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Research Article

Digital Planning and Design of Landscape Based on Intelligent Sensor Network

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According to the development of landscape digitization and the actual market demand, a digital landscape system based on intelligent sensor network is designed and implemented. The system consists of two parts: sensor node and display terminal, forming a star intelligent sensor network. Sensor node measurement is sent to display control terminal through intelligent sensor network. The display control terminal serves as the aggregation node. Based on geometry transformation, free form, and bionics, the method of constructing complex surface and the method strategy of optimizing complex surface are put forward from geometry and bionics theory. Then, the material types and construction methods of landscape composite surface are discussed and studied. According to the process and project of site cognition and landscape planning and design, six special models are established: ecological sensitivity evaluation model, construction suitability evaluation model, project site selection model, road line selection model, quasinatural waterscape construction model, and vertical design model. According to the characteristics of each landscape planning and design project, the logic generation and parameter composition of the model are discussed, and the application of the model is empirically studied and discussed based on actual cases.

1. Introduction

With the advent of the digital era, the form and connotation of design have undergone significant changes, and the concept of design is also constantly changing. Modern design is the organic combination of science and art and technology and human nature; there is no correlation between one and the other, so it is not one-sided. The progress of science and technology and the development of scientific theories provide a scientific platform and means for design and promote the design industry to be rational from another aspect [1]. The emphasis on rationality shows that practitioners in the field of design take a more mature view of design and explore the essential laws and methods of design. To grasp things with a rational attitude is a dynamic way of development, which is also in line with the complexity and systematic needs of living environment subjects. Landscape design has the dual attributes of art and science, always walking between sensibility and rationality. Facing the changing trend of contemporary design from sensibility to "rationality and sensibility interwoven," it is inevitable to seek theories and methods in the new era for the development of landscape planning and design.

Sensor network is composed of many on the space distribution of automatic device of a computer network, collaboration [2] by sensors, microchip processors, wireless sensor network node interface, and the power of four modules. Compared with general sensors, intelligent sensors have the following three advantages: through software technology it can achieve high-precision information collection and low cost, with a certain degree of programming automation ability [3], function diversification. Intelligent sensor network is a computer network composed of many spatially distributed intelligent sensors, which can realize high-precision information acquisition and share the huge amount of data processing in the network with intelligent sensors. A number of intelligent sensors can be composed of high-precision, powerful red energy measurement and control network

and low cost, easy installation, configuration, upgrade, and maintenance.

Corresponding to the planning and design mechanism of digital landscape architecture, the model is the prototype of specific methods and paths. Aiming at the process of digital landscape planning and design based on coupling principle, this paper discusses the digital evaluation of landscape planning and design and the construction of planning and design model. The digital evaluation model includes ecological sensitivity evaluation model and construction suitability evaluation model. The digital planning and design model consists of four parts: project positioning model, road route selection model, waterscape construction model, and vertical design model. From ecological sensitivity model to vertical design model, it is consistent with the process of design promotion, interlocking and with feedback upon each other. The model reflects the logic of the algorithm. The research of this paper focuses on the construction of the above six digital models, and ArcGIS and Civi13D are selected as the platform of model operation. Combined with engineering examples, the practical application of digital model in planning and design is explained in detail.

2. Related Work

Chaos theory, system theory, emergence theory, and fractal theory have exerted great influence on modern architectural theories and methods. Under the background of the great development of computer and information technology, architecture has entered the digital era together. A group of architects have actively explored digital design and construction. Academic circles have shown unprecedented enthusiastic response to the advent of the digital era. Many famous universities have carried out research, application, and practice of digital technology in architecture and planning and achieved fruitful results [4]. Landscape architecture is a compound discipline that coordinates the relationship between man and nature. It is both artistic and scientific. It requires scientific analysis and establishment of all objective elements related to it, and art is also required to describe and carry specific semantic meanings of places [5]. The complexity of objects and targets has more or less resulted in the slow adoption of digital technology in the landscape architecture industry compared to architecture and urban planning.

This paper discusses the application and trend of digital technology in landscape design and successively discusses 3D model and visual technology in landscape design [6, 7], communication and collaboration in landscape planning and design [8], digital methods developed in geographical design [9], landscape planning and design of systematic thinking [10], and other digital landscape themes. In the conference held, we discussed on Representing, Evaluating, and Designing Landscapes: Digital Approaches [11]. In recent years, they gradually shift their focus to using digital technology to solve the practical problems of landscape architecture. Under the framework of digital technology, a heated discussion on landscape information modeling (LIM) and GeoDesign (GeoDesign) has emerged [12]. The proposed concept of building information modeling (BIM), design and construction innovation, Building Information Modeling-Transforming Design and Construction to Achieve Greater Industry Productivity pointed out: BIM is a process of designing, constructing, and operating a project using digital information model [13]. BIM has become a hot topic in the field of architecture, and how BIM can be applied in the planning and design of landscape architecture has been discussed in the field of landscape architecture. Some scholars believe that BIM cannot support the study of large-scale environment and is not good at site design [14], so they put forward the concept of LIM. LIM is similar to BIM in terms of concept and connotation. For landscape architecture projects, LIM focuses on a relatively large scale. LIM is a practical technique and tool for collaborative design and life cycle management through the creation of digital information models; as a systematic solution, part of the digitalization ideas and technologies is included [15]. Geographical design adopts multidisciplinary comprehensive research and provides a unified platform for communication in these fields through information technology, which is used to solve outstanding problems through optimization of geographical location and orientation at regional and global scales. Taking site design into account is the basis of geographical design research and development [16]. As a response to the "geographic design framework," the biggest highlight is that it can realize the rapid iteration of the "geographic design process change model." A number of scholars around the world have carried out research on geographical design, and several thematic conferences have been held at home and abroad [17]. In literature [18], related concepts of digital strategy of landscape architecture are elaborated, major digital design methods and application software platforms are analyzed, and flowcharts of digital planning and design of landscape architecture are summarized. He pointed out that the digital process of landscape architecture planning and design can be subdivided into four basic steps: environmental cognition, design construction, design evaluation, and design media, including environment space simulation of landscape architecture, analysis technology: simulation and prediction of plant landscape; numerical analysis and evaluation of landscape architecture ecology; landscape planning, design, and management information system; theory and technology of digital generation and digitization in landscape architecture planning and design; landscape planning and design visualization and digital simulation technology, virtual reality technology; digital construction technology of landscape architecture; BIM application in landscape architecture; numerical evaluation method of landscape architecture; numerical control construction system; innovative digital technology, interdisciplinary research in digital technology, experimental design, and construction; and landscape architecture theory in digital age. Literature [19] discusses the auxiliary role of computer technology in landscape planning and design from three aspects: geographic information system, eco-aided design technology, and model construction. From the perspective of the current research situation, the research on geographical design is still in its infancy, mostly focusing on the definition of its concept, the framework and the

discussion of possible content, and the prediction of the future development trend. There are few concrete empirical studies and few practical applications.

At present, domestic ZigBee technology and intelligent sensor network technology combined with the application of intelligent landscape research are more and more common. For example: (1) combining the characteristics and advantages of ZigBee technology and GPRS technology, a wireless ZigBee sensor network capable of remote monitoring of the water environment in the field was realized [20]. And the solar power supply system is applied to the network; the ZigBee network in the system is a tree network, using the air temperature and humidity sensor, soil moisture sensor, rainfall sensor to detect environmental information, using Delphi 7.0 programming environment to develop upper computer monitoring software. (2) Design an intelligent sensor network based on CC2430 to automatically control the landscape system [21], which can monitor abundant environmental information, such as soil moisture, environmental temperature, and illumination, and transmit the information sent by the sensor to the processor in combination with the sensor fusion technology to make accurate judgment of irrigation behavior. (3) Build a ZigBee intelligent sensor network-based landscape control system, focusing on the AD (Altium Designer) hoc network process of intelligent sensor network [22, 23]. The node uses the competition mechanism in the channel for communication channel, each node periodically in a state of sleep and to monitor channel switching, when nodes be wakened from sleep began scanning around each node, until the monitoring signal to other nodes, first of all nodes to establish a list of adjacent nodes, then there will be a signal of node address added to the list. Ad hoc networking is reflected in that nodes update the routing list and reselect routes at an interval, thus forming the topology of the entire network [24]. Intelligent sensor network is a distributed network system composed of a large number of sensor nodes that integrates monitoring, control, and wireless communication functions [25]. The basic purpose of network design is to collaboratively perceive, collect, process, and transmit the monitoring information of perceived objects in the geographical area covered by the network and report it to users [26]. Intelligent sensor network has many nodes and limited energy and requires long-term work. It has the characteristics of large network scale, self-organization, self-maintenance, low rate, low power consumption, low cost, and short distance. Intelligent sensor network, supported by microelectromechanical technology, embedded technology, and communication technology, has become one of the fastest developing wireless network technologies and plays an important role in the era of Internet of Things.

3. Research on Landscape Planning Model Based on Intelligent Sensor Network Analysis

3.1. Intelligent Sensor Network Architecture. A typical smart sensor network is shown in Figure 1. A large number of sensor nodes are densely deployed inside or on the edge of the monitoring area to perceive the information of the monitored area, conduct preliminary processing, and transmit it to the sink node. According to different network topologies, sensor nodes may communicate directly with sink nodes or transmit data to sink nodes in the way of multihop relay. The sink node sends data to the management node through the mobile Internet or the Internet. Users can manage and configure the sensor network, view the collected monitoring data, and publish monitoring tasks through the management node.

Smart sensor node is the basic functional unit of wireless sensor network, and its processing ability, storage ability, and communication ability are relatively weak. In multihop networks, each sensor node has the dual functions of terminal and router in traditional networks. In terms of hardware composition, sensor module can be divided into sensor module, processor module, communication module, and electric-only module, as shown in Figure 2.

The power module provides power for the sensor node and other modules. Sensor nodes are generally powered by miniature batteries. For energy-saving and cost considerations, embedded processors with low power consumption and low cost are usually selected. Based on actual monitoring task requirements, determine whether to transplant an embedded operating system for task allocation and scheduling, a dedicated network management device with more adequate energy supply, memory, and computing resources or a wireless communication interface without detection function. According to different requirements, the topology of wireless sensor network is different, and the realization form of sink node is different. In general, the sink node selects the CPU with strong performance, rich hardware resources, and stronger processing capacity, storage capacity, and communication capacity than the sensor node. For simple tasks, the sink node uses a single program (no operating system) for software design. For some special applications, such as extremely complex functions or high concurrency of control logic, you can transplant an appropriate operating system to allocate hardware and software resources and schedule tasks of the entire device to ensure system reliability and stability.

3.2. Optimization of Complex Surface in Landscape Design. Before the optimization of complex surface, it is necessary to analyze the characteristics of the surface to be optimized, including the analysis of the curvature of the surface, the analysis of the continuity of the surface, and the analysis of the structure of the surface. Curvature and continuity can be visualized in the form of maps. The analysis of complex surface is a necessary stage, which is the process of checking surface quality. Through this process, we can find the defects or defects of surface structure and optimize the surface according to these defects or defects so that the surface can meet the construction requirements.

The concept of surface continuity is proposed for spliced surfaces. The quality of interfacing between surfaces affects the smoothness of surfaces. In general, the geometric continuity of surface can be roughly divided into five degrees, respectively, G0, G1, G2, G3, and G4. From G0 to G4, the

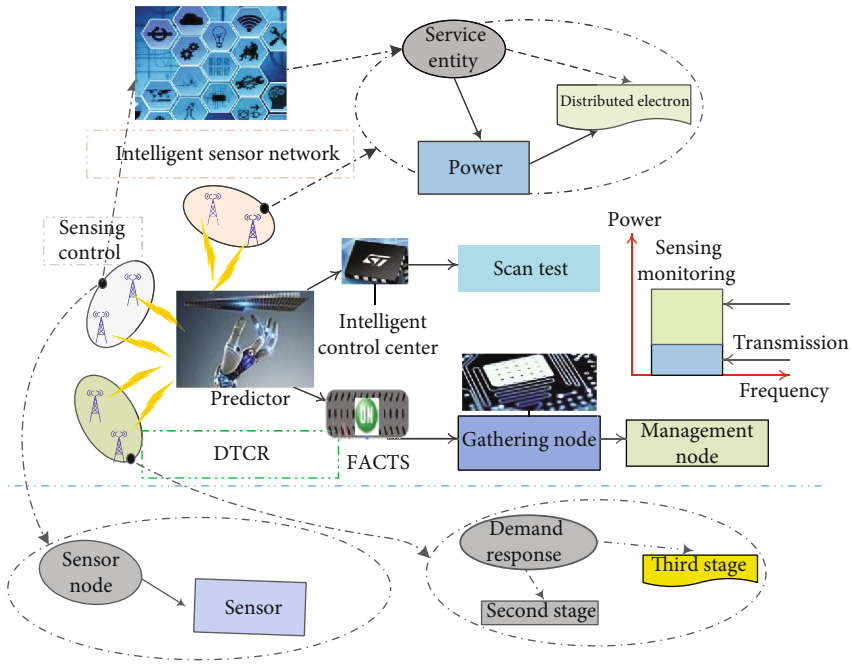

Figure 1: Architecture of intelligent sensor network.

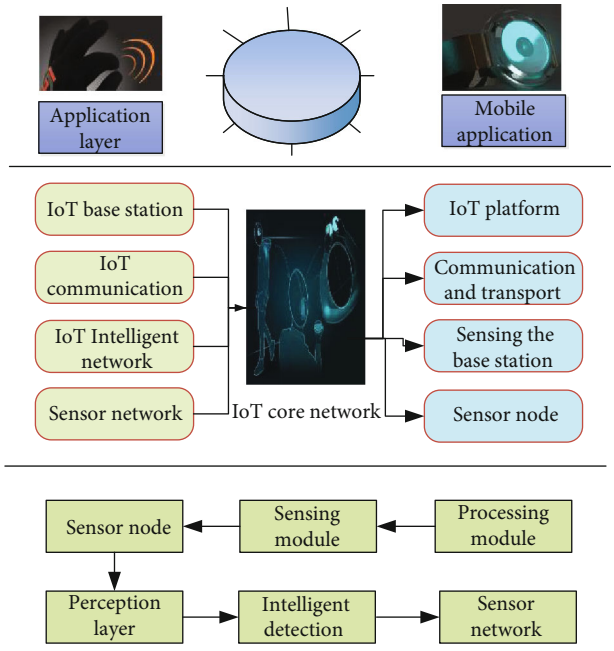

Figure 2: Sensor node composition.

smoothness of surface connection becomes higher and higher, and the precision of surface modeling is also higher and higher. G0 refers to the continuity of dots on the curve or surface, no breakpoint in the middle of the curve, and the surface is connected but has obvious joints. G1 means that the dots on a curve or surface are continuous and all connected curves or faces are tangent. G2 means that the dots on the curve or curve are continuous, and the curvature at the contact points of the curve or surface is the same: G3 and G4 are more complex, involving higher-order curves, and their curvature change rates are continuous. Some industrial products are required to achieve the accuracy of G3 and G4. Compared with industrial design, landscape design has a larger scale. From the perspective of construction and crowd use and visual experience, the continuity of music I (I) is not required to be very high, and generally, the accuracy of G3 and G4 is not required (Table 1).

The paradigm and model together form the basis of understanding the planning and design mechanism of digital landscape architecture and explain the planning and design of digital landscape architecture from the theoretical and technical aspects, respectively. See Figure 3.

The traditional design process mainly relies on the designer's experience and feelings: first of all in your mind for design of general conception and strategy and then manually sketch map, using the 3D design software modeling of the preliminary program, in the process repeatedly, adjust and modify the plan, and in the solution after the final drawings. This design process is divided into several stages. Only after the completion of the previous stage can we enter the next stage of work. There are relatively clear boundaries between the processes. At the same time, due to the fact that the design completely depends on the experience of the designer which will inevitably reflect a strong personal will, it is difficult to fully reflect the situation of the site, the design process is ambiguous, and the design results are subjective. The introduction of digital models has changed that. Relying on the digital model, the designer determines the factors affecting the design as parameters, connects the elements of the design system through the construction of the model, describes the design process, and finally controls the generation of the final design result by adjusting the parameters with the computer platform. This design approach is based on process logic thinking and is more rational and accurate,

Table 1: Comparison between the degrees of continuity of surfaces.

Surface continuity	G0	G1	G2	G3	G4
Characteristics	Position to contact	Tangent continuous	Continuous unsmoothness	Curvature	Curvature
Curvature	Discordance of direction	Curvature lines break in the same direction	Curvature line position continuous	Curvature line position continuous	Curvature line position continuous
Explain		Continuity of derivative	Second-derivative continuity	The third derivative is continuous	
A zebra crossing	Staggered discontinuity	Continuous corner	Continuous and smooth	Continuous and smooth	Continuous and smooth

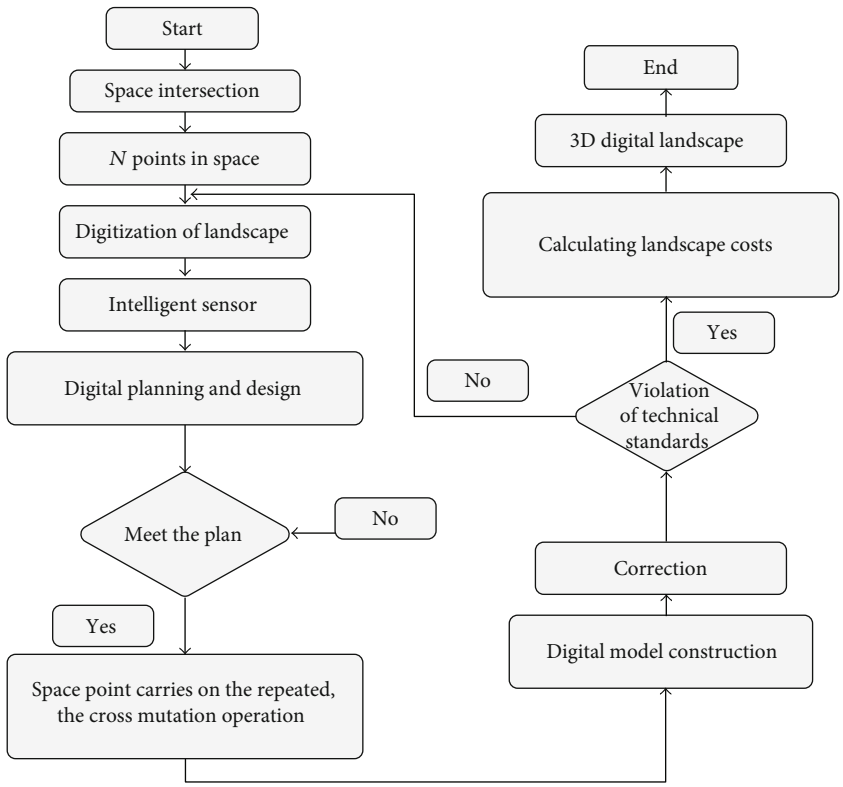

Figure 3: Digital landscape planning and design mechanism diagram.

considering the actual situation of the site and the role played by various elements of the system in the design.

Modeling research is closely linked to the needs of qualitative and quantitative research in landscape architecture. There are two kinds of relations between qualitative and quantitative research in the research method of combining qualitative and quantitative research. The first is the time relation, which refers to the sequence of occurrence of both in the research. The second is the primary and secondary relationship, that is, the primary and secondary methods used in the research. Therefore, there are three types of mixed research methods: one is sequential; qualitative research and quantitative research are in the same position, including qualitative to quantitative, quantitative to qualitative, and both simultaneous use; the second is the primary and secondary type, including qualitative, quantitative, and vice versa; the third is the comprehensive model, namely, the above two kinds of mixed, multilevel use. The model of digital landscape planning and design embodies the comprehensive relationship between qualitative and quantitative methods. Qualitative and quantitative methods appear alternately and complement each other in the operation of the model.

4. Construction of Digital Landscape Planning and Design System Based on Intelligent Sensor

The design of landscape architecture not only refers to the surrounding of a certain structure, a certain space, a certain

plant community, and some independent pieces but also for things in a certain regional scope; not only planners and landscape architects are needed but also ecological experts, soil experts, geographers, etc., to gather information from different fields. It not only applies landscape architecture, ecology, and planning but also integrates various disciplines for guidance. The integrated theory of landscape architecture design is the life cycle process in the planning and design process. Landscape architects should grasp the whole process of design projects from preliminary design, preliminary design to design construction and management, and integrate them into management. Even if the designer is only involved in one part of the design, when the whole project design is integrated, the information transmission should reduce a lot of unnecessary mistakes and waste.

(1) Digitally express the physical and functional characteristics of a facility

(2) A shared knowledge resource

(3) The process of sharing information related to the facility and providing a reliable basis for all countermeasures throughout the life cycle of the facility

(4) In the different stages of the construction project, the participants support and reflect the coordination of various responsibilities by embedding, extracting, updating, and modifying information in the information model

In order to achieve the design effect of "digital landscape" presenting perfect landscape image, designers should collect, measure, and record relevant environmental, natural, and human activity data, including terrain, landform, elevation, rivers, lakes, hills, types, and quantity and quantity of ground buildings and plants. Natural data include air quality, soil properties, snow and rain, wind, light, and other data; human activities include crowd, behavior, business, assembly, production, and other data. "Digital landscape" must digitize these data, and this process is digital landscape information collection. It is the image, video, sound, text, and related landscape information for digital processing or through digital equipment (such as digital camera, video camera, and scanner) the image, sound, text, and related landscape information digitization and in accordance with certain rules, classification of the establishment of information database, recorded in memory, for future analysis, evaluation, production, design, planning, and management services.

In addition to the characteristics of iteration, systematicness and nonlinearity are also important characteristics of modern landscape planning and design process. System analysis is to regard all elements in the landscape site as interrelated whole and pay attention to the analysis of the correlation between elements on the basis of independent analysis of elements. Comprehensive judgment is based on the results of system analysis, after integrated analysis, weighing each element to make a design judgment. System analysis and comprehensive judgment are dialectical unity; system analysis is the premise of comprehensive judgment; only through analysis can we provide the basis for the design to solve problems and deepen the understanding of the design. Comprehensive judgment is the summary, induction, perfection, and improvement of analysis. The interaction between the two activities is described above. The discussion about linearity and nonlinearity originated in nature, and for a long time, the study of nature was limited to linear methods. However, the achievements of natural science show that human beings are faced with a complex nonlinear world, not only linear can be covered. The discussion of nonlinearity quickly extends to all fields, and the design world is no exception. Landscape architecture planning and design are faced with a complex nonlinear world, so it is necessary to treat design problems with nonlinear thinking. Nonlinear thinking brings complexity of design process and nonlinearity and uncertainty of design result. The open and uncertain design results bring about multiple solutions, but the final implementation of the scheme is really unique. It is difficult for designers to judge the quality of the scheme simply through subjective evaluation, so the selection and evaluation mechanism in the regular design process is inevitable and necessary. Figure 4 shows the design process of digital landscape planning of intelligent sensor network.

From Figure 4, the six special models correspond to the main special design content of landscape planning and design, which belong to the process of digital landscape planning and design and have close logical connection. A special study is aimed at more clearly analyzing and interpreting the digital design process, guided by various special models for building intelligent sensor networks, realizing each special "coupling" and manifesting the connection between special designs and site, but also reflected in the tracking and coordination between different special process, unified in digital landscape planning and design system.

5. Example Verification

At present, the road route selection methods based on ArcGIS software platform are mostly used in the study of highway route selection problems of transportation majors. Most of them are based on digital elevation model (DEM), using cost distance algorithm tools to calculate, combined with genetic algorithm and other methods to carry out auxiliary optimization of route selection. Whether the cost distance algorithm can be applied to road route selection in landscape environment is worth further discussion and research.

The first step of constructing digital landscape planning and design road route selection model based on intelligent sensor network is to determine the primary and secondary factors influencing road route selection in the site, determine the cost of secondary factors, and determine the weight of impact factors through Delphi method, analytic hierarchy process, and other evaluation methods. The second step is to make each factor dimensionless and assign values through the reclassification function of ArcGIS software. The third step is to make use of the superposition analysis function to superimpose the cost graph of second-level and first-level factors in turn to obtain the comprehensive cost graph. The last step is to use the shortest path analysis tool of ArcGIS software to calculate the optimal path. Because road

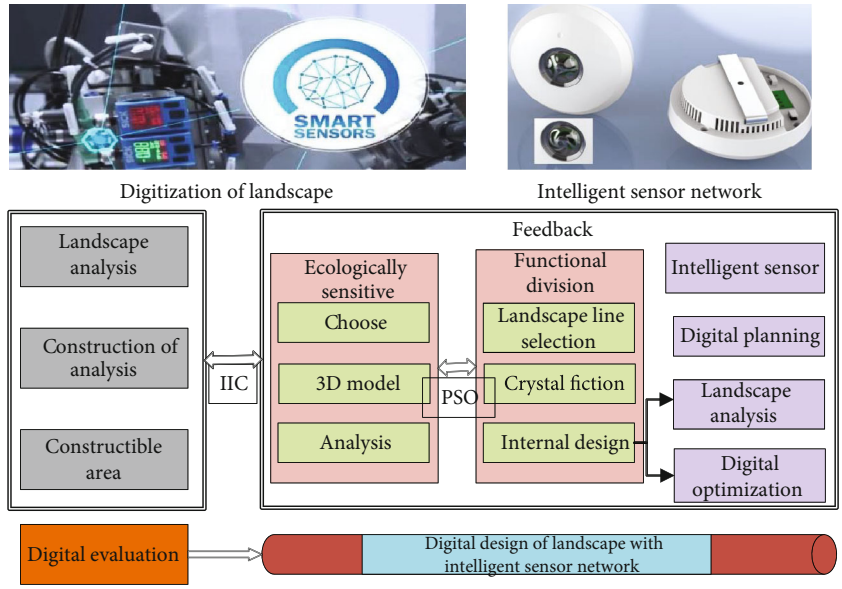

Figure 4: Landscape architecture digital planning and design process based on intelligent sensor network.

alignment is a complex system problem, it is not possible to obtain the optimal road alignment scheme completely by a computer. After determining the initial route selection scheme, it is necessary to optimize the road alignment scheme in the way of human-computer interaction, which is also one of the important steps in the process of road selection. According to the above process, the variables involved in this model include influence factor, grading, and grading assignment. The following is to study and discuss the line selection results generated by different parameter inputs of the above three variables. The hierarchical comparison of the comprehensive cost map in this paper is reflected in the comparison of grade 3, grade 6, grade 9, and grade 12 of slope single factor cost, as shown in Figure 5.

In order to analyze the difference of spatial heterogeneity of each landscape type with scale change, the slide-frame algorithm was used to calculate the voidness index of each landscape type in 1987 and 2003, and the double natural logarithmic curve was made, as shown in Figure 6. As can be seen from the void index curves of 1987 and 2003, the void index values and curve shapes of different landscape types in 2003 changed greatly compared with 1987, that is, the void index of 2003 decreased to different degrees compared with 1987, and the size order and curve shapes of different landscape types were different. It indicates that the spatial heterogeneity of landscape pattern has changed greatly in the past 16 years.

Through the intelligent landscape network distribution mode, design a variety of viewing guide routes (guide theme), dynamically analyze the mutual information difference between each viewing path and landscape network resource layout, and increase the experience of visitors. Four tourist routes were selected in the experiment, and the distribution of emotional factors of landscape routes is shown in Table 2.

Emotional variation factors (emotional edge and emotional node changes) were obtained randomly, and the emotional regulation items were gradually expanded from 50 to 600. The applicability detection curve of landscape network resource items was calculated as shown in Figure 7, which was used to judge the effectiveness of landscape elements after they were put into ornamental activities.

(1) In dynamic path landscape planning and design, the initial emotional magnitude of electric "novelty" landscape route is not the largest, but with the regulation of emotional variation factors, it can improve the landscape viewing efficiency

(2) In the design of landscape sightseeing routes, the rationality of sentiment difference and landscape route design can be obtained through emotional observation, and the most satisfactory sightseeing routes can be designed for customers by combining the characteristics of emotional changes

6. Conclusion

This article is based on the guidance of intelligent sensor network to the digital landscape architecture planning and design process as the main body, building the system of digital landscape architecture planning and design, including the six interrelated special model; the digital landscape architecture planning and design process was described in detail: starting from the place of cognitive, in the workplace, on the basis of full research and information collection, quantifiable elements obtained from analysis are transformed by software calculation and analysis algorithm to form variables and parameters, which accurately describe various environmental factors and reflect the place faithfully. According to the characteristics of each design, such as type and target, appropriate special design model is selected to build the association between design elements and site conditions. The generated parameters are input into algorithm

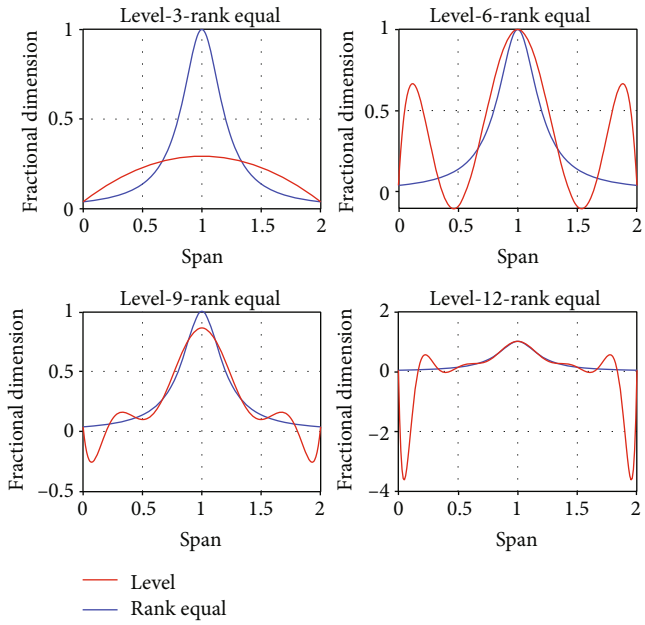

Figure 5: Line chart of assignment growth corresponding to different numbers of grades.

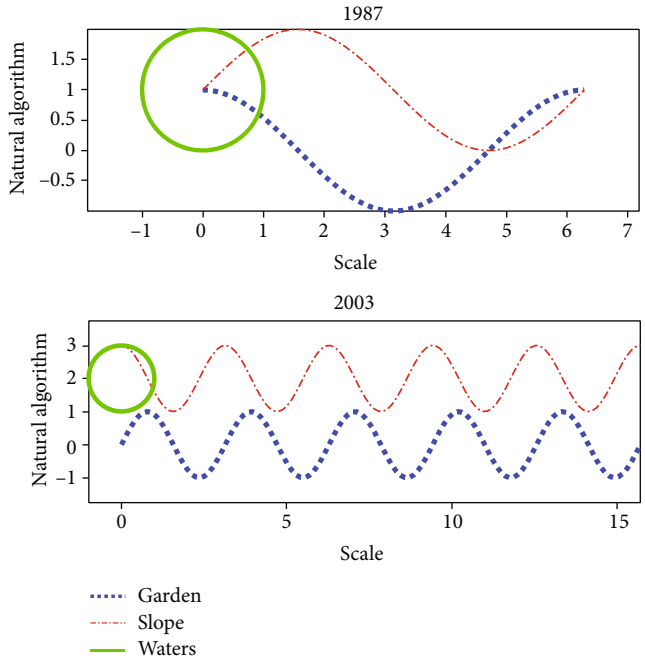

Figure 6: Voidage curves of different landscape types.

Table 2: Composition of mood factors of landscape routes.

Landscape line	$Z1$ such emotions	$Z2$ such emotions	$Z3$ such emotions	$Z4$ such emotions
1	60	20	25	15
2	15	50	35	25
3	15	15	20	30
4	10	15	20	30

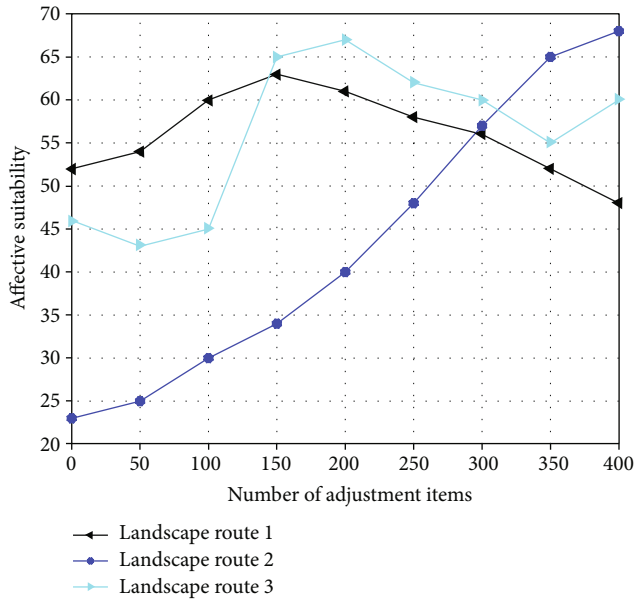

Figure 7: Suitability test curve of tour routes.

software and auxiliary design software, and the design result is finally formed, which is presented in the form of full data model. In the design evaluation stage, the data model can be analyzed and evaluated by means of digital analysis, and the results of analysis can be fed back to the design for further adjustment and optimization. The parametric vertical model of landscape architecture embodies all elements of vertical design in the same digital terrain model and constructs the dynamic relationship between elements. Starting from the three main components of the vertical design of road, water system, and site and taking earthwork balance as the vertical optimization target, the construction of parameter vertical optimization model will be the next research focus.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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