Application of drones and artificial intelligence to monitor and protect natural ecosystems

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Abstract. In recent years, the integration of drones and artificial intelligence (AI) technologies has emerged as a promising approach for the conservation and management of natural ecosystems. This paper explores the application of drones and AI in monitoring and safeguarding these invaluable environments. Drones, equipped with various sensors such as cameras, LiDAR, and thermal imaging, offer unprecedented capabilities for data collection over large and inaccessible areas. Coupled with AI algorithms, these platforms can analyze vast amounts of data quickly and accurately, providing valuable insights into ecosystem health, biodiversity, and environmental changes. The utilization of AI enables the automation of tasks such as species identification, habitat mapping, and anomaly detection, significantly enhancing the efficiency and effectiveness of monitoring efforts. Machine learning algorithms can be trained on large datasets to recognize patterns and anomalies, enabling real-time detection of threats such as illegal logging, poaching, and habitat destruction. Furthermore, drones equipped with AI-powered systems can facilitate adaptive management strategies by providing timely and precise information to decision-makers. By monitoring changes in vegetation, water quality, and wildlife populations, conservation practitioners can implement targeted interventions to mitigate threats and promote ecosystem resilience.This paper highlights several case studies where drones and AI have been successfully employed in ecosystem monitoring and protection, ranging from tropical rainforests to coral reefs and savannas. These examples demonstrate the versatility and scalability of the approach across diverse habitats and geographical regions.

1 Introduction

The integration of drones and artificial intelligence (AI) has emerged as a powerful tool for monitoring and safeguarding natural ecosystems, marking a significant advancement in environmental conservation efforts. As global concerns regarding biodiversity loss, habitat degradation, and climate change intensify, the need for innovative and efficient methods to monitor and protect ecosystems has become paramount. Drones, also known as unmanned aerial vehicles (UAVs), equipped with advanced AI algorithms, offer a promising solution to address these challenges.

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In recent years, the application of drones has expanded beyond military and recreational use to encompass a wide range of environmental monitoring and conservation activities. These aerial platforms provide researchers, conservationists, and policymakers with unprecedented access to remote and inaccessible areas, allowing for the collection of high-resolution imagery, data, and real-time information. When coupled with AI technologies, drones can analyze vast amounts of data quickly and accurately, enabling comprehensive ecosystem assessments, species monitoring, and habitat mapping.

This introduction sets the stage for exploring the various applications of drones and AI in monitoring and protecting natural ecosystems. By harnessing the capabilities of these cutting-edge technologies, conservation efforts can be enhanced, contributing to the preservation of biodiversity, the restoration of degraded habitats, and the sustainable management of natural resources.

The robust growth in sustainable bond markets and other responsible investment instruments will heighten scrutiny on the reliability of non-financial reporting. Investors will increasingly demand substantial evidence beyond mere sustainability goal-setting in a company's development strategy. Consequently, companies will face greater accountability for the accuracy of information regarding achieved results and implemented activities, potentially facing litigation risks. Systematic practices of misrepresentation regarding corporate sustainability efforts (greenwashing) will likely trigger regulatory responses from both governmental and non-governmental entities, leading to expanded and stricter requirements for corporate non-financial reporting.

Vladimir Linnik, a professor at the State University of Energy and Energy's Department of Economics and Management, highlights the potential of artificial intelligence (AI) in mitigating the negative impact of greenhouse gases resulting from the combustion of fossil fuels.

According to Linnik, AI-driven solutions have already demonstrated their ability to enhance the efficiency of electricity generation. Additionally, AI can optimize energy consumption by intelligently controlling lighting and heating systems in buildings and streets. By reducing electricity demand, less fuel needs to be burned at power plants, thereby lowering greenhouse gas emissions.

Linnik points out the "Smart Power Plant" project in Russia as a notable initiative in this regard. This project is recognized as a significant component of the country's future energy system, indicating a growing recognition of the role of AI in addressing environmental challenges in the energy sector.

In Russia, the development of an AI-based reference system called "EcoVika" has emerged, offering consultations on environmental issues and sustainable development. This platform allows users to access information on environmental concerns, receive tips and advice, and even consult with experts if the AI-generated responses are insufficient.

Hydrogen energy stands out as a key area where AI can deliver substantial benefits. The integration of neural networks in this field can notably enhance the efficiency of hydrogen production and optimize processes related to its storage, transportation, and utilization. Linnik highlights AI's potential in determining optimal locations for hydrogen filling stations, as well as devising efficient routes for delivering hydrogen fuel cylinders. Additionally, AI can facilitate predictions of hydrogen consumption and optimize its distribution.

In urban settings, AI is already playing a pivotal role in improving environmental conditions by aiding in waste management and optimizing urban transportation. For instance, AI algorithms can assist in charting optimal routes for garbage trucks and analyzing air pollution data to inform decisions regarding traffic regulations.

2 Research methodology

The UN Framework Convention on Climate Change was established in 1994 with the goal of stabilizing greenhouse gas concentrations in the atmosphere to prevent adverse anthropogenic effects on the climate system. Subsequently, annual UN climate change conferences have been held, with the most recent one occurring in 2021 in Glasgow. Transitioning to low-carbon energy, achieving economic decarbonization, and attaining carbon neutrality have become central themes within the environmental aspect of the ESG (Environmental, Social, and Governance) agenda.

In 2019, the European Commission unveiled the "European Green Deal," aiming to eliminate greenhouse gas emissions entirely by 2050 and position Europe as the first climate-neutral continent. In 2020, Chinese President Xi Jinping announced plans to achieve carbon neutrality for the Chinese economy by 2060. Russia has also outlined a transition to low-carbon development in various strategic documents, including strategies for socio-economic development with reduced greenhouse gas emissions until 2050, the Energy Strategy until 2035, and concepts for the development of hydrogen energy.

The environmental component of this agenda focuses on reducing greenhouse gas emissions, minimizing damage to nature from human economic activities, ensuring access to drinking water, reducing water and air pollution (including sulfur and nitrogen oxides), and decreasing municipal solid waste while transitioning to a circular economy.

The World Economic Forum's report provides updated recommendations for companies to disclose ESG information, particularly regarding the environmental aspect. Key indicators proposed for reporting include greenhouse gas emissions, the presence of economic activities in protected natural areas and areas crucial for biodiversity, water intake and consumption in regions facing water scarcity, land use for agriculture, forestry, and mining, adherence to sustainability standards or certification programs, impact on land use and ecosystems, air pollution levels, fertilizer usage and its impact on water quality, plastic consumption, solid waste generation, and the proportion of materials recycled (circularity index). These indicators help assess and monitor companies' environmental performance and adherence to sustainable practices.

3 Results and Discussions

However, the momentum towards decarbonization initiatives may escalate due to the desire for greater independence from fossil fuels, prompting increased investment in renewable energy sources. Potential bans on importing hydrocarbons from Russia and surging energy prices will further drive the acceleration of the ESG agenda. The imperative to mitigate climate and environmental impacts and transition towards a more efficient economy will be reinforced by the necessity to seek alternatives to traditional hydrocarbon supplies, including the expansion of alternative energy sources. A case in point is Germany, aiming to achieve 100% green energy by 2035, fifteen years earlier than initially planned.

On the demand side, changing consumption patterns among households and corporate consumers are bolstering the ESG agenda. A surge in demand for renewable energy sources is evident among the public amid growing awareness of traditional energy source shortages. For instance, the UK has witnessed a 20% surge in demand for solar panels on private homes in response to soaring fuel bills, projected to increase from £693 to £1,971.

The dominance of the environmental factor (E) in reporting, goal-setting, and information dissemination, a consistent feature of the ESG paradigm, is expected to persist and strengthen. According to S&P Global, 80% of the world's largest companies report exposure to transition risks linked to climate change, with a similar proportion committed to emissions reduction. This trend is partly attributed to the Paris Climate Agreement of 2015. However, a Deloitte study suggests that, despite the primary focus on environmental risks, certain companies, particularly in the IT sector, may prioritize social risks that could affect long-term investor interests.

Linnik underscores the significance of AI-driven systems like IBM's Green Horizons project, which leverage data to forecast pollution levels and resource consumption. Similar technologies are being developed in Russia, including air pollution monitoring systems employing artificial intelligence. Moreover, the utilization of AI and computer vision, coupled with satellite data, enables the detection of changes in ecosystems and issues such as pests and droughts. Organizations like NASA utilize satellite imagery analysis and machine learning to evaluate and predict the health of phytoplankton in oceans worldwide.

With the ongoing construction boom leading to an increase in construction waste, unauthorized industrial landfills have become a pressing issue. To address this, drones equipped with IP cameras and AI technologies offer a solution. These drones can autonomously identify violations by capturing the driver's face and license plate number of vehicles illegally dumping garbage. Such evidence can then be utilized in legal proceedings, eliminating the need for inspectors to undertake unsafe tasks of independent monitoring. According to forecasts by sociologists and demographers, the global population may surpass 9.7 billion people by 2050, presenting humanity with several critical challenges. Among these challenges, feeding the entire population, combating global warming effectively, and addressing environmental pollution and municipal solid waste (MSW) are paramount. Solutions are being sought in various areas, including growing vegetable protein to remove animals from the protein food chain, reducing greenhouse gas emissions through forest restoration and other means, and employing artificial intelligence to protect the planet's ecosystem and preserve resources for future generations.

The COVID-19 pandemic in 2020 led to a significant improvement in the environmental situation on the planet due to a sharp reduction in production volumes and transport operations. CO2 emissions decreased by 25% during the initial lockdown period. The ecological environment encompasses human interaction with various spheres, including the hydrosphere, atmosphere, and soil, aiming to create comfortable living conditions. It's imperative to address environmental issues at the ecosystem level, considering both human influence and natural processes.

Experts in the field of "smart ecology" advocate for the use of autonomous and connected electric vehicles as a priority area for Earth's ecosystem development. Leading European countries plan to phase out internal combustion engines and diesel vehicles by 2030, replacing them with electric vehicles and implementing algorithmic models to optimize road traffic and reduce greenhouse gas emissions. Computer algorithms are also being used in distributed energy networks to predict peak periods accurately, adjust electricity supplies, and enable users to store and utilize electricity efficiently.

"Smart agriculture" programs utilize drones and artificial intelligence to optimize agricultural processes, reduce water consumption, and minimize the use of fertilizers and pesticides, leading to increased agricultural productivity and improved environmental conditions. Additionally, artificial intelligence plays a crucial role in climate informatics, accurately forecasting weather patterns, meteorological phenomena, and natural disasters. AI-driven algorithms are also employed in "smart emergency management" systems to predict and mitigate risks and threats posed by natural disasters in real-time.

The development of "comfortable connected cities" under the "Smart City" concept integrates artificial intelligence to assess resource consumption, regulate traffic flows, and enhance urban management efficiency. This system enables effective zoning of city territories, design of protective structures, and optimal planning for territorial development and building resettlement within government renovation programs. Artificial intelligence facilitates real-time monitoring and regulation of electricity, water, and resource consumption, as well as traffic flow and citizen movement within cities.

4 Conclusions

The application of drones and artificial intelligence (AI) in monitoring and protecting natural ecosystems offers a promising avenue for advancing environmental conservation efforts. Through the synergistic use of these technologies, significant strides can be made in addressing the multifaceted challenges confronting biodiversity and ecosystem health.

Drones equipped with advanced sensors and imaging capabilities have revolutionized ecological monitoring by providing access to remote and inaccessible areas. These aerial platforms can capture high-resolution imagery, LiDAR data, and other environmental parameters, enabling comprehensive assessments of ecosystems. From tracking changes in land cover and vegetation to monitoring wildlife populations and habitat fragmentation, drones offer a versatile tool for gathering vital environmental data.

However, the true power of drone technology is unlocked when combined with artificial intelligence algorithms. AI enables the automated analysis of large volumes of drone-collected data, allowing for rapid processing and interpretation. Machine learning algorithms can identify patterns, classify ecological features, and detect anomalies with a level of accuracy and efficiency unmatched by manual methods. This capability enhances our ability to monitor ecosystem dynamics, detect environmental changes, and assess the effectiveness of conservation interventions.

One of the key advantages of drones and AI is their cost-effectiveness and scalability. Compared to traditional monitoring methods such as ground surveys or manned aerial missions, drones offer a more economical and efficient means of data collection. They can cover large areas in a fraction of the time, making them particularly suited for monitoring expansive or inaccessible landscapes. This scalability enables conservationists to conduct more frequent and widespread assessments, leading to a more comprehensive understanding of ecosystem health and resilience.

Moreover, the timely and actionable insights provided by drone and AI technologies empower conservationists to implement targeted conservation strategies. By identifying priority areas for protection, assessing the impact of human activities, and guiding habitat restoration efforts, these technologies facilitate evidence-based decision-making. This proactive approach can lead to more effective conservation outcomes, including the protection of endangered species, the restoration of degraded habitats, and the mitigation of human-wildlife conflicts.

However, the widespread adoption of drone and AI technologies in conservation is not without challenges. Regulatory constraints, privacy concerns, technical limitations, and the need for capacity building and training represent significant barriers to their implementation. Addressing these challenges will require collaboration between governments, conservation organizations, researchers, and technology developers to develop robust frameworks, guidelines, and standards for responsible drone use in environmental monitoring and protection.

In conclusion, the integration of drones and artificial intelligence represents a transformative approach to conservation, offering new opportunities to safeguard natural ecosystems and biodiversity. By harnessing the power of technology, stakeholders can work together to address pressing environmental issues and ensure the long-term sustainability of our planet's natural resources.

References

1. G.V. Vorontsova, G.V. Chepurko, R.M. Ligidov, T.A. Nalchadzhi, I.M. Podkolzina, Problems and perspectives of development of the world financial system in the conditions of globalization, **57**, 862-870 (2019)
2. V.V. Goncharov, I.M. Kalyakina, E. Ivanchenko, A.I. Sakhbieva, Problemas econômicos, políticos e jurídicos atuais e perspectivas para o desenvolvimento dos BRICS. Laplage Em Revista, **7(1)**, 383-389 (2021)

3. Y.A. Ivanchenko, T.V. Vorotilina, S.S. Teygisova, I.S. Shul'zhenko, K.A. Selivanova, Fenômeno da competição no ambiente educacional. Revista on line de Política e Gestão Educacional (2022)
4. I. Podkolzina, A. Tenishchev, Z. Gornostaeva, H. Tekeeva, O. Tandelova, Assessment of Threats to Environmental Security and Climate Change. BIO Web of Conferences, **63**, 04002 (2023)
5. I. Podkolzina, A. Tenishchev, Z. Gornostaeva, H. Tekeeva, O. Tandelova, Ecological and Food Security in the Conditions of the Geopolitical Situation in the Worldglobal Digital Transformation Trends in Real Sectors of the Economy. SHS Web of Conferences, **172**, 02041 (2023)
6. L. Agarkova, T. Gurnovich, S. Shmatko, I. Podkolzina, V. Filonich, Priority directions of development of the cluster of innovative education in the regional agro-industrial complex. International Journal of Monetary Economics and Finance, **6(2)**, 718 (2016)
7. A.S. Salamova, O. Dzhioeva, Green transformation of the global economy in the context of sustainable development, 152-159 (2023)
8. A.S. Salamova, Global networked economy as a factor for sustainable development, 03053 (2020)
9. V. Sebestyén, E. Domokos, J. Abonyi, Focal Points for Sustainable Development Strategies: Text Mining-Based Comparative Analysis of Voluntary National Reviews. Journal of Environmental Management, **263** (2020)
10. S.G. Shmatko, L.V. Agarkova, T.G.Gurnovich, I.M. Podkolzina, Problems of increasing the quality of raw material for wine in the stavropol region, **7(2)**, 725-730 (2016)