A Gamma Spectrum Radionuclide Identification Method Based on Attention Mechanism and Residual Network

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Abstract

Isotope identification is a critical foundation for nuclear material control, environmental radiation monitoring, and nuclear security assurance. Traditional gamma spectroscopy analysis methods suffer from limited identification accuracy and insufficient feature extraction capabilities, making them inadequate for meeting the practical demands of high-precision isotope identification. To address this challenge, this paper proposes a deep learning model based on residual neural networks for the automatic parsing of gamma spectrum data and isotope identification. The model integrates a residual structure with a Squeeze-and-Excitation (SE) attention mechanism, incorporates the Mish activation function to enhance gradient flow and information transmission, and employs layer normalization to improve training stability and convergence efficiency. Tailored to the characteristics of gamma spectra, the Huber loss function with strong robustness is adopted as the optimization objective. Experimental results demonstrate that the model achieves a Mean Absolute Error (MAE) of 0.0022, Root Mean Square Error (RMSE) of 0.0031, and Coefficient of Determination (R^2) of 0.9932 on the validation set. Attention visualization analysis reveals that the model automatically focuses on characteristic energy peak regions of key isotopes, such as the 661.7 keV peak of 137Cs and the 1173.2 keV and 1332.5 keV double peaks of 60Co, thereby effectively parsing the implicit isotopic energy features within the spectrum and achieving precise identification through comparison with isotope characteristic libraries, which demonstrates excellent physical interpretability and practical application potential.

Full Text

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