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Editorial: Artificial intelligence in environmental engineering and ecology: towards smart and sustainable cities

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Editorial on the Research Topic
Artificial intelligence in environmental engineering and ecology: towards smart and sustainable cities

Introduction

The escalating global population intensifies resource scarcity, biodiversity decline, and climate change, placing immense pressure on ecosystems and generating numerous social, economic, and environmental crises. Embracing sustainable development presents a pathway to mitigate these environmental challenges through enhanced resource efficiency and conservation efforts. Given the intricate relationship between population growth and its environmental ramifications, a collaborative interdisciplinary strategy, integrating diverse fields of knowledge, is essential. Recognizing the Sustainable Development Goals as a blueprint for a viable future, interdisciplinary research within civil and environmental engineering assumes paramount importance. It is now critical to formulate interdisciplinary solutions aimed at realizing these goals, particularly focusing on fostering sustainable cities and communities, ensuring access to affordable and clean energy, providing clean water and sanitation, promoting responsible consumption and production patterns, advancing industry, innovation, and infrastructure, and enacting effective climate action. Meeting the pressing demands for sustainable urban environments, accessible and clean energy sources, safe water and sanitation systems, conscientious consumption and production practices, advancements in industry, innovation, and infrastructure, and robust climate action requires the immediate development of interdisciplinary solutions to achieve the Sustainable Development Goals.

This Research Topic "Artificial Intelligence in Environmental Engineering and Ecology: Towards Smart and Sustainable Cities" is floated with an intention to capture the essence of latest research to advance the field of environment and sustainability. This compilation

showcases cutting-edge innovations and actionable solutions aimed at achieving the Sustainable Development Goals, particularly highlighting interdisciplinary engineering research pertinent to SDGs 3, 6, 7, 9, 11, 12, 13, 14, and 15 for a sustainable future. The purpose of this Research Topic is to bring together a range of innovative studies pushing the boundaries of thought on integrating environmental engineering and artificial intelligence. The editorial outlines the contributions and the ways in which they help us better understand application of AI in environmental engineering for smart cities. With contributions from researchers across several countries including China, United States, India, Turkey, Iran, Denmark, Republic of Korea, Romania, Australia, the Research Topic features 10 scholarly papers that include three review articles and seven original research papers. These ten papers in this Research Topic, delve into critical Research Topic such as water contamination, prediction of air pollutants, pile fire detection, reducing smart city corporate carbon intensity and overall environmental pollution. The researchers employ a variety of AI methodologies including deep learning, Convolutional Neural Networks (CNN), Gene Expression Programming (GEP), Graph Attention Networks (GAT), K-Nearest Neighbor (KNN) Fuzzy Modeling, Causal Spatio-Temporal Attention Networks (Causal-STAN), and autoencoders (AE).

Review articles: establishing the role of artificial intelligence in environmental and infrastructure monitoring

The three review articles present the potential of utilizing AI capabilities in environment and smart city related problems to arrive at a suitable solution. Kaveh and Alhajj summarize various approaches to crack detection to enhance the current practices, Chakurkar et al., present potential of AI in detecting cracks in infrastructure works in smart cities. This review highlights two key approaches for the detection of cracks that are deep learning and traditional computer vision. In addition to the crack detection, the review also discusses ways to quantify the crack severity level. Similarly, Popescu et al., through a review, have summarised AI solutions for hazardous substance monitoring in different environments including air, water and soil along with AI powered technologies for pollution monitoring including spectroscopy, ground-based monitoring sensors, aerial imaging and unmanned aerial vehicles (UAVs), ground robotics, satellite remote sensing.

In addition to the review articles the Research Topic comprises of following original researches.

Original research: innovative applications of AI in environmental engineering

The seven original research papers present leading AI techniques applied to a range of environmental challenges. Each contributes unique insights and solutions aimed at achieving sustainable development goals through smart technologies.

Chao and Qiu present a novel fuzzy modeling approach for estimating air pollution concentrations that integrates an enhanced evidence theory with comprehensive weighting and the K-nearest neighbor (KNN) interval distance within the framework of the matter-element extension model. Capable of reducing the error rate by 38% relative to alternative methods, the authors point towards improving computational efficiency using AI in air quality monitoring.

Similarly, Bashardoost et al., present potential of autoencoder (AE) in denoising the input data for deep learning and then using it for building CNN algorithm to carry out spatial modeling and risk mapping of air pollutants including PM 2.5, PM 10, SO_2, NO_2, O_3, and CO. With prediction accuracies ranging from 0.8 to 0.96, the study highlights CNN-AE model's impressive precision when generating the pollution risk map. Meanwhile, Wang et al. explore GEP to construct the relationship between pollutant gas and $PM_{2.5}/PM_{10}$ and back propagation neural networks (BPNN) as a baseline method. With the experimentation, they demonstrate usability of the proposed approach in environmental modelling. Wang et al. develop spatio-temporal attention causal convolutional neural network (Causal-STAN) architecture for predicting PM2.5 concentrations, proving it to be a superior architecture as compared to recurrent network model.

Furthermore, Joshi et al. present investigations of the application of multiple machine learning algorithms to detect wildfires. Applying novel deep learning with ensemble approach to the early detection has proven to be promising. Anaadumba et al., propose use of Graph Attention Network (GAT) to predict lead contamination in drinking water proving to be better than XGBoost machine learning algorithm. Peng et al. demonstrate using the difference-in-differences model to empirically analyze the impact of the smart city pilot policy on corporate carbon intensity.

Key studies demonstrate significant advancements in prediction accuracy, risk mapping, and early detection of environmental hazards. The Research Topic underscores the growing role of AI in tackling air and water pollution and calls for more research in areas like soil contamination and solid waste management. Contributions from countries across multiple continents demonstrate the global interest in applying AI to sustainability challenges. The Research Topic has benefited from a broad international authorship, with China contributing the most papers. The use of diverse AI tools from traditional models to cutting-edge neural networks shows that tailored solutions are often effective and necessary depending on the specific problem being addressed. Use of AI methods could help address more comprehensive environmental goals promising a more resilient, efficient, and sustainable future.

The Research Topic is guest-edited by scholars from Australia and India, with editorial coordination led by Dr. Vaishnavi Dabir. The editorial team wish to extend gratitude to the entire Frontiers team for their continuous support throughout the publication process. This collaborative effort has offered a platform for researchers to share their perspectives and innovations in applying AI to environmental engineering.

Author contributions

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