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Editorial

GeoAI: Integration of Artificial Intelligence, Machine Learning, and Deep Learning with GIS

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Geographic Information Systems (GIS) have become increasingly important in various fields such as urban planning, environmental management, transportation, and agriculture. GIS allows for the collection, analysis, and visualization of spatial data, enabling decision-makers to make informed decisions based on spatial patterns and relationships. However, as the amount of spatial data continues to grow exponentially, traditional GIS methods are facing challenges in handling and analyzing such large datasets.

Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) are emerging technologies that have shown great potential in improving GIS. AI involves the development of intelligent machines that can perform tasks that typically require human intelligence, while ML focuses on the development of algorithms that enable machines to learn from data. DL is a subfield of ML that uses neural networks to process large and complex datasets.

This Special Issue of *Applied Sciences* presents a collection of research papers that explore the integration of GIS with AI, ML, and DL. The papers cover a wide range of topics, including image classification, object detection, land cover mapping, and urban growth prediction. The main contribution of the papers is to develop new methods for processing and analyzing large spatial data sets. These methods have shown great potential in improving the accuracy and efficiency of these tasks compared to traditional GIS methods.

Liu et al. [1] propose a method for generating labeled remote sensing scene images (RSSI) using element geometric transformation and generative adversarial networks (GAN)-based texture synthesis, which addresses the limitations of conventional scene generation methods. The method involves segmenting the RSSI, performing geometric transformations on the elements, extracting texture information, and using GAN-based modeling to generate the texture. The generated RSSI achieved better visual effects and increased the complexity of the scene, while the performance of convolutional neural networks (CNN) classifiers was reduced, indicating the proposed method's potential for generating diverse scene data with sufficient fidelity even with a small sample size.

Zhao et al. [2] compare twelve machine learning regression algorithms for the spatial decomposition of demographic data with multisource geospatial data, using grid search and cross-validation methods to ensure optimal model parameters. Results show that all global regression algorithms used in the study exhibited acceptable results, with k-nearest neighbors (KNN) being the most accurate. The study also found that multisource geospatial data significantly improved the accuracy of spatial decomposition results, and the proposed method can be applied to the study of spatial decomposition in other areas.

Iddianozie and McArdle [3] investigate the impact of data representation on machine learning model performance for inference tasks on spatial networks. The authors explore the use of homogeneous and heterogeneous representations of spatial networks, and argue that representations that explicitly encode the relations between spatial entities would improve model performance. Through an empirical study using graph neural network models, the authors demonstrate that heterogeneous representations improve model performance for downstream inference tasks on spatial networks.

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Muhadi et al. [4] propose a semantic segmentation method based on CNN for identifying water regions from surveillance images and estimating river water levels. The performance of two well-established deep learning algorithms, DeepLabv3+ and SegNet networks, was evaluated using several evaluation metrics, and both networks achieved high accuracy, with DeepLabv3+ outperforming SegNet. The proposed water level framework was evaluated using Spearman's rank-order correlation coefficient, showing a strong relationship between estimated and observed water levels. The proposed approach has high potential as an alternative monitoring system for flood management and related activities.

Bosisio et al. [5] propose a methodology for optimizing the siting and timing of primary substations to expand distribution networks, using a geographic information system, particle swarm optimization algorithm, and Voronoi diagram-based approach. The optimization criteria prioritize serving every customer from the nearest primary substation to reduce delivery distance, cost, electric losses, and service interruption. The methodology was tested using Unareti's distribution system in Milan and Brescia and was found to be effective in guiding distribution system operators in expanding their networks to address energy transition challenges.

Lu and Liu [6] propose a spatial–temporal approach for forecasting PM2.5 using temporal and spatial features for 48 h. The proposed approach considers the relationship between weather similarities and PM2.5 similarity, and the air quality similarities of adjacent monitoring stations. The experimental results show that the proposed approach outperforms the two well-established measurement-based methods in terms of PM2.5 forecast error, using AirBox data.

Overall, this Special Issue demonstrates the great potential of AI, ML, and DL in advancing GIS research and applications. These emerging technologies provide new opportunities for handling and analyzing large spatial datasets, improving the accuracy and efficiency of spatial analysis tasks, and developing new tools and frameworks for integrating GIS with other disciplines. I hope that the papers in this Special Issue will inspire further research and development in this exciting field.

Conflicts of Interest: The authors declare no conflict of interest.

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