Intelligent CAD Modeling and Reinforcement Learning Application in Environment and Landscape Design

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Abstract. With the rapid development of modern technology and computer technology, the concept of environment and landscape design has undergone revolutionary changes. With the rapid development of new technologies, the detailed control that was difficult to carry out in environmental and landscape design has been quickly solved. However, in the process of designing the structure, the designer still uses traditional design methods and tools, which have great limitations. Therefore, based on CAD intelligent modelling and reinforcement learning algorithms, this paper studies the environment and landscape design. Firstly, the development of computer-aided intelligent modeling and reinforcement learning applications at home and abroad is introduced. The advantages of CAD intelligent modelling technology in environment and landscape design are emphatically analyzed. From the perspective of environment and landscape design, the three-dimensional modelling and rendering of landscape scenes are analyzed. From drawing generation, color, texture research, and other schemes to completing the algorithm comparison. Finally, with the help of a reinforcement learning algorithm, the structure optimization path is proposed to explore the spatial distribution and planning of landscape design. To improve the design and planning efficiency of the reinforcement learning algorithm to adapt to the unknown interference environment faster, similarity samples are proposed to complete the anti-interference calculation. The results show that the application of CAD intelligent modelling and reinforcement learning algorithm makes the generation of environment and landscape design more in line with the requirements of modern construction. The scene rendering effect is good, and the optimization of landscape planning reflects the intelligent design development concept.

Keywords: Environment and Landscape Design; Intelligent Generation; CAD Modeling; Reinforcement Learning Algorithm; Planning and Design
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1 INTRODUCTION

With digital technology sweeping the world today, urban construction and environmental landscape design are ushering in unprecedented development opportunities [1]. The introduction of digital concepts has brought a new way of thinking and creative means to environment and landscape design. More and more designers use big data, the Internet of Things, artificial intelligence and other high-tech to achieve landscape design optimization and support precision services [2]. It not only improves the living experience of experiencers but also enables intelligent design to coexist harmoniously with people [3]. Therefore, an intelligent-oriented environment and landscape design planning are not only conducive to promoting the innovative development of urban construction space but also an important way of sustainable development of green landscapes [4]. Intelligent technology and computer-aided tools play multiple roles in landscape design, both as disseminators of information and carriers of culture. Designers use computer-aided tools to add regional culture into environment and landscape design, enhance the cultural connotation of landscape works, and provide the public with a richer experience [5]. The new model of interactive environment and landscape design enables the experient to intuitively feel the history, culture and artistic atmosphere of the city in a multi-dimensional space, and deepen the cognition and understanding of the urban characteristics of a certain region. Environment and landscape design plays a core role in contemporary urban construction, which is not only a bridge between humans and nature, but also promotes commercial activities [6]. Under the guidance of modern digital concepts, more and more interactive landscapes have become an important standard for spatial planning. Through the combination of these environments and landscapes, designers show the culture and heritage of the city. The intelligent landscape design scheme reflects the history and social customs of the city in its unique style. At the same time, the new construction of landscape design also transforms the commercial space into an open place integrating entertainment, culture and social interaction, which not only improves the efficiency of space use but also demonstrates its rationality [7].

Intelligent CAD (Computer Aided Design) modelling technology not only greatly improves design efficiency and accuracy but also achieves intelligent generation and optimization of design schemes through the integration of big data analysis and artificial intelligence algorithms. Through highly realistic 3D rendering technology, designers can observe in real-time the visual effects and functional performance of different design schemes under different seasons and weather conditions, enabling rapid iteration and optimization. In the stage of landscape maintenance and management, the reinforcement learning system can automatically adjust the configuration of landscape elements based on real-time monitored environmental data, such as soil moisture, air quality, tourist flow, etc. By combining user behaviour data such as travel routes, dwell times, satisfaction surveys, etc., reinforcement learning models can learn and predict user preferences [8]. Based on diverse information such as terrain data, vegetation distribution, and climate conditions, the intelligent CAD system can automatically generate preliminary landscape design drafts that comply with ecological and aesthetic principles—integrating key indicators in visual perception research, such as colour matching, spatial layout, and landscape element diversity, into CAD models and simulating human visual experience through algorithms to provide the scientific basis for design decisions. Reinforcement learning, as a machine learning technique that learns optimal behavioural strategies through trial and error, has enormous potential for application in environmental and landscape design. Such as irrigation strategies, vegetation pruning plans, etc., to achieve optimal resource allocation and continuous improvement of landscape quality. In complex landscape design projects, it is often necessary to consider goals from multiple dimensions, such as ecology, economy, and society. Reinforcement learning algorithms can handle such multi-objective optimization problems. Further guidance will be provided on the adjustment of the design scheme, creating a more humanized and interactive landscape space. By constantly trying and adjusting, find the best balance point between various goals [9].

Landscape design is a scientific field closely related to society and ecology. It involves changing terrain, transplanting plants, repairing buildings, and decorating roads to create a leisure environment in which people and nature coexist in harmony in a certain area. Environmental and landscape design usually uses a variety of design software to complete the blueprint of landscape planning. With the development of computer technology, computer-aided landscape design has gradually become the mainstream due to its convenient and time-saving characteristics, and it is also a key factor affecting the quality of environmental and landscape design drawings. Computer-aided CAD technology has a powerful creative and visual impact [10]. With convenient modification and quick drawing, it has become a core tool in environment and landscape design. In addition, in landscape design spatial layout planning, people also use reinforcement learning algorithms to explore the optimal solution generated by the path, to simplify the environment and landscape design process. It is convenient for construction personnel, designers and residents to complete the convenient communication of tripartite integration. Nowadays, more and more environment and landscape designs are integrated into CAD computer-aided modelling and reinforcement learning algorithms. On this basis, this paper also uses the two aspects to study drawing generation, data management, environmental rendering, spatial planning and other aspects of environment and landscape design.

2 CAD TECHNOLOGY AND REINFORCEMENT LEARNING APPLICATION DEVELOPMENT STATUS

At the beginning of the 20th century, Western countries led by the United States began investing in research on computer rendering. Simple drawing tools were no longer sufficient to meet the needs of social development at that time, until the emergence of computer-aided CAD technology and graphic processing systems in the middle and later stages, and computer-aided design scheme generation officially entered the historical stage. Meanwhile, the surface technology of CAD is combined with various sensing devices, allowing designers to interact with computers through external devices. Subsequently, a gradually improving CAD system began to take shape. So far, it has been able to produce realistic graphic scanners, complete 3D and multi-space drawing adjustments, and gradually become popular in major enterprises and fields. With the development of CAD technology towards standardization and intelligence, Stupariu et al. [11] analyzed the software interfaces related to this technology. This provides certain assistance for the transformation of CAD technology to achieve comprehensive functions. The introduction of artificial intelligence and expert systems has greatly improved the solving ability of CAD systems. From a societal perspective, computer-aided CAD modelling systems have become powerful tools in the information age and have fully penetrated various construction industries. It is not only a simple application of computer and digital technology in design, but also brings profound changes to design structure and operation. It can meet the public's participation needs and facilitate interaction between homeowners and designers. At present, there are many mature CAD modelling systems in China. These computer-aided drawing systems can perform many functions, such as mechanical design, 3D geometric modelling design, and data management. They are multifunctional system modules based on parameterized integrated processing. Xia et al. [12]'s CAD modelling system tends towards superior parameterization and convenience, which also enables CAD software to shift from 2D drawing to CNC programming and other industries.

Intelligent CAD modelling technology provides strong support for the precise design and aesthetic evaluation of forest landscapes. Automatically adjust management measures such as irrigation, pruning, pest control, etc., based on this information to maintain and improve the aesthetic quality of forest landscapes. By integrating high-resolution terrain data, vegetation distribution maps, ecological simulation models, and human perception research results, intelligent CAD systems can generate highly realistic 3D forest landscape models. For example, during the forest maintenance phase, reinforcement learning systems can monitor the real-time status of forest ecosystems, such as soil moisture, vegetation growth status, and tourist behaviour patterns. These models can not only be used to showcase the aesthetic effects of different design schemes but also to simulate visual experiences under different seasons, weather, and perspectives, helping

Xu and Wang [13] better understand the interactive relationship between landscape dynamics and human perception. In addition, CAD models also support user-defined parameter adjustments, allowing designers to intuitively explore the impact of different design variables on aesthetic quality, thereby achieving design optimization. Reinforcement learning technology, with its strong adaptability and optimization capabilities, has shown great potential in the continuous optimization of forest landscape aesthetics. During the evaluation phase, intelligent CAD models can serve as input data sources for machine learning algorithms, automatically extracting landscape features such as species diversity, tree density, and canopy structure to provide accurate data support for aesthetic quality prediction models. By defining clear reward mechanisms, such as aesthetic quality ratings based on user satisfaction, ecological health, or economic benefits, reinforcement learning algorithms can learn how to find the best landscape management strategies in complex and constantly changing environments. Zeng et al. [14] can build a comprehensive and intelligent forest landscape aesthetic evaluation and optimization platform by combining intelligent CAD modelling, reinforcement learning, and human perception-based machine learning techniques. In addition, the platform can also be combined with graphical user interface tools to provide the public with an intuitive forest landscape exploration and experience platform. Meanwhile, the system can continuously optimize management strategies based on user feedback and changes in ecological data, ensuring the long-term sustainable development of forest landscapes. This platform not only enables precise design and aesthetic evaluation of forest landscapes but also provides scientific decision support for forest managers through continuous learning and optimization, promoting the sustainable development of human ecosystem services. Users can browse forest landscapes from different regions through this platform, understand their aesthetic features and management strategies, and even participate in discussions on landscape design. This not only enhances public awareness of the ecological value of forests but also promotes the popularization and improvement of environmental awareness.

In recent decades, artificial intelligence has made significant progress, with machine learning being the fundamental method and reinforcement learning being a branch of machine learning. This concept was first proposed by American scholars in the 1950s, and in the 1980s, reinforcement learning theory made breakthrough progress in various basic aspects of research data. Nowadays, reinforcement learning has become a popular research topic in fields such as artificial intelligence and automatic control. Reinforcement learning, as an interactive learning method, has the characteristics of action search and delayed return. This is a learning process that maps environmental states to actions. It is now known that Japanese and other related researchers typically use reinforcement learning algorithms to construct environmental models. The dynamic programming calculation of reinforcement learning algorithms, combined with various functions such as priority scanning, eliminates the non-updating state in traditional strategy iterations and plays a good role in environmental and landscape design planning. Reinforcement learning algorithms can converge to the optimal strategy in design planning, providing reliable parameter assistance for planning and design. In addition, Zhao [15] also uses a new heuristic function model to update and optimize reinforcement learning applications to improve planning efficiency. This method of reducing the dimensionality of optimized model states improves the effectiveness of the original iterative algorithm and achieves effective optimization in terms of space and time complexity. It can be seen that reinforcement learning algorithms have their unique performance in design planning and spatial processing problems.

3 RESEARCH ON ENVIRONMENT LANDSCAPE DESIGN BASED ON CAD INTELLIGENT MODELING AND REINFORCEMENT LEARNING ALGORITHM

3.1 Research on 3D Rendering Scene of Environment and Landscape Design Based on CAD Intelligent Modeling

Environment and landscape design forms an environment of coexistence between man and nature in the region by changing space, terrain, plants, water bodies and buildings. Being an environmental designer requires a variety of detailed design drawings that can be fully understood by construction personnel. CAD computer-aided modelling tools can draw digital blueprints and become the key content that affects the quality of environmental landscape design drawings.

In the environment and landscape design, there are many categories of design drawings, and the plan refers to the view generated by the normal projection in the horizontal direction within the design scope, which is mainly used as a reference for the location of ground buildings, road widths, greening, decoration, and other facilities. The three-dimensional design diagram mainly aims at the landscape architecture perpendicular to the landscape design surface and horizontal direction, and the three-dimensional landscape design diagram mainly expresses the detailed scale relationship, such as the undulation height and terrain in the figure. In addition, there are sections and renderings, which refer to the use of assumptions in the design system to complete the cutting of plants, water, and other natural landscapes. Effect drawing refers to the conversion of a two-dimensional design plane into a three-dimensional dynamic landscape by using the three-dimensional principle of perspective. All planned horizontal schemes can be visually displayed immediately to verify their final effect and then presented to the customer in an intuitive perspective to facilitate communication between the designer and the user. We demonstrate the generation effect of four kinds of design drawings in environment and landscape design using CAD intelligent modelling, as shown in Figure 1.

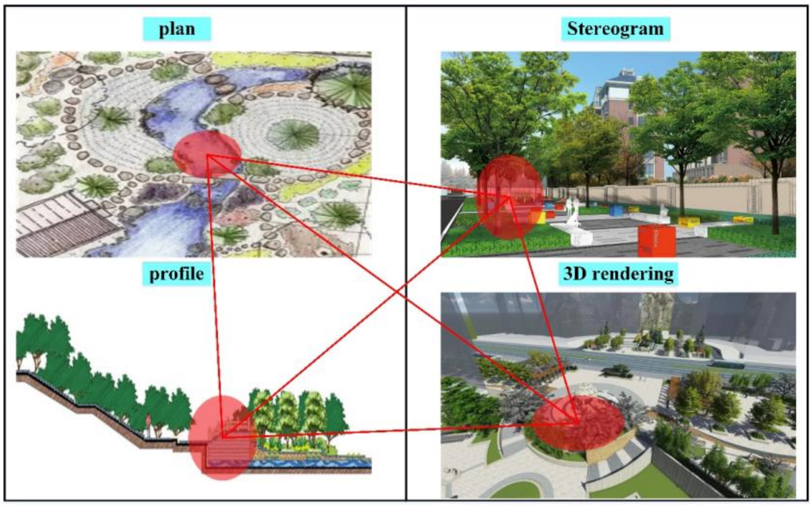

Figure 1: The generation effect of 4 types of design drawings.

As can be seen from Figure 1, the plan mainly uses two-dimensional images, the three-dimensional landscape design plan shows the distribution of the garden landscape and water body through a three-dimensional display, and the section diagram shows the detailed architectural and ecological structure. 3D renderings This perspective method reflects the design scene is more intelligent and dynamic. For landscape design and environment design, image rendering and post-processing are very critical. We use the intelligent modelling ability of CAD to complete the rendering process of the effect drawing. In the actual rendering case, the surrounding environment elements are added through the CAD modelling database to show better light and shadow and true reflection in the 3D design drawing. Although it will greatly increase the processing time of the computer, this generated scene is more flexible, convenient, and intuitive. At the same time, CAD modelling is faster in terms of time processing. In this study, we compared the speed of CAD intelligent modeling with the time processing results of ordinary modeling software in rendering images, adding materials, and other functions. The statistical results are shown in Table 1.

Link	*CAD intelligent modeling*	*Ordinary modeling software*
Rendered Image	1.2s	3.4s
Material addition	0.6s	2.1s
Light treatment	0.5s	1.1s
shadow casting	0.9s	1.7s
Geometric construction	1.3s	3.2s
Beautification treatment	0.7s	2.1s
Data Storage	0.8s	1.8s
Scene generation	1.3s	2.8s

Table 1: Statistical analysis of time coefficients for data processing using two modelling software.

It can be seen from Table 1. Compared with the time processing coefficient of common modelling software, CAD intelligent modelling is faster and shorter. For the generation of multiple scenes, automatic integration can be achieved to complete the task.

3.2 Research on Optimization of Environment and Landscape Design Planning Based on Reinforcement Learning Algorithm

Although computer-aided design has become an important tool in the field of environment and landscape, it is still very narrow in the practical process. Designers are also not innovative in their use of computer algorithms. This is mainly because in the environment and landscape design, space layout and planning have always been the core content that affects the design quality, which involves many factors related to the environment design of landscape design. Ordinary computer software still has obvious defects in data processing, and most designers still use traditional design media tools, such as sketches and models. Not aware of the use of computer algorithms to assist design ideas and to make a reasonable division of space. A reinforcement learning algorithm is a learning process from environmental state to action mapping and can obtain cumulative data from the environment as feedback to add to the active learning training. Reinforcement learning obtains evaluative feedback signals from multi-dimensional information to optimize decision-making through continuous trial and error and interaction with environment design. It is a goal-understanding, goal-oriented decision-learning method that emphasizes direct communication with the surrounding environment and space, which is one of the characteristics that distinguishes it from other machine learning supervised and unsupervised. Reinforcement learning uses the most basic principles to increase the probability of behavioural strategies to solve problems such as long-term returns and interaction with space. We use the methods of feature point capture and correlation to make statistics on the application of reinforcement learning algorithms in various fields, as shown in Figure 2.

As can be seen from Figure 2, reinforcement learning algorithms have a good potential for development in the fields of industry, mechanical manufacturing, and architectural design. At the same time, the industrial field can also be divided into the chemical industry, mining industry, power industry, food processing industry, textile industry, and so on. At the same time, the field of mechanical manufacturing also has its divisions. Reinforcement learning algorithms also have unique advantages in the field of architectural design. He regards the learning process as an exploratory process, and its basic model structure is shown in Figure 3.

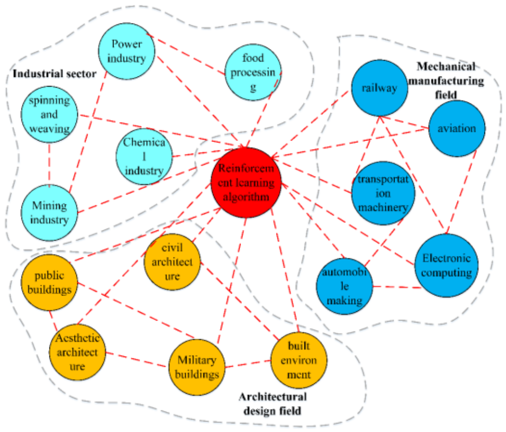

Figure 2: The Application of Reinforcement Learning Algorithms in Various Fields.

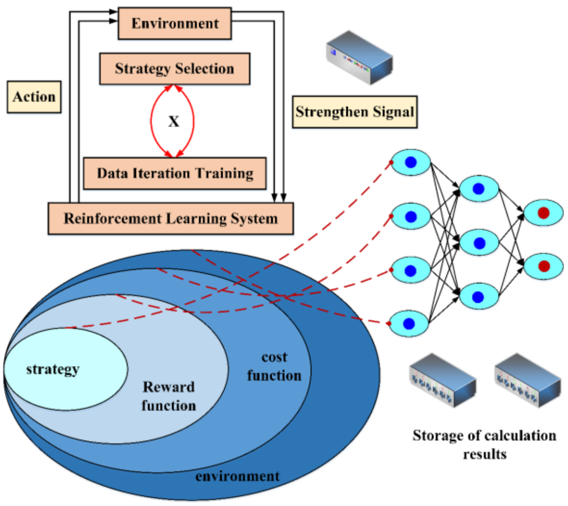

Figure 3: Basic model structure.

It can be seen from Figure 3 that in reinforcement learning systems, strategy selection actions can act on the environment. After receiving the action, the surrounding environment generates the reinforcement signal, which is input to the reinforcement learning system for data iteration training. Combining the performance of the four elements of strategy, reward function, value function, and environmental model, the quality of data in each state can determine the final action and overall performance of the design plan. In addition, the application of reinforcement learning in environment and landscape design planning also requires a combination of total renewal and sample renewal strategy evaluation. The iterative network of data is used to judge whether the final design scheme meets the practical application requirements. In a random environment, the completed landscape design needs to take into account the fully updated and sampled data. For special state actions, we need to use the formula to define:

$$Q(x,u) \rightarrow f(x,u,x)[p(x,u)+y\max] \tag{1}$$

$$\sum_{x}^{i=1} f(u) = p(u) + \max Q[x,u]_0 \tag{2}$$

Given the next stage of the sampling action, the corresponding formula changes as follows:

$$Q \to (U,X) + a[p(x,u) + \min Q_X - Q_U] \tag{3}$$

If the convergence analysis of the contained parameters is performed using reinforcement learning under certain conditions, then the reward value will go back one step. The function value update formula of the algorithm is as follows:

$$V(x) = a + d[r + y(x)^{'} - m] \tag{4}$$

Among them, a it's called a learning factor. Since there is a lot of historical experience to refer to in environment and landscape design, we also added these experience values to the algorithm to improve the convergence speed of the algorithm:

$$v = (x) + b[m + qV(x) - v^{'}(e)]e(x) \tag{5}$$

$$e(x) = \begin{cases} ye(x), x \neq x \\ ym(y) + 1, x = x_t \end{cases} \tag{6}$$

Next, we use the Markov decision process to remove and model the interference problems around landscape and environmental design. To represent the environment state space and the current planning schedule, the probability distribution of the next state needs to be calculated when performing the preceding and following actions:

$$s_t = [p_1 - p, m_1 - m, ..., r_1 - r] \in a \tag{7}$$

In the formula, s_t Represents the average calculated probability. The calculation process of the total transmission rate of the modelling system is as follows:

$$P(T-1)_s = p_t g_s \tag{8}$$

$$g_s = \delta(f_{us} - m) + p_{t-1} \tag{9}$$

Among them is an indicator function that represents an algorithm. The quality of landscape design planning depends on the interference of surrounding signals and data. For space states that are difficult to predict in advance, we also need to predict in advance:

$$T = pg_{t-1}\delta(f + m)_0 \tag{10}$$

According to the above formula, the predicted state can be obtained:

$$ST^2 = [p_{t-1}, p_{t-2}, ..., p_{t-n}] \tag{11}$$

$$S = S \leftarrow S_T + A / pg_r \tag{12}$$

After the distribution of multiple factors affecting environment and landscape design in the predicted state is fully traversed, the sorting formula is as follows:

$$AR = (f_{T+1}, P_{T+1}, v) \in w \tag{13}$$

After traversing the influencing factors, complete the data de-interference operation, and finally output the modelling environment calculation formula under the reward function:

$$\max E[r + \sum_{r=1}^{0} y(s,a)] \tag{14}$$

$$d(x) = p + nT / \max E \tag{15}$$

The above formula can adjust the spatial planning details of the environment and landscape design. Based on the output results, the final planning path can be automatically generated. In the subsequent practical operation, we also need to compare the application effect of reinforcement learning algorithms in environment and landscape design.

4 ANALYSIS OF ENVIRONMENTAL LANDSCAPE DESIGN RESEARCH RESULTS BASED ON CAD INTELLIGENT MODELING AND REINFORCEMENT LEARNING ALGORITHM

4.1 Analysis of Research Results of Environment and Landscape Design 3D Rendering Scene Based on CAD Intelligent Modeling

With the popularization of computer technology in the design field, the forms of environment and landscape design have changed. CAD computer-aided technology has given a new interpretation to some complex designs that are difficult to complete. In landscape design conception, designers use CAD software to complete the construction and rendering of three-dimensional scenes. On the one hand, the architect maintains the beauty of the design, on the other hand, he gives full play to the imagination of the space, integrates the design experience with the aesthetic quality, and uses CAD modelling technology to complete the calculation reasoning and optimal analysis of the three-dimensional parameters contained in it. This makes the 3D rendering scene move from virtual construction to reality. Before importing the CAD modelling system, it is necessary to remove all unnecessary line layers according to the actual situation of the environment and landscape design. And from the render mode to ensure that there is no interference data to improve the accuracy of modelling. At the same time, it involves some large workload situations, designers can divide the design area into several small blocks in CAD modelling, and finally summarize it into the same database. To better verify the effect of CAD intelligent modelling, we compared the data processing speed of CAD modelling and ordinary modelling technology in the process of 3D rendering scene generation.

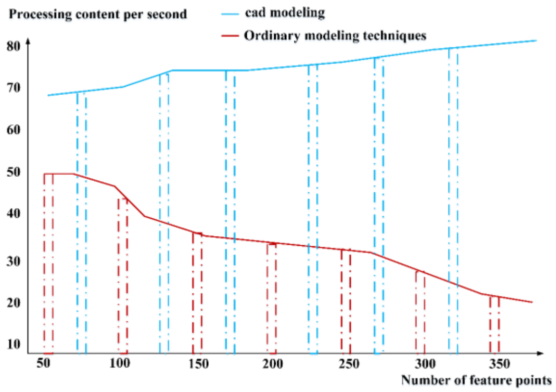

Figure 4: Comparison of data processing speed between the two.

As can be seen from Figure 4, with the increase in the number of feature points processed in the generated data, the processing speed of CAD intelligent modelling technology remains above a certain standard range, while the processing speed of ordinary modelling software tends to decrease obviously when processing large amounts of data. When the model is established, the CAD intelligent modelling system can also match colours and materials to quickly generate the initial design drawing. The CAD system also has its material library, allowing designers to assign a variety of material maps on any design surface and display them in real-time on a 3D display, achieving WYSIWYG.

4.2 Analysis of Research Results of Environment and Landscape Design Planning Optimization Based on Reinforcement Learning Algorithm

In recent years, intelligent technologies such as deep learning and reinforcement learning are full of unique advantages in the aided design system, and the design field makes full use of intelligent algorithms to complete the spatial layout of design planning. Compared with other machine learning technologies, reinforcement learning algorithms are more suitable for spatial and three-dimensional planning and collocation. Through the calculation process of the reinforcement learning algorithm, we carried out repeated independent simulation experiments and compared the influence of different region planning on the algorithm. The information contained in environment and landscape design is divided into three categories: building distribution, natural ecological distribution and water resource distribution. To verify the effectiveness of the reinforcement learning algorithm, we analyzed the noise coefficient changes between it and the ordinary machine learning algorithm in the above three types of planning.

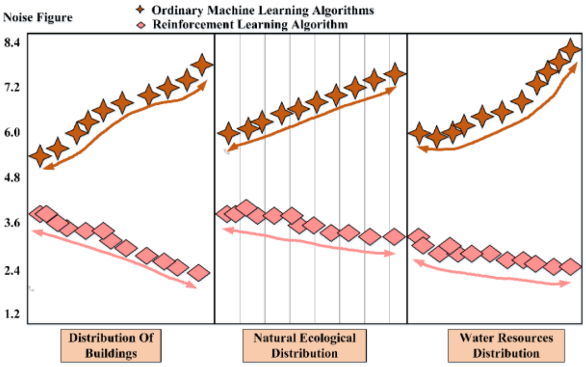

Figure 5: Analysis of Changes in Noise Coefficient.

As can be seen from Figure 5, general machine learning algorithms are easily affected by complex environmental factors in the process of landscape design planning of these three categories, so the noise coefficient generated is generally high. The reinforcement learning algorithm has less noise coefficient when dealing with complex subject processes such as buildings, natural ecology and water resources. Further, verify that the planning path generated by the algorithm is the optimal strategy for landscape design. Because of the complexity of such problems as environment and landscape design, we also compare the computational convergence speed of the two, as shown in Figure 6.

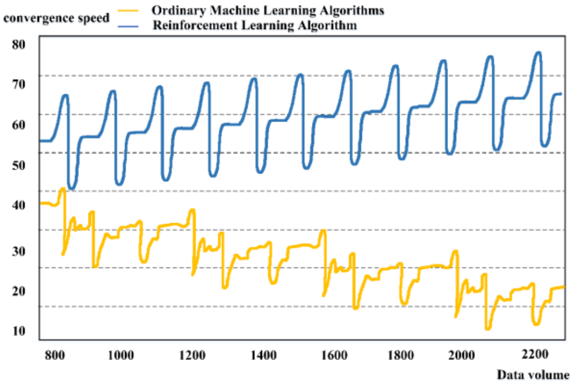

Figure 6: Analysis of the convergence speed of both calculations.

It can be seen from Figure 6 that the landscape design planning scheme generated by the reinforcement learning algorithm has a faster computational convergence speed. This also means that with the help of the same data resources, the design modelling completed by the reinforcement learning algorithm is faster and easier. In the process of verifying the effectiveness of the algorithm, we also compared the running time of the two algorithms, and obtained the following table through the time test statistics of the four environments of road planning, green space planning, building planning and water resources planning.

Environment	*Test set*	*Reinforcement learning algorithm*	*Ordinary machine learning algorithms*
road planning	1	0.08s	0.35s
	2	0.07s	0.37s
	3	0.06s	0.36s
Green space planning	1	0.10s	0.15s
	2	0.08s	0.18s
	3	0.06s	0.17s
Building planning	1	0.09s	0.16s
	2	0.11s	0.20s
	3	0.08s	0.21s
water resources planning	1	0.12s	0.23s
	2	0.11s	0.25s
	3	0.09s	0.18s

Table 2: Time testing statistics of two algorithms in four environments.

It can be seen from Table 2 that in the four planning environments of the two algorithms, the running time of the reinforcement learning algorithm is obviously shorter, and the number of test sets also meets the standard of algorithm verification. Therefore, the application of reinforcement learning algorithms in landscape design planning is good.

5 CONCLUSIONS

In the environmental landscape design industry by information technology and modern urban development, to make landscape design more in line with people's aesthetic and intelligent needs, this paper studies three-dimensional modelling, scene rendering, intelligent planning and other contents of environment and landscape design with the help of CAD modelling and reinforcement learning algorithm. Firstly, from the analysis of the application status of computer-aided software, it can be seen that CAD intelligent modelling systems can simplify the complex landscape design and construction process. We introduce the process of scene rendering with CAD in detail and compare CAD 3D modelling with traditional design software to demonstrate the feasibility and reliability of computer-aided tools. Based on the multiple developments of CAD intelligent modelling, colour matching, lighting analysis, modelling conception and scene rendering are studied from the perspective of environment and landscape design. Finally, to solve the problems of intelligent planning of environment and landscape design, we add a reinforcement learning algorithm to solve the problem of slow convergence. Using the Markov decision formula, the non-optimal action of spatial planning is eliminated, and the algorithm becomes more intelligent and efficient. The research results show that CAD intelligent modelling and reinforcement learning algorithms can improve the rendering effect of 3D scenes in environment and landscape design, and simplify the landscape design planning process.

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