DOI: 10.1002/dug2.70004

EDITORIAL

DUSE WILEY

Machine learning and Big Data in deep underground engineering

This special issue of *Deep Underground Science and Engineering* (DUSE) showcases pioneering research on the transformative role of machine learning (ML) and Big Data in deep underground engineering. Edited by guest editors Prof. Asoke Nandi (Brunel University of London, UK), Prof. Ru Zhang (Sichuan University, China), Prof. Tao Zhao (Chinese Academy of Sciences, China), and Prof. Tao Lei (Shaanxi University of Science and Technology, China), this issue highlights the innovative applications of ML technique in reshaping structural safety, tunneling operations, and geotechnical investigations.

As underground engineering challenges grow in complexity, ML and Big Data have become indispensable tools for improving prediction accuracy, optimizing operational efficiency, and ensuring the long-term safety and sustainability of infrastructure. By leveraging vast datasets, automating critical processes, and predicting complex engineering outcomes, these technologies are enabling smarter, more reliable engineering practices that drive both performance and resilience.

The contributions to this special issue illustrate the diverse and impactful applications of ML and Big Data in deep underground engineering. One article introduces ALSTNet, an advanced data-driven model that integrates long- and short-term time-series data using autoencoders to predict tunnel structural behaviors. When applied to strain monitoring data from the Nanjing Dinghuaimen tunnel, ALSTNet outperforms traditional models, offering promising potential for early disaster prevention in real-world engineering scenarios. Another study presents two robust ML models—Gene Expression Programming (GEP) and a Decision Tree-Support Vector Machine (DT-SVM) hybrid algorithm—to assess pillar stability in deep underground mines. Validated with 236 case histories, these models demonstrate exceptional accuracy and provide valuable tools for project managers to evaluate pillar stability during both the design and operational phases of mining projects. Yet another study demonstrates the use of fuzzy C-means clustering combined with ML models in Tunnel Boring Machine (TBM) operations. This innovative approach enhances prediction accuracy, providing more reliable insights for TBM tunneling processes and boosting efficiency in underground excavation projects.

Several other papers focus on optimizing monitoring systems for underground structures. One contribution presents a low-cost micro-electromechanical systems (MEMS) sensor designed to monitor tilt and acceleration in underground structures. Aided by ML algorithms, this sensor facilitates real-time monitoring and early warning capabilities, thereby significantly improving safety during underground construction. Another paper introduces a ML-based optimization model for underwater shield tunnels, showing how strategically placed monitoring points—such as at the spandrel and arch crown—can improve the accuracy of stress distribution predictions and enhance structural health monitoring.

Additionally, this special issue addresses the challenge of predicting rock fragmentation post-blasting. A suite of hybrid ML models—Random Forest, AdaBoost, and Gradient Boosting—optimized with the Bayesian Optimization Algorithm (BOA), showcases superior prediction accuracy. These models offer an advanced and highly reliable method for predicting rock fragmentation in mining engineering applications. The integration of ML with sensor technologies, optimization algorithms, and predictive models in these papers highlights the tremendous potential of AI to revolutionize deep underground engineering. As these technologies continue to evolve, they promise to drive substantial improvements in safety, efficiency, and environmental sustainability within the sector.

Through this special issue, DUSE reaffirms its commitment to promote the application of ML technique in deep underground engineering. We look forward to future contributions that continue to explore new applications and push the boundaries of what is possible in this rapidly advancing field.

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