AN END-TO-END DEEP LEARNING MODEL FOR PREDICTING TOTAL INCOMBUSTIBLE CONTENTS IN COAL/STONE DUST

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Coal dust explosions are a significant threat to underground coal mines. To reduce this risk, the combustible coal dust must be diluted with stone dust to increase the total incombustible contents (TIC), typically measured through time-consuming laboratory tests. Current machine learning models for TIC prediction from high-dimensional spectral data often require extensive preprocessing, such as feature exaction, outlier removal and scaling, which increases complexity and manual effort.

We present a Convolutional Neural Network (CNN) with residual connections method for end-to-end analysis of raw near-infrared (NIR) spectroscopy data to classify the TIC of coal/stone dust, effectively eliminating most preprocessing steps. Using 300 samples from Australia coal mines, the model's performance with varying number of residual blocks were evaluated. The results show that the introduction of residual blocks significantly enhances the classification accuracy of the CNN model, even without hyper-parameter optimization, by enabling the model to automatically extract the most relevant features from the high-dimensional spectral data. However, the optimal number of residual blocks is crucial as excessive blocks can decrease the model's performance.

Two challenges were identified. First is the class imbalance, where the model struggles with predicting the least represented class. Second, the high similarity among some raw NIR samples with significant difference in TIC values, affects model's generalization. Despite these challenges, our study demonstrated the potential for developing a reliable and efficient end-to-end deep learning model for TIC prediction using NIR spectroscopy, providing a significant reduction in preprocessing efforts.