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Article

Evaluation and Implementation of Landscape Aesthetics Based on Cloud and Edge Computing

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Abstract: People's aesthetic requirements for landscape environment are improving, and we can also see very beautiful as well as characteristic urban parks, street side green areas and scenic spots with certain aesthetic value around us, and we can find that people's demand for the living environment they live in regarding beauty is also strengthening. The synergistic development of edge computing and cloud computing is an important development trend in the future, and integrating them into landscape design is an inevitable choice and requirement for developing gardens and building a beautiful China. Based on this, this study first proposes a methodological framework based on machine learning to model and predict GSS, and then proposes a data-driven multi-style terrain synthesis method. The experimental results prove that the optimized landscape perception model optimizes the landscape path aesthetics according to the relevant theories and actual cases of landscape planning and construction.

Keywords: Machine learning, Edge calculation, Landscape, Landscape perception model optimization

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1. Introduction

As the habitat environment is closely linked to the development of the times, the pace of urbanization, the severe climate change, resulting in clothing, food, housing and transportation in the "residence" is no longer a simple proposition. If you want to add a touch of life in the steel jungle, trace its roots to the construction of the habitat environment can not be separated from the embellishment of the garden. The "Beautiful China" proposed by the 18th National Congress is a unification of the world vision, national height and people's feelings. From a certain point of view, it is hoped that the public can experience and appreciate the richness of natural and humanistic landscapes in an international perspective. Later, at the 19th National Congress, the concept of ecological civilization was reiterated once again: the pace of China's modernization in the new era is the harmonious coexistence of man and nature, meeting the constant demand for material and spiritual wealth while implementing a more high-quality, extensive and comprehensive ecological layout to people's needs for a green ecological environment. People have higher requirements for the environment they live in, and landscape construction has become an important vehicle for improving people's quality of life and optimizing environmental quality after meeting the most basic greening functional requirements. The creation of garden art, in the final analysis, should still rely on the political, economic, artistic, social and other basic aspects, and from bottom to top, from point to point, to meet and communicate with people in the modern city for development and habitat requirements. In the "people-oriented" slogan, although there are some of this as a gimmick, but for gardeners, from the needs of life, psychological requirements, the outside world should be, ecological structure and other multiple perspectives, to create a real "people" garden world, and In order to meet people's spiritual aspirations for landscape gardening, for urban ecological construction, residents' spiritual construction, the construction of garden art disciplines have an important significance of guidance.

But in the one-sided pursuit of landscape visual effects of the interests of the urging, whether it is the creation of new landscapes, or site transformation throughout China, a large number of one-sided graphic aesthetics and connotations have been inappropriately emphasized, while other gardens contain the basic meaning and function is lost and abandoned. Large tree transplants, large areas of hard paving, ecological corridors are truncated, do not consider the "ecological position" principle is also common, in the era of national policies, social collective advocate ecological values, landscape design to give full consideration to the ecological benefits of the environment, so that man-made landscape and the natural environment in harmony to create a better living environment.

Cloud computing is a collective term for many supercomputing models done using various computer technologies, and the main technologies included are virtualization, data management, data storage, programming models, etc. Edge computing refers to an open platform that converges computing, applications, storage, and core network capabilities at the edge of the network, very close to the source of data or objects, and provides distance-based intelligent services to meet the needs of digitalization in terms of dynamic services, intelligent applications, agile connectivity, and security protection. We use cloud and edge computing to evaluate the landscape aesthetics, study the current problem of insufficient landscape functions in China, combine theory with practice, conduct scientific argumentation and analysis, and propose methods to expand the functions of gardens, so as to provide some reference for the development and construction of gardens in China.

As mentioned in literature [1, 2], edge computing technology, as one of the key technologies to ensure the performance requirements of emerging intelligent Internet of Things services in terms of low latency and high reliability, has attracted close attention from scholars and industry at home and abroad in recent years. In the industrial sector, cloud service providers, hardware manufacturers, network operators and other giants have successively released their own edge computing service platforms, computing service infrastructure and solutions for industry vertical application scenarios [3,4]. According to [5, 6], since edge computing tasks and service scheduling of resource constrained heterogeneous edge computing systems and the performance of computing intensive business services. According to [7, 8], the European Telecommunications Standards Edge computing allows intelligent user terminals to unload complex tasks that cannot be processed to computing service facilities with strong computing power [9, 10]. Researchers in [11, 12] proposed that, compared with remote ECS, since the base station, edge server and other devices are deployed near the user's network edge, they can ensure the low latency and high reliability transmission of computing tasks and results, thus ensuring the strict requirements of services on service performance. According to [13, 14], theoretical exploration in architecture is also constantly enriched and developed. In short, the virtual and real problems in Chinese garden aesthetics actually reflect the two worlds of gardens: the world of things and the world of Tao [15, 16]. According to [17, 18], when we interpret the problem of falsehood and reality in Chinese garden aesthetics, we should see that although the garden world, as the manifestation of "Tao", is a negation and transcendence of the garden reality [19].

According to [20], with the progress of the times, gardens have been developing and gradually become a tourist attraction suitable for people of all ages, different social strata, different cultural backgrounds and different professional backgrounds. According to [21], the construction and development of national gardens are highly valued by the national government, and some countries have also set up relevant management institutions and formulated corresponding management regulations on this basis. According to [22, 23], the construction and development path of gardens in China conforms to the basic laws of world development, and has been developed and improved in a long period of accumulation.

According to [24, 25], affected by the research on public participation, China has adopted some forms of public participation and specific implementation approaches in landscape planning and design in combination with the actual situation. At the stage of development, the number of domestic gardens increased rapidly.

To sum up, there are many achievements in the exploration and practice of landscape architecture in China. However, as an independent system, the exploration and research on the path aesthetics and function of landscape architecture are not many in this area, and there are few comprehensive research achievements in the system of combining theory with practice. Its definition and meaning also lack a professional and authoritative unified conclusion.

China is currently in a period of industrialization and post-industrialization. Needless to say, the urban and environmental problems that occurred in the United States and other developed countries in the 1950s and 1960s have unfortunately been repeated on Chinese soil, and more seriously. The urban and environmental problems faced by the Chinese landscape profession are summarized as;

1. the rapid expansion of the urban population and the serious threat to the basic living environment of the inhabitants,
2. the extreme lack of outdoor sports and leisure space,
3. extremely tight land resources,
4. limited financial resources,
5. limited natural resources,
6. invasion of European and American cultures.

All these problems have become self-evident. What I would like to emphasize here is how the Chinese landscape architecture profession should play an irreplaceable role in solving these major problems, establishing the direction of development of the modern and future landscape architecture profession in China while contributing to society, and establishing the image of the landscape architecture profession and professionals. The research on landscape gardening in this paper combines advanced technologies such as machine learning and edge computing to help establish and improve the theoretical system of landscape garden planning and construction in China and promote the improvement and development of the theoretical system.

2. Landscape Perception Model Optimization

The theory of landscape perception, which originated in the 1950s, is an independent theory developed in environmental psychology research, combining environmental psychology and landscape aesthetics to jointly study human perception and preference for the environment and landscape [26]. The American scholar Owen argued that human landscape perception is an ongoing, complex and dynamic process, and proposed a model of the landscape perception process that unifies the results of human, landscape, and human-landscape interactions into a closed loop [27]. The external environment is the main source of perceptual information generated by humans, and humans mainly rely on their own sensory organs to realize the perception of the external environment, i.e., vision, hearing, touch, taste, and smell. Simply put, landscape perception is the study of human perception of the external landscape environment and the interrelationship between human and the external landscape environment [28, 29]. In order to better explain the mechanism of landscape on human perception, scholars proposed a landscape perception model as shown in Figure 1. The model is based on the functional theory that landscape perception is regarded as the interaction between human and landscape. The human aspect is composed of individual experience, knowledge, expectation and sociocultural background; The landscape part includes landscape elements and the whole composed of all elements; The interaction between the two results, which in turn affect the other two components of

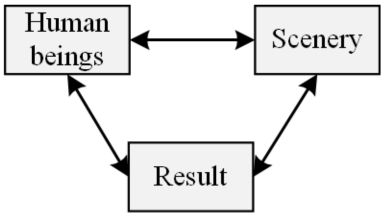

Figure 1. Landscape Perception Model

the model. From this model, we can find that perception, individual and landscape are an interactive relationship, and landscape elements play a very important role in perception.

After the word vector training is completed, it is found that the actual training effect is consistent with the expectation. A comment can be regarded as a set of words. The vector of comments can be expressed by the arithmetic mean of all word vectors in the comment. The calculation method is shown in the formula:

$$\text{Vector}_{\text{sentence}} = \frac{\sum_{i=1}^{n} \text{Vector}_{\text{wordi}}}{n}. \tag{1}$$

After 50 fold cross validation, the calculation results of five evaluation indicators were obtained in turn, including Spearman rank correlation coefficients (ρ). The calculation formula of the five indicators is as follows:

$$\rho(y, \hat{y}) = \frac{\sum_{i=1}^{n} (y_i - \bar{y})\left(\hat{y}_i - \bar{\hat{y}}\right)}{\sqrt{\sum_{i=1}^{n} (y_i - \bar{y})^2 \sum_{i=0}^{n_{ammple}-1} \left(\hat{y}_i - \bar{\hat{y}}\right)^2}}, \tag{2}$$

$$R^2(y, \hat{y}) = 1 - \frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2}, \tag{3}$$

$$MAE(y, \hat{y}) = \frac{1}{n} \sum_{i=1}^{n} |y_i - \hat{y}_i|, \tag{4}$$

$$MSE(y, \hat{y}) = \frac{1}{n} \sum_{i=1}^{n} (y_i - \hat{y}_i)^2. \tag{5}$$

The objective function of GAN can be expressed as:

$$\min_G \max_D V(D, G) = E_{x \sim p_{\text{data}}(x)}[\log D(x)] + E_{z \sim p_z(z)}[\log(1 - D(G(z)))]. \tag{6}$$

The formula is used to calculate the perception frequency of each landscape element at the garden scale:

$$F_{LEi} = \frac{n_{LEi}}{n_{\text{park}j}}. \tag{7}$$

The correlation coefficient of these two sets is recorded as adaptive distance correlation, and the equation is as follows:

$$FDC = \frac{C_{FD}}{\sigma_F \sigma_D}, \tag{8}$$

where, C_{FD} is defined as follows:

$$C_{FD} = \frac{1}{n} \sum_{i=1}^{n} \left(f_i - \bar{f}\right)\left(d_i - \bar{d}\right). \tag{9}$$

	Landscape index	Pylandstats parameter	Formula	Ecological significance
	Area	Area	ai, j	Plaque area
	Perimeter	Perimeter	pi, j	Patch perimeter
	Perimeter area ratio	Perimeter _ Area _ Ratio	$\frac{pi,j}{ai,j}$	Perimeter and face scale, used to measure shape complexity
Landscape index at patch scale	Shape index	Shape _ Index	$\frac{.25pi,j}{\sqrt{ai,j}}$	Measure the shape complexity, similar to the perimeter area ratio, and further standardize
	Fractal dimension	Fractal _ Dimension	$\frac{2\ln(.25pi,j)}{\ln(ai,j)}$	The measurement of plaque shape complexity is more appropriate for comparing a series of patches with different scales
	Euclidean proximity distance	Euclidean	Nothing	The plate aggregation
Landscape index of element scale	Total area of elements	Total _ Area	$\sum_{j=1}^{nj} ai, j$	Total area of elements

Table 1. Selected Landscape Index and Interpretation

	Landscape elements	Abbreviation of landscape elements	Element Description	Element word statistics
Natural factor	Terrain	Top	Elevation, slope, etc.	55
	Vegetation	Veg	Trees, flowers, lawn lamps	246
	Biology	Ani	Birds, bees, butterflies, etc.	75
	Water body	Wat	Rivers, lakes, etc.	168
Cultural elements	Historical buildings	HA	Site buildings, etc.	108
	Recreational buildings	RA	Pavilions, corridors, halls, exhibition centers, etc.	122
	Service building	SA	Tourist center, toilet, restaurant, etc.	57
Supporting facilities	Recreational facilities	RF	Seats, fitness equipment, playground, cruise dock, etc.	95
	Service facilities	SF	Parking lot, signboards, trash cans, lights, etc.	197
	Management facilities	AdF	Landscape maintenance equipment, ticket entrance and exit, etc.	113
	Art facilities	ArF	Sculpture, stone landscape, etc.	92

Table 2. List of Landscape Elements

Composition of fitness landscape feature vector:

$$fl = \left[LFDC, H(0), H\left(\frac{\varepsilon^*}{128}\right), H\left(\frac{\varepsilon^*}{64}\right), H\left(\frac{\varepsilon^*}{32}\right), H\left(\frac{\varepsilon^*}{16}\right), H\left(\frac{\varepsilon^*}{8}\right), H\left(\frac{\varepsilon^*}{4}\right), H\left(\frac{\varepsilon^*}{2}\right)\right]^{\mathrm{T}}. \tag{10}$$

This study refers to the landscape pattern indicators used and recommended in the urban landscape related research, and selects the landscape pattern index that may affect tourists' perception and satisfaction of elements and has a clear ecological meaning to quantify the landscape pattern. The specific landscape index, calculation formula and ecological meaning are shown in Table 1.

3. Methods

According to the process of establishing the landscape element dictionary, the final obtained landscape element dictionary is shown in the following table. The dictionary has 3 major categories, 11 sub-categories, and 1328 commonly used Chinese landscape element words, as shown in Table 2.

Edge computing allows intelligent user terminals to unload complex tasks that cannot be processed to computing service facilities with strong computing power, such as base stations or edge servers in edge networks, to meet the task computing requirements of computing intensive intelligent services. The basic principle of the decision tree model is to use a tree structure similar to the roots, branches and leaves of trees to achieve classification or regression operations of complex data. Its basic structure is shown in Figure 2.

Edge computing and fog computing have a lot of technical similarities. They both provide computing processing services near the service generation location, further extending the service scope of existing cloud computing systems, and making up for their deficiencies. As one of the three physical environments in the construction of ecological environment, acoustic environment is the basic component of space environment, and soundscape is an important carrier for people to feel and un-

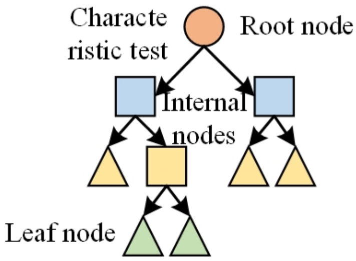

Figure 2. Landscape Decision Free Model Optimization Structure

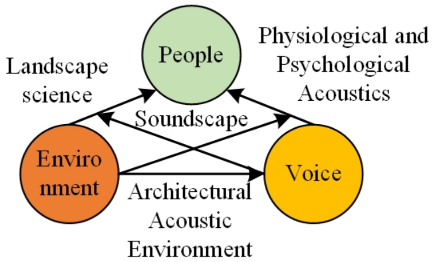

Figure 3. The Relationship Between the Three Elements of Sound and Landscape in the Landscape

derstand urban space. The soundscape research mainly includes three elements: people, sound and environment, as shown in Figure 3.

Based on the social media data for the theme evaluation of green space landscape, using text content analysis and machine learning based technical means, extract the structured content of GSS evaluation from the text big data, and build an efficient, systematic and quantitative method framework for recreation satisfaction modeling and quantitative analysis taking urban green space as the object. Supervised learning is the most common method of emotion analysis based on machine learning. This method uses machine learning algorithm to characterize the data after text processing through corpus tagging, and the specific algorithm flow is shown in Figure 4.

The "landscape picture" analysis method based on landscape pictures is a quantitative evaluation method for the pollution degree of landscape. This research method divides the space places of the research object in advance, and then analyzes various visual elements contained in the pictures, as well as the position, color, height and other factors of these visual elements, based on the data of landscape pictures in the corresponding space places, and obtains the corresponding scores, as shown in Figure 5.

The framework flow is shown in Figure 6.

According to the current urban development theory in China, cities are generally divided into five categories from the scale system. What is the concept of China? What size cities are small and medium-sized? To make this concept clear is of guiding significance for the research on the expansion of garden landscape functions in small and medium-sized cities. From all possible combinations, 45 data sets were obtained by randomly sampling at the set magnification. If there is category imbalance in the data set itself, it is necessary to reconstruct the data set while expanding based on the solution proposed in Section 3, give different expansion ratios to each category, and adjust the number to relative balance, as shown in Figure 7.

4. Case Study

Landscape function is a very complex concept, which contains all factors that must be considered in design, including technical factors, social factors, aesthetic factors and emotional factors. It can refer to the exchange of material, energy and information between the landscape and the surrounding

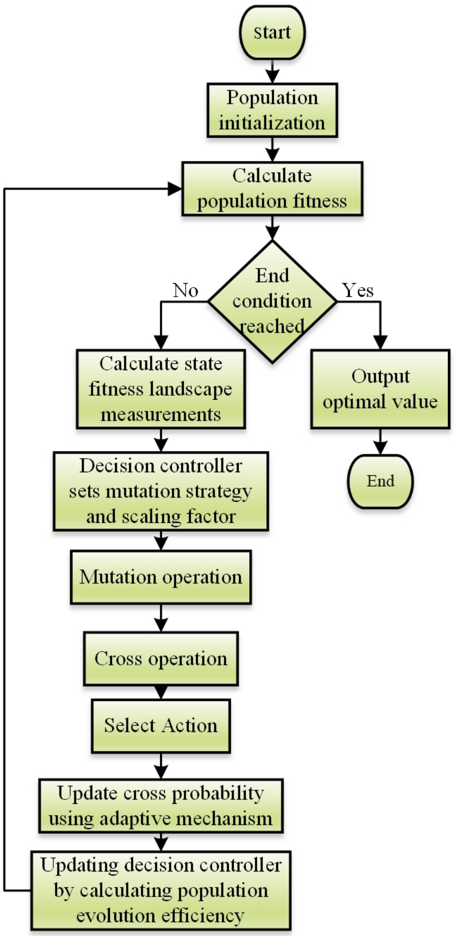

Figure 4. MMFLDE Algorithm Optimization Flow Chart

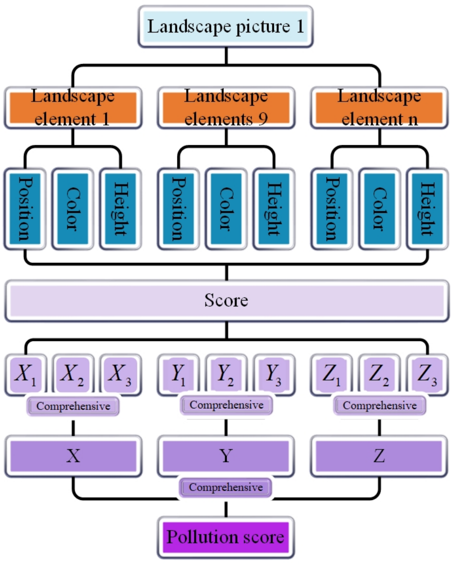

Figure 5. Rating Framework

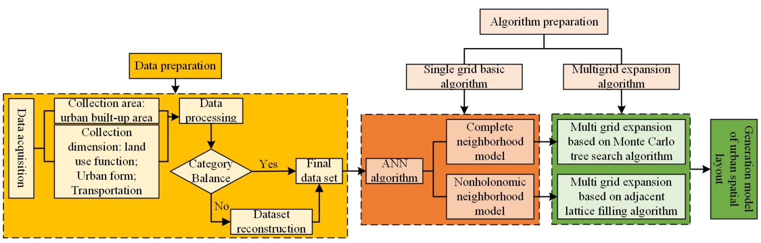

Figure 6. Landscape Function Analysis Framework Flow Chart

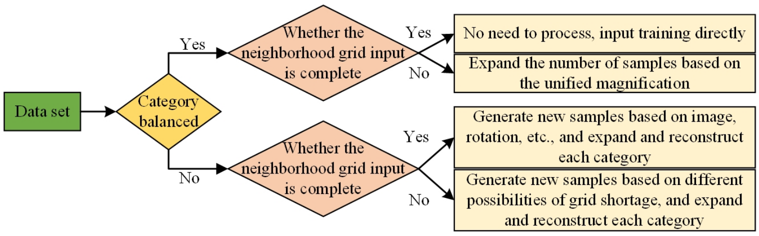

Figure 7. Selection of Landscape Function Data Set Processing Methods in Different Situations

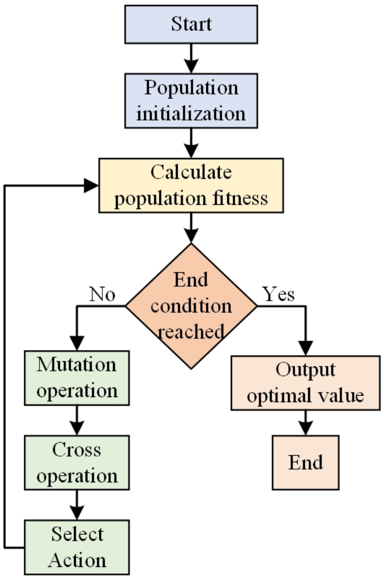

Figure 8. Landscape Path Aesthetic Standard Differential Evolution Algorithm Optimization Process

environment, as well as various changes and performances in the landscape. From the perspective of the role of landscape in social economy, the landscape function can also be understood as the beneficial role it brings to the natural environment, social ecology, local culture and local residents. In a general sense, landscape functions can be summarized as follows: ecological service function, leisure and recreation function, popular science education function, greening and beautification function, social and economic function, etc. The standard DE algorithm is easy to implement because of its simple operation and only three control parameters, namely population size, scaling factor and crossover probability, as shown in Figure 8.

The entity of the garden is any material thing that exists in the garden, and its objective existence creates the visual appreciation of the garden and becomes the direct carrier for realizing the tourism, residence and outlook of the garden. In addition, entities assume certain functions in gardens, which is the most fundamental difference between entities that exist objectively in gardens and those depicted in boundary paintings, and the vocabulary of landscape elements is established using the seed word expansion method, as shown in Figure 9.

In the material construction of the garden, there are material functional requirements, such as providing for relatives and storing grain, and more spiritual functional requirements, such as lecturing, livestock and cranes, seeing the mountain, playing the piano, poetry, reading, fishing, and seclusion. This is the landscape composition layout that realizes the aesthetic ideal of ”traveling in art” by virtue of material functions. Although, in the landscape composition of Chinese gardens, especially in the literati freehand brushwork gardens, the requirements of spiritual life are more important than the requirements of material life, but the satisfaction of these requirements must be achieved through material entities. It can be said that the spirit of Chinese gardens is attached to the shape and quality

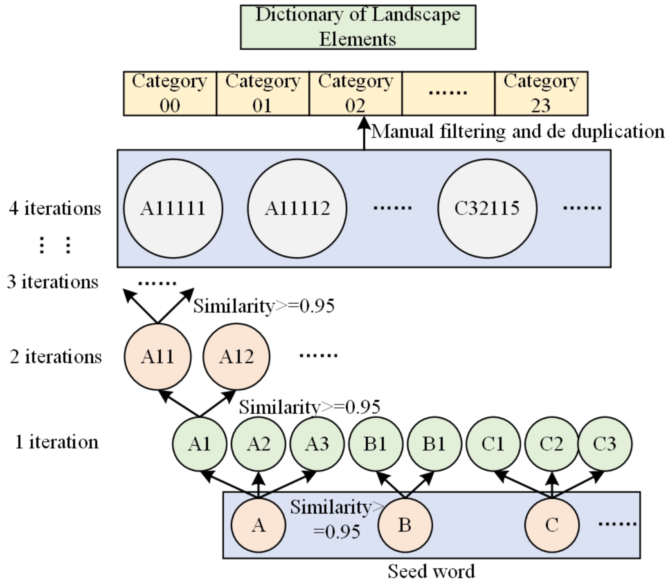

Figure 9. Detailed Process of Landscape Element Dictionary Construction

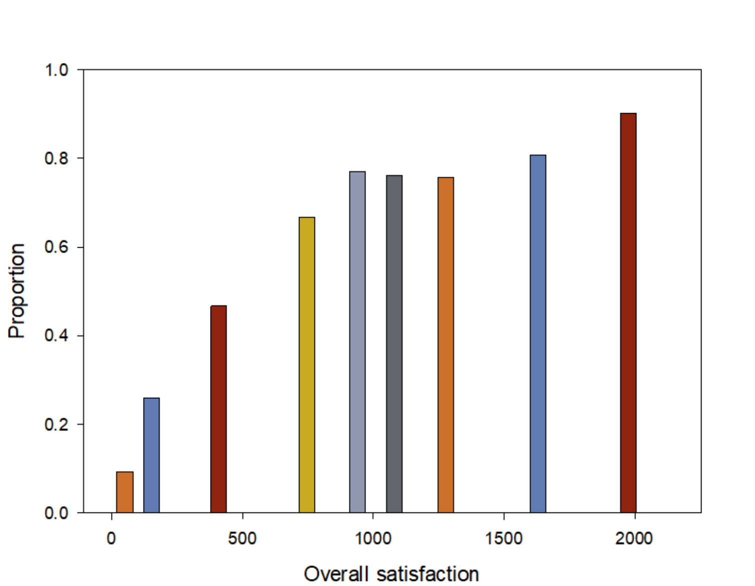

Figure 10. Overall Satisfaction Distribution of Users with Landscape Functionality

of the garden landscape, and each landscape element of the garden contains Chinese thoughts and feelings. It is a concentrated embodiment of the Chinese nation's cultural psychology, aesthetic habits, aesthetic pursuit and life ideal. The satisfaction distribution of 50 landscape users is shown in Figure 10.

Although the perception rate of historical and leisure buildings in some gardens is very high (such as Linglong Gardens and Temple of Heaven Gardens), the average perception rate of cultural elements is relatively small (the average value is 0.079). In the aspect of factor perception satisfaction, the overall trend of the three categories is similar to the factor perception frequency, but there are significant differences among the 11 subcategories. In particular, the perception frequency of terrain, animals, historical buildings, recreational buildings and artistic facilities is low, but the satisfaction is high, which indicates that the perception frequency of elements and the perception satisfaction of elements are not necessarily consistent. The above conclusions are further confirmed by the correlation analysis between factor frequency and factor satisfaction in Table 3.

Machine learning is a branch and common application direction of artificial intelligence (AI). The algorithm/system designed by machine learning theory can automatically learn data characteristics

Landscape elements	Pearson correlation coefficient	Significance (double tail)
Top	-0.274	0.155
Veg	0.103	0.469
Ani	0.044	0.777
Wat	0.486***	0.000
HA	0.207	0.143
RA	-0.280	0.845
SA	-0.037	0.788
RF	0.342***	0.014
SF	0.091	0.521
AdF	0.005***	0.015
ArF	-0.055	0.691

Table 3. Correlation between Perceived Frequency and Satisfaction of Landscape Elements. Note: *** p<0.079.

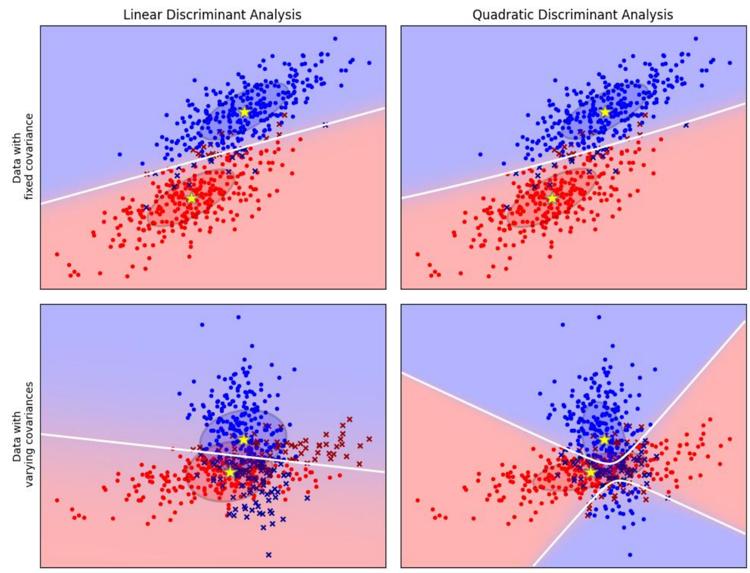

Figure 11. Keras Module Optimization

from given data and form "experience" from the training and learning process to perform prediction and decision-making tasks on unknown data. Because the design of machine learning algorithm is based on a large number of statistical principles, it is sometimes called statistical learning method, the Keras module structure is shown in Figure 11.

Machine learning algorithms can predict unknown data documents to achieve the goal of batch execution of scheduled tasks by learning the characteristics of known data, analyze the flaws of algorithm design and parameter setting, and use Keras to build a neural network, as shown in Figure 12.

In summary, edge computing technology can make up for the shortcomings of existing cloud computing technology in terms of low latency and high reliability by deploying a computing infrastructure with relatively sufficient capacity and resources near the edge of the service network, while meeting the simultaneous demand for performance and resources of emerging IoT services. This will enable the viewing public from all over the world to deepen their impression of the landscape in the corresponding small space, so as to better realize the effect of the garden mood of intermingling scenes.

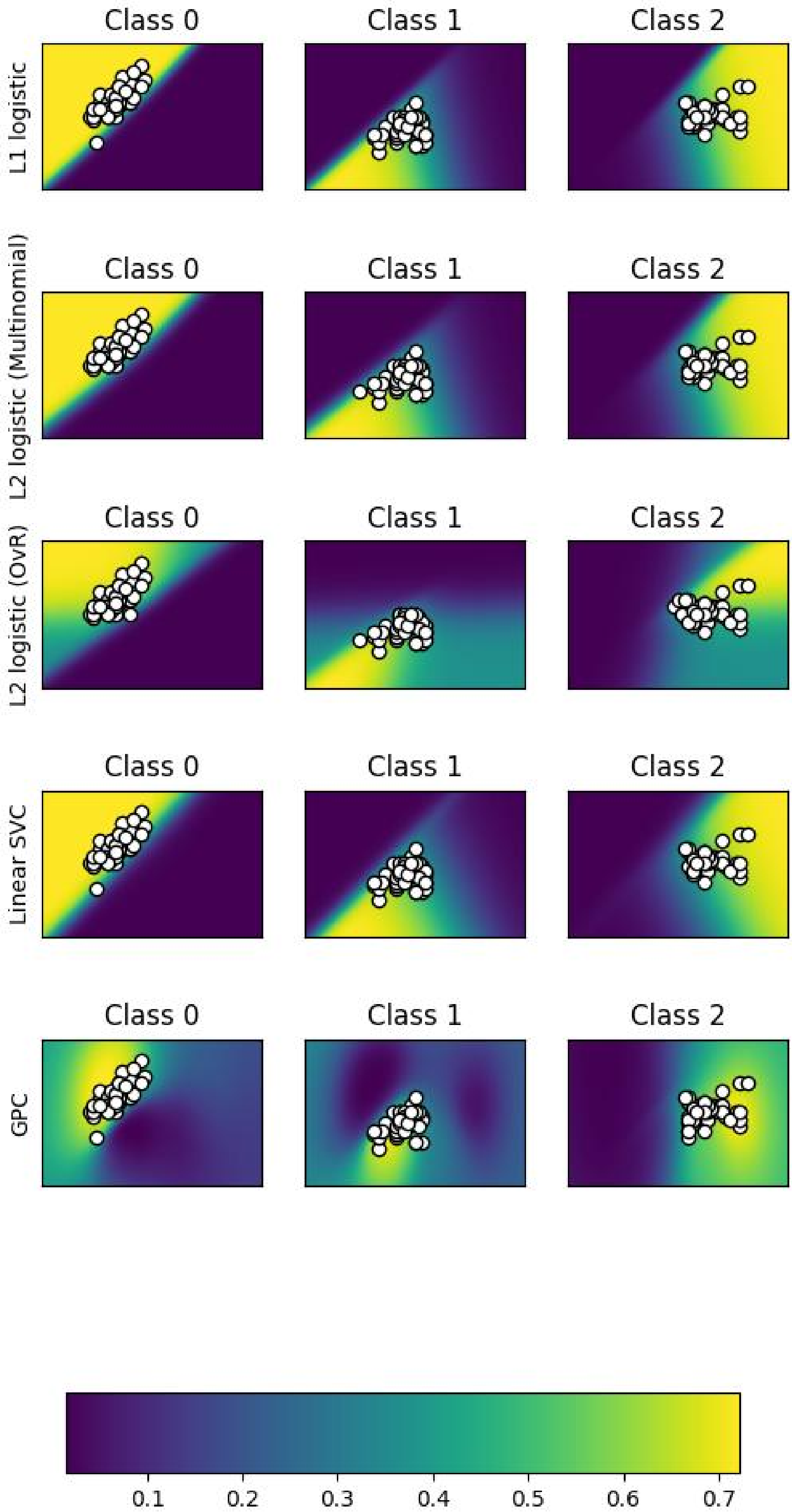

Figure 12. Building a Garden Landscape Function Optimization Process using Keras

5. Conclusion

This paper takes Chinese landscape gardens as an example to study the expansion of landscape functions in Chinese landscape gardens, discover their common problems by studying the same type of landscape gardens, and propose corresponding planning and design strategies to guide the planning and construction of Chinese landscape gardens. The basic needs of users reflect the internal factors of garden context creation, while culture is its external factors, the two are inseparable and complementary, and should be taken into account. In addition, when combining user needs and culture to create the garden context, we should not ignore the ecological benefits, but pay attention to the ecological benefits, cultural values, and user needs of the three aspects of the integration, coordination and balance.

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Conflict of interest

The author declares no conflict of interests.

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