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Environmental Management System for Nature Reserves Integrating Virtual Simulation Technology

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Abstract: The nature reserve is an important facility to protect the natural ecosystem and biodiversity, and the environmental management of the nature reserve is very important, which can ensure the protection and maintenance of the ecosystem and biodiversity of the nature reserve. The environmental management of nature reserves needs to protect the natural ecosystem, prevent human activities from damaging the natural ecosystem, maintain biodiversity and protect species diversity and ecosystem diversity. In addition, strict protection measures need to be formulated and implemented to reduce the interference of human activities to the natural environment. In short, the environmental management of nature reserves is significant for the protection of natural ecosystems and biodiversity. Therefore, this paper would optimize and design the environmental management system of the reserve through virtual simulation technology. The model construction algorithm on the basis of virtual simulation technology was used to simulate the environmental management process of natural reserves. By establishing a virtual model, the impact of different human activities on the natural environment can be simulated in order to evaluate and optimize the environmental management plan. In addition, virtual simulation technology can also help managers conduct training and simulation exercises, and improve environmental management ability and decision-making level. Experiments showed that before the implementation of environmental management, the number of cattle, sheep and deer in the nature reserve was 2214, 1865 and 1374 respectively. After the implementation of environmental management, the number of cattle, sheep and deer in the nature reserve was 2645, 2113 and 1587 respectively. Obviously, after the implementation of environmental management, the number of animals in the nature reserve has been relatively good growth, and its natural resources and ecosystem have been well protected. The experimental results showed that the virtual simulation technology can be better applied in the environmental management of the nature reserve, effectively improve the environmental management efficiency of the nature reserve, and optimize the ecosystem in the nature reserve. This result pointed out a beneficial development direction for the environmental management of nature reserves and provided reliable technical support for environmental protection.

1. Introduction

With the development of society, the issue of environmental protection has received widespread attention from the society. With the increasingly prominent issues of global climate change, environmental pollution, loss of biodiversity and so on, people's awareness of environmental protection has been continuously improved, and the demand for environmental protection has become increasingly strong. When carrying out environmental protection, the environmental protection of natural reserves is particularly important. Environmental management of natural reserves refers to the process of effective management and protection of natural reserves in order to protect natural ecosystems and biodiversity. The nature reserve is an important facility to protect the natural ecosystem and biodiversity. Through environmental management, the ecosystem and biodiversity of the nature reserve can be protected and maintained.

According to the relevant information, the following scholars' research on environmental management is listed. Andriansyah Andriansyah believed that the natural resources needed by human beings were limited in quantity and quality. The purpose of his research was to understand how the government manages the environment through its policies. He pointed out that with the support of high-quality human resources, it is necessary to establish a fair and firm environmental law enforcement agency to manage natural resources and environment in a sustainable manner [1]. Claassens C. E believed that waste management is an important consideration for development in the protected area. He put forward suggestions for improving the consideration of waste management measures in environmental protection management [2]. Park Car pointed out that the dimensions and principles of sustainable development have not been systematically incorporated into the environmental management of natural reserves, and the comprehensive environmental management performance appraisal system was expected to become an effective environmental management tool for national institutions [3]. Pan Xumei believed that the reserve has dual tasks of "protection" and "use". Moreover, tourism is also an effective tool for environmental protection. He discussed the evolution process of the interaction between tourism and environment in the reserve, and pointed out that the improvement has promoted the change of landscape diversity and natural degree in the reserve [4]. The above research topic has studied environmental management from multiple directions, which has certain reference value for the research work of this topic. However, the above research directions do not link environmental management with virtual simulation technology, which limits the depth and practicability of further research in this topic.

After consulting the materials, people found the following research literature on environmental management and virtual simulation technology. Yu Yingmin studied the virtual simulation of pollutants in the process of oil spill diffusion in case of pollution accidents. The virtual simulation includes visualizing the invisible pollutant diffusion process on the computer interface, showing the current emergency response problems of water pollution accidents [5]. Rawson Rebecca pointed out that virtual reality technology has the application, experience and effectiveness of highly immersive environment. He studied the role and performance of virtual simulation technology in environmental management education. The results showed that this technology can improve the teaching efficiency of environmental management education [6]. After reading the above articles carefully, people can understand that the research of the above scholars provided a good direction for the research of this topic, but it was only carried out in theory, and the results lack practicality and authenticity. Therefore, in order to optimize their research issues, more practical investigations woould be carried out.

This paper studies the design of the nature reserve environmental management system integrating virtual simulation technology. Through virtual simulation technology, it can provide an efficient, flexible and convenient solution for the nature reserve environmental management, and

can also reduce the human intervention and management costs of the nature reserve. The nature reserve environment management system integrated with virtual simulation technology can help the nature reserve management department to monitor and manage the environment of the nature reserve. The system can generate various visual charts and reports to help the management department understand the environmental conditions of the nature reserve and formulate corresponding protection measures. In short, the nature reserve environmental management system integrating virtual simulation technology can provide powerful technical support and management means for the management department of the nature reserve, and promote the sustainable development of the nature reserve.

2. Evaluation on Natural Reserves and Virtual Simulation Technology

2.1. Basic Concept and Management Content of Natural Reserve Environment

The nature reserve is a special environmental protection measure aimed at protecting natural resources and biodiversity [7-8]. It is a special area set up by the government or other statutory bodies to prohibit or restrict human activities to protect the natural environment and ecosystem. The management of the environment in nature reserves is very important for protecting natural resources, maintaining the health and balance of ecosystems, and promoting the sustainable development of human society. Its main management contents are as follows.

(1) Species protection

Species protection refers to taking effective measures to protect and manage the species in the nature reserve to prevent their extinction and loss, including protecting the habitat of species, preventing the invasion of species, protecting the reproduction and reproduction behavior of species, and ensuring the survival and reproduction of species [9-10]. Generally, species protection includes the following aspects:

Habitat protection of species: species need to survive and reproduce in specific habitats. Therefore, protecting the habitat of species is one of the important measures for species protection. Measures need to be taken to ensure the integrity, stability and security of habitats and protect the habitats and ecosystems of species.

Prevention of species invasion: there are usually some invasive species in nature reserves, which would destroy the living environment and ecosystem of local species. Therefore, measures need to be taken to prevent the invasion and spread of invasive species and protect the living environment and ecosystem of local species.

Protection of species' reproduction and reproduction behavior: the reproduction and reproduction behavior of species is an important guarantee for their survival and reproduction. Therefore, it is necessary to take measures to protect the breeding behavior of species, including protecting the breeding place, providing safe breeding conditions, and protecting the breeding season of species.

(2) Water resources management

Water resources management refers to the monitoring, assessment, management and protection of water resources in the nature reserve. Effective measures are taken to protect and manage water resources, prevent waste and pollution of water resources and ensure their sustainable use [11]. Generally, water resources management includes the following aspects:

Water resources monitoring: the establishment of a scientific water resources monitoring system to monitor the water resources in the nature reserve, including water quantity, water quality, hydrology and other aspects, is essential.

Water resources assessment: according to the water resources monitoring results, the water resources status in the nature reserve is assessed, including the sustainable utilization level of water

resources, the quality of water resources and other aspects.

Water resources protection: measures need to be taken to protect the water resources in the nature reserve, including the conservation of water resources, the protection of the ecosystem of water resources, and the prevention of water pollution.

(3) Land use management

Land use management refers to the investigation and assessment of the land use in the nature reserve, and the adoption of effective measures to protect and manage the land to prevent the excessive use and destruction of the land. Generally, land use management includes the following aspects:

Land use planning: according to the conditions of land resources, land use needs and other factors in the nature reserve, a scientific land use plan is formulated, including land functions, land protection, land use and other aspects.

Land use supervision: it is necessary to establish a scientific land use supervision system to supervise and manage the land use in the nature reserve, including the rational use of land, the protection and management of land, and the standardized use of land.

Land protection measures: effective measures need to be taken to protect the land resources in the nature reserve, including land restoration, ecological environment protection, forest protection, wetland protection, etc.

Land planning adjustment: according to the implementation of land use planning and the change of land resources, the land use planning is adjusted and optimized to ensure the sustainable use of land resources.

Among them, the management content of the nature reserve environment is shown in Figure 1.

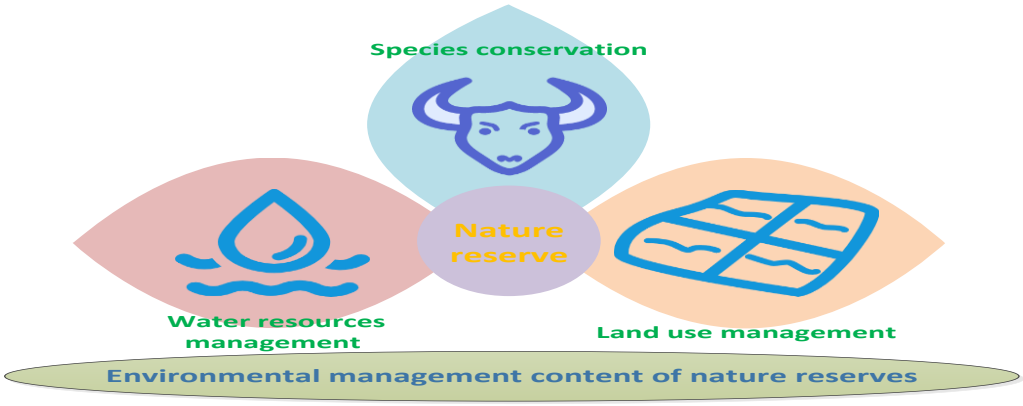

Figure 1. Management content of the nature reserve environment

2.2. Concept and Steps of Virtual Simulation Technology

Virtual simulation technology uses computer technology to simulate the real world. It can let people conduct various activities and interactions in this world [12-13]. Virtual simulation technology needs to comprehensively use the knowledge of physics, mathematics, computer science and other disciplines to realize the simulation of the physical world. Its application fields are very wide, such as education, medical, military, entertainment, games and other fields. The steps of virtual simulation technology usually include the following aspects:

(1) Model construction

In virtual simulation technology, it is first necessary to build virtual models, which mainly include physical models and mathematical models [14-15]. It should be noted that when building the model, the actual situation and technical requirements should be comprehensively considered to ensure the accuracy and practicability of the model.

Physical model: the physical model refers to the mathematical model that establishes the physical characteristics of objects in the virtual simulation system, such as motion laws and interactions. Physical models are usually constructed based on physical principles and experimental data, such as Newton's laws of motion, laws of conservation of energy, etc.

Mathematical model: the mathematical model refers to the mathematical model that establishes the mathematical characteristics of the motion state, position, speed, etc. of the object in the virtual simulation system. Mathematical models are usually constructed based on physical principles and experimental data, such as calculus, linear algebra, etc.

(2) Data collection

In the data acquisition link of virtual simulation technology, it mainly includes the acquisition of physical quantities such as the position, velocity and acceleration of objects. Attention should be paid to the quality and accuracy of data to ensure the accuracy and reliability of the virtual simulation system. There are two main methods of data collection:

Sensor: sensor refers to the equipment used to collect physical quantities, such as accelerometer, gyroscope, barometer, etc. The sensor is usually placed on the object in the virtual simulation system to collect data such as the motion state and environmental parameters of the object.

Simulator: simulator refers to the equipment that simulates the motion state and environmental parameters of objects with computer programs. They are usually built based on physical principles and experimental data, such as particle simulators, fluid simulators, etc.

(3) Data processing

Data processing is an important part of virtual simulation technology, which mainly includes data preprocessing, filtering, noise reduction, data compression and other steps. There are many methods of data processing, including linear regression, support vector machine, neural network, etc. Selecting appropriate methods according to the actual situation is essential to improve the performance and efficiency of the virtual simulation system. This link is to improve the performance and efficiency of the virtual simulation syste while ensuring the accuracy and reliability of the model.

Data preprocessing: data preprocessing refers to the processing of collected data, such as noise removal, data smoothing, etc. The purpose of preprocessing is to remove the interference and noise in the original data and improve the quality and accuracy of the data.

Filtering: filtering refers to smoothing the pre-processed data to reduce noise and fluctuation in the data. The purpose of filtering is to make the characteristics of the data more obvious while avoiding the problem of over-fitting.

Noise reduction: noise reduction refers to denoising the pre-processed data to remove clutter and interference in the data. The purpose of noise reduction is to make the characteristics of the data more obvious while avoiding the problem of over-fitting.

Data compression: data compression refers to the compression of collected data to reduce storage space and transmission bandwidth. The purpose of data compression is to improve data storage efficiency and transmission efficiency.

(4) Visual display

Visual display is an important part of virtual simulation technology, which mainly includes animation, image, video and other forms of data display. It needs to consider the accuracy and real-time of data to ensure the performance and efficiency of the virtual simulation system, so that users can more intuitively understand the motion state, position, speed and other data of objects in the virtual simulation system.

Animation: animation refers to displaying the motion state of an object in the form of a continuous frame sequence to facilitate the user to observe the motion track and motion state of the object.

Image: image refers to displaying the position, speed, acceleration and other data of the object in the form of image, so that users can observe the position, speed and other information of the object.

Video: video refers to displaying the motion state of an object in the form of video so that users can observe the whole motion process of the object.

The steps of virtual simulation technology are shown in Figure 2.

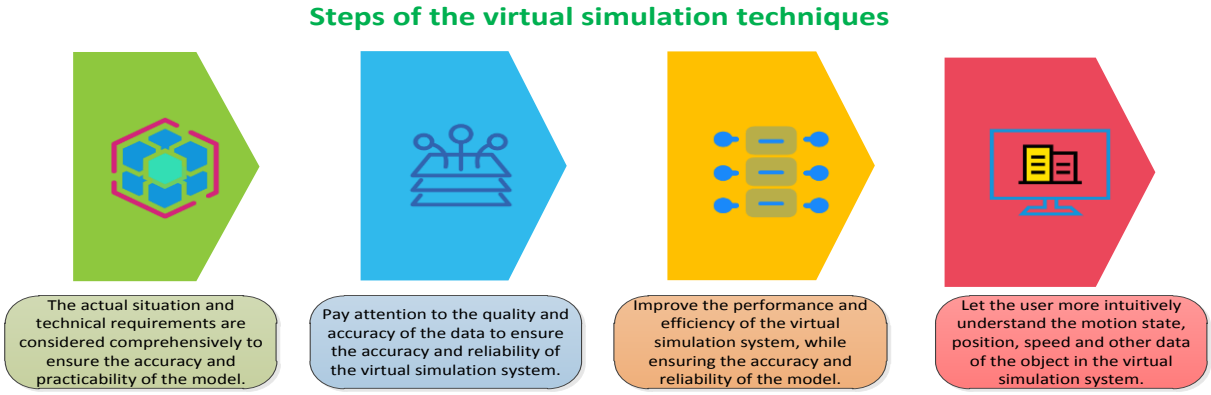

Figure 2. Steps of virtual simulation technology

3. Model Building Algorithm Based on Virtual Simulation Technology

In virtual simulation technology, model building is an important link. By modeling and simulating various physical and chemical phenomena in the real world, people can build a virtual world with realism and interactivity. In 3D models, texture is a part of visual experience. To better describe the importance of the local texture of the model, this algorithm introduces the concept of vertex texture saliency to enrich and optimize the texture of the model.

The Q matrix of vertex v can be divided into:

$$Q = \begin{bmatrix} A & b \\ b^T & c \end{bmatrix} \tag{1}$$

Among them, A is the 3×3 matrix of vertex v coordinate; b is a 1×3 matrix; c is the model parameter.

Then, the texture saliency of vertex v_t is calculated:

$$\delta(v_t) = \frac{\sum_{i=0}^{n} \frac{S_{ev_ti}}{S_{v_ti}}}{n} \tag{2}$$

Among them, n is the number of triangular faces of vertex v_t. S_{ev_ti} is the texture area corresponding to the i-th triangle of vertex v_t. S_{v_ti} is the area of the ith triangular face of vertex v_t.

Then, the sharpness and texture saliency are fused, and the formula is as follows.

$$\varepsilon = v_0^T(A^{\sigma v_1} * B^{\delta v_1} * Qv_1 + A^{\sigma v_2} * B^{\delta v_2} * Qv_2)v_0 \tag{3}$$

Among them, σ is the sharpness of the vertex. δ is the texture saliency of the vertex. When A=B=2, the formula can be converted to.

$$\varepsilon = v_0^T(2^{(\sigma+\delta)v_1} * Qv_1 + 2^{(\sigma+\delta)v_2} * Qv_2)v_0 \tag{4}$$

Through the formula, the virtual model can be optimized. It integrates the area of the triangular surface of the region and the area of the texture patch between the triangular surfaces, increases the simplification of the sharp part and the texture part of the model, and retains more details than the original edge folding cost, making the virtual model more realistic.

4. Implementation and Test of Environmental Management of Nature Reserves Based on Virtual Simulation Technology

This part first test the model building performance of the model building algorithm based on virtual simulation technology. In this experiment, people need to test the traditional model building algorithm and the model building algorithm based on virtual simulation technology to test the number of vertices and triangles of the model built by the algorithm. The specific classification is shown in Table 1.

Table 1. The number of vertices and triangles of models built by different algorithms

Model types	Traditional model-building algorithms		Model construction algorithm based on virtual simulation technology	
	Number of vertices	Number of triangles	Number of vertices	Number of triangles
Tree	20520	41183	25512	46320
Lake	26574	55230	28451	59668
Cattle	22841	45771	26532	48521

From the experimental data in Table 1, it can be knew that the number of vertices and triangles of the tree model built by the traditional model building algorithm were 20520 and 41183, respectively. The number of vertices and triangles of the tree model built by the model building algorithm based on virtual simulation technology was 25512 and 46320, respectively. In addition, it can be seen that compared with the traditional model building algorithm, the number of vertices and triangles of other models built by the algorithm were more, which showed that the algorithm had more excellent model building ability, and its model was more realistic.

In virtual simulation, the speed of model construction is also an important performance index. Therefore, the model construction speed of these two algorithms would be studied. The experimental data is shown in Figure 3.

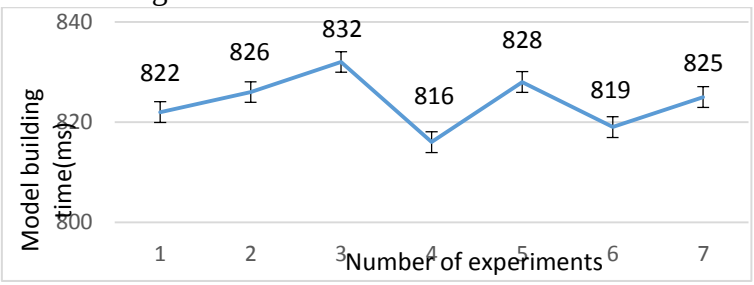

Figure 3(a). Model building time of traditional model building algorithm

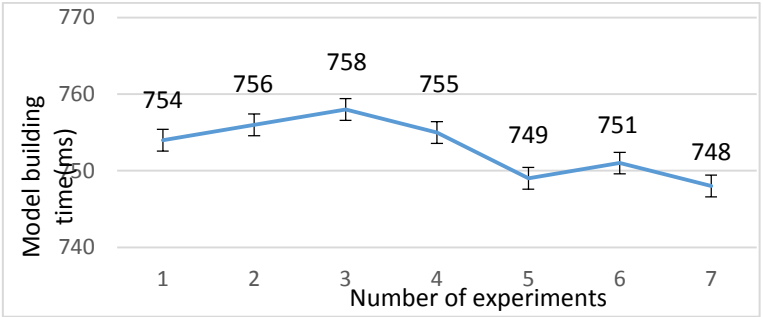

Figure 3(b). Model construction time of model construction algorithm based on virtual simulation technology

Figure 3. Model construction time of different algorithms

From the data in Figure 3 (a) and Figure 3 (b), it was obvious that the model building algorithm based on virtual simulation technology took less time to build the model. After calculation, the average model building time of the traditional algorithm and the model building algorithm based on virtual simulation technology was 824ms and 753ms respectively. This showed that the model building algorithm based on virtual simulation technology had a faster model building speed.

Finally, it is also necessary to carry out actual environmental management in the nature reserve to explore the environmental management system based on the model construction algorithm of virtual simulation technology and its environmental management role in the nature reserve. In this experiment, the environment management system based on virtual simulation technology would be used to carry out statistical analysis of the situation before and after the implementation of environmental management in nature reserves. The experimental data is shown in Figure 4.

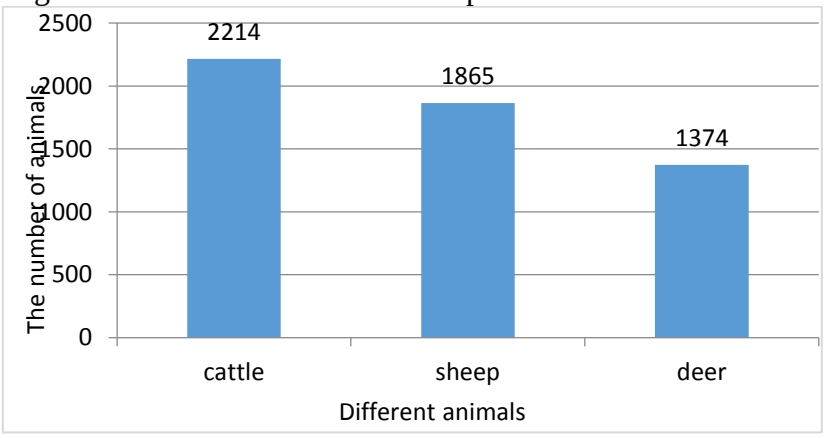

Figure 4(a). Number of animals before environmental management

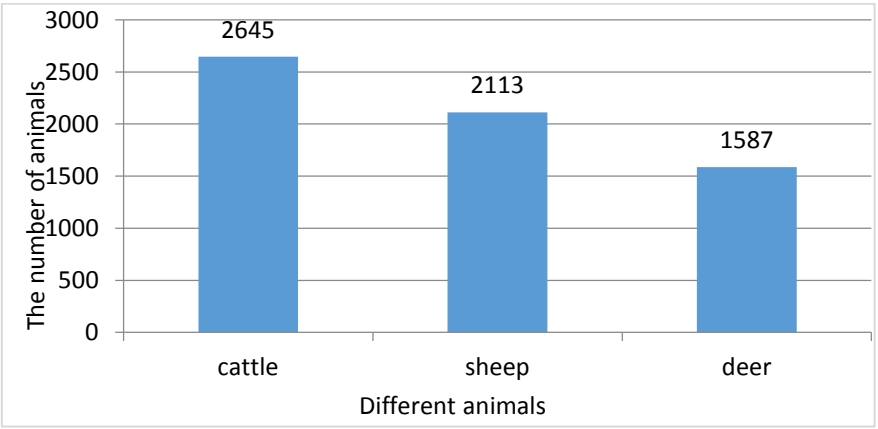

Figure 4(b). Number of animals after environmental management

Figure 4. Number of animals before and after the implementation of environmental management

Through the analysis of Figure 4 (a) and Figure 4 (b), it can be seen that before the implementation of environmental management, the number of cattle, sheep and deer in the nature reserve was 2214, 1865 and 1374 respectively. After the implementation of environmental management, the number of cattle, sheep and deer in the nature reserve was 2645, 2113 and 1587 respectively. Obviously, after the implementation of environmental management, the number of animals in the nature reserve has increased relatively well, which shows that the environment of the nature reserve is better and its natural resources and ecosystem are well protected.

5. Conclusion

Virtual simulation technology is a simulation method based on computer technology and virtual reality technology. It can simulate various situations and phenomena in the real world in the virtual environment, thus realizing the simulation and experiment of the real world. In this paper, the virtual simulation technology was used to optimize and construct the environmental management system of the nature reserve. The environmental management system of the nature reserve can use the virtual simulation technology to simulate the environmental conditions of the nature reserve, provide monitoring and management tools for the administrator of the nature reserve, and improve the management efficiency and protection effect of the nature reserve. Through experiments, it has been proved that using the environmental management system based on virtual simulation technology, the animals in the nature reserve have been significantly increased, the environment has been improved, and the environmental protection of the nature reserve has been realized. In general, the nature reserve environment management system integrated with virtual simulation technology can help managers better manage the environment of the nature reserve, improve management efficiency, and protect natural resources and ecosystems.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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