A Postprint of the Rockburst Intensity Prediction Method Integrating Convolutional Neural Networks and Transformer

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Date: 2025-07-29T19:11:12+00:00

Abstract

Rockburst is a dynamic instability hazard triggered by the sudden release of elastic strain energy from rock masses during deep underground engineering excavation, representing one of the prevalent geological disasters in deep subsurface projects. The frequent occurrence of rockburst incidents poses severe threats to both personnel safety and property, rendering accurate prediction of rockburst intensity critical for addressing this challenge. This study proposes and implements a multi-model deep learning framework for rockburst intensity prediction that integrates Convolutional Neural Network (CNN) and Transformer architectures (CNN-Tran model). The CNN-Tran model efficiently processes high-dimensional complex data by leveraging CNN's capability to extract local features while preserving critical information, combined with Transformer's strength in capturing global relationships. Initially, principal component analysis and feature selection are conducted on collected rockburst sample data from domestic and international sources. Subsequently, comparative experiments are performed for feature selection, with the selected features and label characteristics constituting the model dataset. Finally, the proposed methodology is applied to train and predict on this dataset, with experimental comparisons conducted against Support Vector Machine (SVM), Random Forest (RF), Deep Neural Network (DNN), Recurrent Neural Network (RNN), CNN, Long Short-Term Memory (LSTM), and Transformer models. The experimental results demonstrate that the CNN-Tran model achieves superior performance across four evaluation metrics—accuracy, precision, recall, and F1-score—significantly outperforming alternative models, thereby validating its accuracy and high precision in rockburst intensity prediction. This substantiates that the CNN-Tran model can effectively mitigate or even prevent engineering accidents, consequently safeguarding human life and property.

Full Text

Rockburst Intensity Prediction Using a Multi-Model Deep Learning Approach Integrating Convolutional Neural Networks and Transformer

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Abstract

Rockburst is a dynamic instability disaster caused by the sudden release of elastic strain energy in rock masses during deep underground excavation, representing one of the most common geological hazards in deep underground engineering. With frequent rockburst incidents posing severe threats to personnel safety and property, accurate prediction of rockburst intensity has become critical for addressing this challenge. This paper proposes and implements a multi-model deep learning prediction framework for rockburst intensity (CNN-Tran model) that integrates Convolutional Neural Networks (CNN) and Transformer. By combining CNN's capability to extract local features while preserving important information with Transformer's ability to capture global relationships, the CNN-Tran model efficiently processes high-dimensional complex data.

The methodology involves conducting principal component analysis and feature selection based on collected domestic and international rockburst sample data, followed by experimental comparison to select optimal features for constructing the model dataset alongside label features. The proposed model is then trained and evaluated on this dataset, with comprehensive comparisons against Support Vector Machine (SVM), Random Forest (RF), Deep Neural Network (DNN), Recurrent Neural Network (RNN), CNN, Long Short-Term Memory (LSTM), and Transformer models. Experimental results demonstrate that the CNN-Tran model significantly outperforms all comparison models across four evaluation metrics: accuracy, precision, recall, and F1-score, thereby validating its effectiveness and high precision in rockburst intensity prediction. These findings indicate that the CNN-Tran model can effectively reduce or even prevent engineering accidents, safeguarding both human lives and property.

Keywords: rockburst; rockburst intensity prediction; convolutional neural network; Transformer network; CNN-Tran model

Note: Figure translations are in progress. See original paper for figures.