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Generative Artificial Intelligence Enables Innovation in Biodiversity Conservation

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Opinion
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Abstract

Generative artificial intelligence provides new possibilities for overcoming challenges faced in biodiversity conservation, such as data gaps, knowledge limitations, and decision-making dilemmas. In Today's world, Generative artificial intelligence can help human-being to build an intelligent sensing network to achieve panoramic monitoring of the ecosystem, deep exploration of data value reveals the laws of biodiversity conservation, empower protection decision-making to optimize and improve ecological governance, and innovate science popularization education models to enhance public awareness of protection. Countries worldwide should proactively embrace this technological revolution, fully leverage the empowering role of AI technology, and prudently address potential risks and challenges.

Keywords: Generative Artificial Intelligence; Biodiversity Conservation; Sustainable Development; Ecological Civilization

Introduction

Biodiversity is the foundation upon which humanity depends for survival and development, as well as the lifeblood of the Earth's community of life. Currently, the rate of global species extinction is accelerating, and biodiversity loss has become one of the major crises facing humanity. The International Union for Conservation of Nature (IUCN) Red List of Threatened Species, released in 2021, shows that 38,543 of the 138,374 assessed species are threatened with extinction. The World Wildlife Fund (WWF) released its "Earth Vitality Report 2026," which points out that between 1970 and 2022, the size of monitored wild vertebrate populations worldwide declined by an average of 73%. Some studies have indicated that the current global rate of species extinction is hundreds to thousands of times higher than the rate of extinction under natural conditions; without effective intervention measures, the trend of biodiversity loss will continue to intensify. In recent years, digital intelligence technologies, represented by large language models and generative AI, have flourished, profoundly changing the conditions, tools, and methods by which humans understand nature and protect ecosystems. Generative artificial intelligence, with its powerful data processing, intelligent analysis, and content generation capabilities, provides new technological paths and solutions for biodiversity conservation. From species identification to habitat monitoring and from ecological early warning to protection decision-making, AI technology has demonstrated unprecedented application potential in the field of ecological protection, playing a powerful role in the era of technology that empowers the construction of an ecological civilization.

Building an Intelligent Sensing Network to Achieve Panoramic Monitoring of the Ecosystem

Traditional biodiversity monitoring relies mainly on methods such as manual patrols and quadrat surveys, which have prominent problems such as narrow coverage, poor timeliness, and high costs, making it difficult to meet the needs of large-scale, high-frequency, and precise monitoring. The introduction of generative artificial intelligence technology is driving a revolutionary transformation

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in ecological monitoring systems. By replacing manual identification with intelligent recognition, building a full-domain monitoring network using satellite remote sensing and ground networks, using AI algorithms to rapidly process massive amounts of data, and shifting from passive response to proactive intervention on the basis of real-time early warning, the timeliness and accuracy of ecological protection can be significantly improved.

In the field of image recognition, automatic species recognition systems based on deep learning have been widely used in wildlife monitoring. Researchers have used generative AI technology to train intelligent models capable of identifying thousands of birds, mammals, and insects, and to quickly classify and label massive amounts of images taken by infrared cameras and drones. Image analysis that previously took professionals months to complete can now be performed in hours with the help of AI systems, with recognition accuracy continuously improving. Some cutting-edge research teams have even developed voiceprint recognition systems that can identify species through animal calls, providing a new means for monitoring nocturnal animals and aquatic organisms. In the field of remote sensing monitoring, generative AI technology has enabled the intelligent extraction and analysis of ecological indicators such as vegetation cover, land use change, and wetland succession. By integrating multisource remote sensing data, the AI system can automatically draw high-precision vegetation distribution maps, identify ecologically sensitive areas and ecological corridors, and provide a scientific basis for the delineation and adjustment of ecological protection red lines. Moreover, AI technology can conduct in-depth mining of historical remote sensing data to restore the historical trajectory of regional ecological changes and provide a time-dimensional comparative analysis for evaluating protection effectiveness. In terms of data integration, generative AI demonstrates powerful cross-modal data fusion capabilities. The system can automatically integrate multisource heterogeneous data—such as satellite remote sensing, ground monitoring, species surveys, and meteorological and hydrological data—to construct a comprehensive and multilevel ecosystem perception network. The establishment and operation of this network enable managers to monitor the status of regional biodiversity in real time, promptly detect ecological damage and species anomalies, and realize a fundamental shift from a passive response to proactive prevention.

Deep Exploration of Data Value Reveals the Laws of Biodiversity Conservation

Biodiversity conservation involves fields such as genetic, species, and ecosystem diversity conservation. Within these fields, the goals and tasks of in situ and ex situ conservation of animal habitats, rescue and population rejuvenation of endangered species, prevention and control of invasive alien species, preservation and utilization of genetic resources, ecosystem restoration and function maintenance, and sustainable use and community comanagement frequently overlap. This overlap generates a large amount of data and complex relationships. Generative AI technology, with its powerful pattern recognition and knowledge discovery capabilities, is helping researchers, social organizations, and government departments uncover hidden patterns within massive amounts of data and deepen their understanding of biodiversity conservation.

In species distribution modeling, AI technology has overcome the limitations of traditional statistical models. By integrating multidimensional features such as climate, terrain, vegetation, and human activity data, generative AI can be used to construct more accurate species suitability distribution models and predict the potential distribution areas and migration trends of species. These predictions provide important references for protected area planning, species introduction, habitat restoration, and other conservation efforts. AI models can identify the most critical habitat patches and ecological corridors, guiding the precise allocation of conservation resources, especially for endangered species. Generative AI also has unique advantages in ecological relationship network analysis. The system can automatically identify key species in the food web, analyze the interactions between species, and assess the cascade effects of species extinction. By building complex ecological network models, researchers can simulate the effects of different conservation strategies and optimize resource allocation schemes. Furthermore, AI technology can be used to study the invasion paths and spread mechanisms of alien species, providing decision support for formulating targeted prevention and control measures. In the field of genetic diversity analysis, generative AI is driving the deep integration of genomics and conservation biology. Through the intelligent analysis of large-scale genome sequencing data, AI systems can assess the level of genetic diversity in populations, identify genetic relationships, and detect the risk of inbreeding depression. These studies provide a molecular basis for developing scientific population management strategies and avoiding the genetic erosion of species. Some research teams are also exploring the use of AI technology to assist in the design of protective gene editing schemes, opening up new avenues for the conservation of critically endangered species.

Empowering Protection Decision-Making to Optimize and Improve Ecological Governance

Biodiversity conservation is systematic and dynamic. With the slowdown in global economic development, some countries face a dilemma between protection and

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development. It is difficult to balance assessment criteria such as species endangerment, ecological representativeness, and protection costs, making the contradiction between limited resources and unlimited protection needs in biodiversity conservation increasingly apparent. Generative AI technology is becoming an important auxiliary tool for conservation decision-making, helping biodiversity managers make more scientific and rational decisions in complex situations.

In conservation priority assessments, AI systems can comprehensively consider various factors, such as species endangerment, ecological representativeness, and economic costs, to scientifically rank protection targets. By building a multicriteria decision-making model, AI technology can identify conservation projects with the highest return on investment, avoiding the inefficient allocation of limited conservation resources. In addition, the system features scenario simulation functions that can evaluate the cost-effectiveness of different protection schemes and provide decision-makers with quantitative comparative analyses. In terms of early warning and response to threats, generative AI technology provides keen insights and rapid response capabilities. By monitoring indicators such as forest cover changes, wetland shrinkage trends, and illegal hunting activities in real time, the AI system can issue timely early warning signals, providing law enforcement agencies with accurate target positioning and action recommendations. In the handling of natural disasters and environmental emergencies, AI technology can quickly assess the scope and extent of ecological impacts to guide emergency response and ecological restoration work. In terms of community comanagement and interest coordination, generative AI provides new ideas for resolving the contradiction between protection and development. By establishing a multiparty consultation platform, the AI system can simulate the impact of different management schemes on the interests of all parties and promote communication and dialogue between protection entities and local communities. AI technology can also be used in areas such as the scientific calculation of ecological compensation standards, the intelligent planning of ecotourism routes, and the realization of the value of ecological products, promoting a new paradigm characterized by a virtuous cycle of protection and development.

Innovating Science Popularization Education Models to Enhance Public Awareness of Protection

Public participation is an important foundation for biodiversity conservation, and popular science education is key to increasing public awareness of ecological and environmental protection. Generative AI technology is profoundly changing the content production and dissemination models of ecological science popularization, deeply embedding the concept of biodiversity conservation in the public consciousness. In terms of popular science content creation, generative AI has significantly improved the supply of high-quality content. A popular science writing system based on large language models can transform complex ecological knowledge into easy-to-understand language, creating engaging popular science articles, interesting species stories, and vivid animated scripts. AI technology can also customize personalized science popularization content based on the characteristics of different audience groups, improving the relevance and effectiveness of dissemination. In terms of interactive experience innovation, generative AI provides the public with immersive ecological education experiences. Virtual reality systems based on generative AI can realistically recreate various ecosystem scenes, allowing the public to experience firsthand the vibrancy of tropical rainforests, the vibrant colors of coral reefs, and the magnificent vastness of tropical grasslands. An intelligent guide system can also provide personalized explanation services based on visitors' interests and knowledge levels, making science education more engaging and impactful. In terms of public participation platforms, AI technology has effectively lowered the threshold for scientific observation. With the help of image recognition and species identification apps, the public can take photos of plants and animals they observe daily and upload them to participate in the collection of species distribution data. This "citizen science" model greatly expands the temporal and spatial coverage of data collection while enhancing the public's sense of participation and responsibility. Generative AI can also be used to automatically identify quality issues in publicly submitted data, ensuring data reliability.

Future Development Outlook

Although generative AI has shown broad application prospects in the field of biodiversity conservation, practical exploration in this interdisciplinary field is still in its early stages, and future development requires the continuous promotion of change in the following aspects.

In the field of technology research and development, it is necessary to further improve the professionalism and reliability of AI models regarding ecosystems. Current mainstream general-purpose large language models still lack ecological expertise and require the construction of dedicated pre-training corpora in the ecological field, as well as the development of specialized models for tasks such as species identification and ecological modeling. Furthermore, the interpretability of AI systems urgently needs to be enhanced so that conservationists can understand the basis and limitations of AI recommendations, thereby increasing their trust in these systems. In terms of building data infrastructure, countries need to accelerate the construction

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of open and shared biodiversity data ecosystems. Currently, relevant data are scattered across different institutions, presenting problems such as inconsistent standards and uneven quality, which restrict the in-depth application of AI technology. In the future, we should promote the establishment of unified data standards, exchange protocols, and sharing platforms to facilitate data circulation and utilization while protecting data security. In terms of cultivating scientific and technological talent, countries need to strengthen the training of interdisciplinary personnel. The deep integration of biodiversity conservation and AI technology requires multiskilled personnel who understand both ecological protection and information technology. Currently, innovative explorations have been conducted by developing countries, but their education and training systems remain imperfect. Universities and research institutions need to make systematic, innovative adjustments in areas such as discipline setting, curriculum reform, and practical training. Naturally, the rapid development of AI technology inevitably introduces some moral hazards. This requires countries to conduct in-depth research, formulate corresponding ethical guidelines and regulatory frameworks, and proactively avoid ethical and legal issues such as those related to privacy protection, data security, and algorithmic bias that may arise from biodiversity conservation during the design of standardized institutions.

Conclusions

Biodiversity conservation is essential to the sustainable development of human civilization and serves as a call to establish a clean and beautiful world. As a key driving force of the latest technological revolution, generative artificial intelligence provides new possibilities for overcoming challenges faced in biodiversity conservation, such as data gaps, knowledge limitations, and decision-making dilemmas. Countries worldwide should proactively embrace this technological revolution, fully leverage the empowering role of AI technology, and prudently address potential risks and challenges. By promoting the deep integration of scientific and technological innovation with biodiversity conservation, global efforts can contribute to building a shared community of life on Earth, allowing diverse life to flourish in every nation.

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