to solve the model to complete the spatial structure optimization.

2.3. Spatial structure optimization is realized

Particle swarm optimization constantly updates particle position and particle velocity, that is, it iteratively updates its own information in the solution space to find the optimal solution of the optimization problem. The following figure is a flow chart of solving optimization problems by using improved particle swarm optimization.

![Flow chart of improved particle swarm optimization](image)

In the figure above, the initial velocity and initial position of particles in the improved particle swarm optimization algorithm are randomly selected. The fitness of each particle is calculated according to the following formula:

\[
fit(x) = \frac{1}{1 + s - x}, s > 0, s - x > 0
\]  

In formula (4), \( s \) is a fitness function parameter. The current position and fitness value of each particle are stored in the pbest of the corresponding particle. The position and velocity of the optimal particle in pbest are extracted and updated as the next iteration parameter of the improved pbest.
algorithm. Compare the new fitness function value, update the pbest stored information in the particle until the final global optimal solution is obtained, and output the corresponding solution result.

3. Experiment

3.1. Experiment content
In order to visually compare the practical application effect of the spatial structure optimization method studied above, this paper chooses to conduct a comparative experiment. Contrast methods of contrast experiment for the traditional landscape spatial structure optimization method based on genetic algorithm, this paper studies the optimization method for experimental method, respectively, by comparing the two algorithm of solving the same optimization model of the algorithm of time consuming, and the effect of two landscape spatial structure optimization method to optimize, to the overall evaluation of two method optimization method is practical.

3.2. Experimental process
The relevant data of a certain green garden in city A was selected as the model parameters for solving the genetic algorithm and the improved particle swarm optimization algorithm, and different optimization functions and optimization constraints were set to solve the optimization problem using the two algorithms. The algorithm comparison experiment was carried out in the computer simulation platform. The reliability of the two algorithms in solving several spatial structure optimization problems was evaluated by comparing the two algorithms in solving several spatial structure optimization problems and the time taken by the two algorithms in solving different algorithms.

All the parameters of the experimental garden were input into the computer simulation platform, and the sculpture landscape parameters planned to be put into the garden were input into the computer simulation platform. According to the parameters of the computer simulation platform, the comparative method and experimental method are used to optimize the spatial structure of the sculpture landscape. By comparing the two methods, the rationality of the spatial structure layout of garden sculpture landscape and the overall harmony with the garden environment are obtained. The landscape environment before spatial structure optimization is shown in the following figure.

![Fig.2 Environmental structure of experimental garden](image-url)

By analyzing the experimental data of the above two experiments and synthesizing the experimental conclusions of the two experiments, the final conclusion of this experiment is obtained, and the performance test of the spatial structure optimization method designed in this paper is completed.
3.3. Experimental results
When the genetic algorithm and the improved particle swarm optimization are used to solve the spatial structure optimization problems of different landscape sculptures, the results of the algorithm's solving time comparison are shown in the following table.

| Serial number | Improved particle swarm optimization | Genetic algorithm |
|---------------|--------------------------------------|-------------------|
| 1             | 1.66                                 | 6.26              |
| 2             | 1.36                                 | 6.62              |
| 3             | 1.11                                 | 6.08              |
| 4             | 2.58                                 | 8.34              |
| 5             | 3.04                                 | 8.71              |
| 6             | 2.61                                 | 7.49              |
| 7             | 1.79                                 | 6.95              |

Analysis of the above table shows that when solving the same spatial structure optimization problem, the solution time of the improved particle swarm optimization algorithm is far less than that of the genetic algorithm. It shows that PSO can solve the problem faster. Therefore, on the premise that both algorithms are correct, the improved particle swarm optimization algorithm is more effective.

In the computer simulation platform, the results of optimizing the spatial structure of sculpture landscape in the target garden by using the comparative method and the experimental method are shown in the figure below. By comparing the spatial structure harmony and layout rationality of the optimized sculpture landscape in the two figures, the actual effect of the two methods is evaluated.

![Fig. 3 Comparison of optimization effects of spatial structure](image)

(a) Optimization effect of experimental method (b) optimization effect of comparison method

By analyzing the above two figures, it can be seen that when two different optimization methods are used to optimize the garden sculpture space, the optimized structure of the garden sculpture after the experimental method can enable garden tourists to browse with the best moving line, and other elements of the garden and the sculpture landscape in the optimized garden space structure will be more harmonious. At the same time, the vegetation distribution area and the number of sculptures in the gardens optimized by the two methods were compared, and the vegetation area and the number of sculptures placed in the gardens optimized by the experimental method were significantly higher than those optimized by the comparison method. It shows that the experimental method can effectively improve the harmony of the space of garden sculpture and enhance the browsing of the garden after optimizing the space structure of garden sculpture.
4. Conclusion
The application of sculpture landscape in landscape architecture is a common way to improve the accessibility of landscape architecture. However, the harmony between sculpture landscape and garden is affected by the spatial structure distribution of sculpture landscape. In order to optimize the spatial structure of sculpture landscape, this paper studies the optimization method of landscape sculpture landscape space structure based on improved particle swarm optimization algorithm. Through the comparative experiment with traditional landscape sculpture landscape structure optimization method based on genetic algorithm, it is verified that the method in this paper has better effect and reliability in practical application. In the future research, it is still necessary to further study the optimization algorithm to improve the effect of spatial structure optimization.

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