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Special Issue on the Application of Remote Sensing Spatio-temporal Big Data to Effective Environmental Monitoring and Sustainable Development

SUN Genyun[1], REN Jinchang[2], SUN Qian[3], JIA Mingming[4]

1 College of Oceanography and Space Informatics, China University of Petroleum (East China), Qingdao 266580, China;
2 National Subsea Centre, Robert Gordon University, Aberdeen AB10 7AQ, U. K;
3 School of Science, RMIT University, Melbourne 3001, Australia;
4 Northeast Institute of geography and Agroecology, Chinese Academy of Sciences, Changchun 130102, China

The rapid advancement of remote sensing, data science, and geographic information technology has ushered in an era of substantial information explosion. Massive spatio-temporal big data provides rich data resources and technical means have facilitated new opportunities for large-scale and complex monitoring of land and ocean resources and environment, urban changes and natural disasters[1-2]. Nevertheless, the utilization of spatio-temporal big data still faces challenges. How to integrate these data so as to understand land and ocean changes more comprehensively and systematically requires breakthroughs in some basic theories and key technologies[3-4]. In the context of the rapid development of artificial intelligence, the fusion of remote sensing spatio-temporal big data and big models, geospatial analysis and other methods provides technical support for us to better understand the diversity and changes of the land and marine environment, and provides a theoretical basis for more effective environmental monitoring and resource utilization.

To timely capture the latest achievements and cutting-edge advancements in this context, this special issue focused on invited submissions from both domestic and international researchers. With six contributed articles being selected for publication, they have covered diverse areas in terms of the research topics and applications as detailed below.

In HUANG et al.[5], building extraction in urban areas is focused on urban map updating, urban planning and construction, making use of the high-resolution images from the GF-2 satellite remote sensing. By combining multi-scale segmentation technology and CART classification in an object-oriented classification framework, buildings are successfully extracted with an overall classification accuracy of up to 89.5% and a Kappa coefficient of 0.86.

In TOLIE et al.[6], underwater sensing is emphasized for environmental protection and sustainable energy transition, using multimodal sensing and machine learning. The key tasks include underwater object detection and distance estimation by combining affordable sonar technology with stereo vision-based depth cameras, with achieved accurate depth maps for distances up to 1.2 meters. This is crucial for not only improved underwater robotics navigation, manipulation, and exploration but also for effective monitoring and maintaining energy infrastructure, such as offshore wind farms and underwater pipelines.

In Literature [7], a comprehensive multi-model machine learning and geospatial analytics approach is proposed for robust analysis of car crash occurrence dynamics and the influencing variables in the Greater Melbourne area, Australia. By harnessing Random Forest with Shapley Additive Explanations, Generalized Linear Regression and Geographically Weighted Regression, it has not only highlighted pivotal contributing elements but also enriched our findings by capturing often overlooked complexities, unveiling the complicated interactions intrinsic to vehicular incidents. By incorporating hexagonalized geographic units, road geometry,average land surface temperature, etc., the granularity of crash density is evaluated to pinpoint high-risk zones and influential determinants, for insightful targeted safety interventions.

Taking the Guangxi Beibu Gulf Economic Zone as the study area, the MCR-gravity model is used to construct a higher precision ecological network, using 10-meter high-resolution land use data from 2017 and 2021[8]. The network comprises 11 ecological sources, 91 ecological corridors, and 71 ecological nodes, which are further optimized and comparatively analyzed using circuit theory and network analysis methods. Insightful findings are derived to show an increasing landscape fragmentation and a decline in landscape connectivity as well as enhanced ecological network connectivity within the study area.

Taking the Yellow River Delta as a case, a new framework is proposed to evaluate the heterogeneity effect of human disturbances on wetland landscape patterns[9]. First, the pixel-level Human Disturbance Index (HDI) is derived to quantify the spatial difference of human disturbances, followed by the Geographically Weighted Regression (GWR) model to analyze the spatial correlation between HDI and landscape indices, and Area-Weighted Mean Shape Index (SHAPE_AM). It showed that the HDI and spatial heterogeneity have increased gradually in the past 30 years, where human disturbances mainly occur in coastal areas, along with slightly reduced HDI in most inland areas, though the landscape pattern has changed tremendously, where the useful findings will provide valuable guidance for wetland conservation and management.

In Literature [10], accurate monitoring of rice planting areas is focused, as an important task for supervising the 1.8 billion mu (1 mu $\approx$ 666.667 m^2) of arable land in China, aiming to address the issues of low efficiency, high cost, and insufficient accuracy. A high-precision UAV remote sensing image dataset is constructed for rice identification, covering various growing stages, resolutions, and multiple regions. Deep learning semantic segmentation using the Deeplabv3+ and PSPNet models has been achieved for accurate rice monitoring. By integrating the few-shot transfer learning, the Intersection over Union (IoU) is improved by 5%~10% compared to other approaches.

As elaborated above, the six articles within the special issue are strongly linked to the task of remote sensing spatio-temporal big data based effective environmental monitoring and sustainable development. These have covered not only topics in urbanization, such as building extraction[5], geospatial analysis of car crash patterns[7], analysis and optimization of ecological network change, and evaluation of human impacts on wetland landscapes[8], but also integrated solutions for underwater sensing and navigation[6] and precise monitoring of rice planting areas[10].

In addition, there is a trend to apply multimodal sensing and advanced machine learning, such as deep learning models, where more advanced techniques are needed for covering different technical gaps, such as quality assessment and image enhancement[11], cross-modal learning[12], improving the reliability of pseudo labels[13] and more efficient new models for deep learning[14], to list a few.

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