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Editorial: Emerging trends and advancements of geoinformatics applications in earth and environmental systems

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Editorial on the Research Topic
Emerging trends and advancements of geoinformatics applications in earth and environmental systems

Introduction

Geoinformatics, an interdisciplinary field combining geospatial analysis, remote sensing, and computational technologies, has emerged as a pivotal tool in addressing complex challenges in Earth and environmental systems. By integrating advanced technologies such as Geographic Information Systems (GIS), remote sensing, Geo-AI, and machine learning, geoinformatics facilitates a deeper understanding of environmental dynamics and supports sustainable decision-making. This editorial explores the latest trends and advancements in geoinformatics, with a focus on its applications in domains such as agriculture, forestry, water management, infrastructure, climate resilience, mineral exploration, geohazards, and urban/rural development. Highlighting innovative simulation techniques, statistical reasoning and validation, and cutting-edge technologies like Multispectral and Hyperspectral Remote Sensing and Unmanned Aerial Vehicle (UAV) systems, this Research Topic on emerging trends and advancement in geoinformatics for earth and environmental systems presents seven high-quality research articles selected from twelve submissions, all contributing to the evolving landscape of geoinformatics.

Socio-economic and ecological impacts of coal mining in Yanzhou Coalfield, China

The first study, conducted by Zheng et al., examined the socio-economic and ecological consequences of coal mining in the Yanzhou Coalfield, China, from 1990 to 2020.

Employing socio-economic data, land use analysis, and the Pressure-State-Response (PSR) model, the research evaluates the trade-offs between economic growth and environmental degradation. The findings reveal that coal mining significantly boosted the region's economy, driving GDP growth, industrial output, employment, and urbanization. However, this economic prosperity came at a steep ecological cost. Mining activities transformed agricultural and natural landscapes into industrial zones, leading to a substantial reduction in cultivated land and forests. The study notes increased landscape fragmentation, disrupted ecological connectivity, and land subsidence, which created waterlogged areas unsuitable for agriculture or forestry.

The PSR model highlights a significant decline in ecological security due to intense mining pressures, including vegetation loss and soil degradation. Despite reclamation efforts, full ecosystem restoration remains elusive, underscoring the limitations of current practices. The study recommends integrating ecological security into mining planning, leveraging remote sensing for real-time monitoring, and enforcing stricter environmental regulations. Additionally, it advocates for economic diversification to reduce dependence on coal, promoting long-term sustainability in regions like Yanzhou. This research exemplifies how geoinformatics can quantify environmental impacts and inform sustainable resource management strategies, offering a model for other mining-dependent regions globally.

Fine-grained tree species classification using hyperspectral imagery

The second article, by Zhou et al., focused on fine-grained classification of tree species using hyperspectral imagery from the Chinese Resource-1 02D satellite in Maguan County, Yunnan Province, China. The study employs a Backpropagation (BP) neural network to achieve a classification accuracy of 92.5%, demonstrating the efficacy of hyperspectral data in distinguishing dominant tree species. By identifying optimal spectral bands that capture unique spectral signatures, the research enhances species differentiation in diverse ecosystems. The integration of field measurements with satellite data ensures robust model validation, making the methodology scalable for forest resource management, biodiversity monitoring, and environmental conservation.

The high spectral resolution of the Resource-1 02D satellite outperforms traditional multispectral data, enabling precise species identification. This capability is critical for monitoring forest health, assessing biodiversity, and supporting conservation efforts. The study highlights the potential of hyperspectral remote sensing in large-scale ecological applications, offering a cost-effective and accurate approach to managing forest resources. By bridging advanced machine learning with high-resolution imagery, this research underscores the transformative role of geoinformatics in environmental studies.

Comparative analysis of high-temperature target retrieval using SWIR and TIR data

Yu et al. investigated the use of short-wave infrared (SWIR) and thermal infrared (TIR) data for detecting high-temperature targets, such as forest fires, grassland fires, heap coking, straw burning, and volcanic eruptions in general. The study compares the effectiveness of SWIR (1.3–2.5 μm) and TIR (8–14 μm) data in retrieving thermal anomalies, which have significant environmental and societal impacts. The authors propose two schemes for estimating the reflectivity of background pixels within high-temperature mixed pixels, emphasizing spectral consistency with surrounding normal-temperature objects.

The research demonstrates that SWIR and TIR data offer complementary strengths for rapid, macroscopic detection of high-temperature targets. By leveraging remote sensing technologies, the study addresses the challenge of accurately retrieving temperatures for small-area targets, which is critical for timely disaster response and environmental monitoring. The findings highlight the importance of integrating multiple spectral bands to enhance detection accuracy, paving the way for improved monitoring of geohazards and environmental phenomena.

Adaptability of the FIRST model in the Hobq Desert

Zheng et al. evaluated the applicability of the Framework for Integrated Resource and Sustainability Tools (FIRST) model in the Hobq Desert, a typical arid region in northern China. The study assesses the model's ability to support sustainable land management by integrating ecological and socio-economic factors. The results indicate that the FIRST model is highly adaptable to the desert's unique conditions, effectively guiding land-use planning and management strategies. By balancing ecological protection with economic development, the model offers a robust decision-support tool for combating desertification and managing natural resources.

The study provides actionable insights for policymakers, demonstrating how the FIRST model can inform targeted interventions for sustainable development in arid landscapes. Its findings are particularly relevant for regions facing similar environmental challenges, where geoinformatics can bridge data-driven analysis with practical management solutions. This research highlights the role of integrated modelling in promoting resilience and sustainability in vulnerable ecosystems.

Automating band selection for hyperspectral indices

Peddinti et al. explored a novel approach to harmonize hyperspectral data from AVIRIS-NG with multispectral data from Sentinel-2 satellites. The study develops an automated band selection algorithm to identify the most informative spectral bands, enhancing the accuracy of earth science applications such as land cover classification and vegetation analysis. By aligning AVIRIS-NG's high-resolution data with Sentinel-2's spectral characteristics, the algorithm facilitates seamless data integration, improving the monitoring of ecological and geological phenomena.

The research validates the effectiveness of the selected bands in capturing critical environmental information, demonstrating significant improvements in interoperability between hyperspectral and multispectral datasets. This methodology is particularly

valuable in regions with limited access to high-resolution hyperspectral data, as it leverages the widespread availability of multispectral data. The study underscores the potential of automated band selection to advance remote sensing applications, contributing to more accurate and comprehensive analyses of Earth systems.

Geospatial and AHP-Based groundwater recharge potential mapping

Pirasteh et al. presented a comprehensive approach to delineate groundwater recharge potential zones in Haridwar District, India, using geospatial analysis and the Analytic Hierarchy Process (AHP). The study integrates thematic layers such as land use/land cover, soil type, slope, drainage density, lineament density, rainfall, and geology to create a recharge potential map. By assigning weights through AHP, the research identifies areas with high, moderate, and low recharge potential, providing critical insights for water resource management.

The findings highlight suitable zones for artificial recharge structures, such as percolation tanks and check dams, offering a replicable model for regions facing groundwater depletion. The integration of geospatial techniques with AHP enhances the precision of recharge potential mapping, supporting sustainable water management strategies. This study demonstrates the power of geoinformatics in addressing hydrogeological challenges, with implications for water-scarce regions worldwide.

Spatiotemporal coupling of ecological quality and urbanization in Jiangsu, China

The final study Luo et al. examined the dynamic relationship between ecological environmental quality (EEQ) and urbanization in Jiangsu Province, China, using a coupling coordination degree model. The research reveals significant spatial and temporal disparities in the coordination between urban development and environmental quality. Southern regions of Jiangsu exhibit higher coordination compared to northern areas, where rapid urbanization often outpaces environmental management. The study identifies key influencing factors, including policy frameworks and land-use practices, that shape this relationship.

By highlighting areas where ecological considerations lag behind urban growth, the research provides actionable insights for policymakers. It emphasizes the need for integrated urban planning that prioritizes environmental sustainability, offering a framework for balancing growth with ecological preservation. This study underscores the role of geoinformatics in analyzing complex socio-environmental interactions, contributing to sustainable development goals.

Broader implications and future directions

The seven studies in this Research Topic on emerging trends and advancement in geoinformatics for earth and environmental systems collectively highlight the transformative impact of geoinformatics in addressing pressing environmental challenges. By leveraging GIS, remote sensing, hyperspectral imaging, and machine learning, researchers are developing innovative solutions to monitor and manage Earth systems effectively. These advancements enhance our understanding of complex environmental dynamics, from land use changes to groundwater recharge and ecological quality. They also provide actionable insights for policymakers, supporting evidence-based decisions that promote sustainability and resilience.

Looking ahead, the field of geoinformatics is poised for further growth, driven by advancements in Geo-AI, machine learning, and sensor technologies. The integration of UAV systems and high-resolution hyperspectral data will continue to enhance the precision and scalability of environmental monitoring. Interdisciplinary collaborations will be critical in addressing multifaceted challenges, combining expertise from environmental science, data science, and policy analysis. Additionally, the development of open-access datasets and user-friendly tools will democratize access to geoinformatics, enabling broader participation in environmental management.

However, challenges remain, including the need for standardized methodologies, improved data interoperability, and capacity building in developing regions. Addressing these barriers will require sustained investment in research, infrastructure, and education. As geoinformatics evolves, its ability to provide real-time, high-resolution insights will be paramount in tackling global Research Topic such as climate change, resource depletion, and urbanization.

Conclusion

Geoinformatics stands at the forefront of environmental science, offering powerful tools to address the complex interplay of human and natural systems. The studies in this Research Topic on emerging trends and advancement in geoinformatics for earth and environmental systems demonstrate the field's potential to drive sustainable outcomes across diverse domains, from mining and forestry to water management and urban planning. By embracing emerging technologies and fostering interdisciplinary collaboration, geoinformatics will continue to shape a more resilient and sustainable future for Earth and its inhabitants.

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