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A Study on Enhancing Multi-Radioisotope Identification in CsI(Tl) Gamma Spectra Using 2D Convolutional Neural Networks

Thursday, November 14, 2024 1:00 PM (1h 30m)

Radio-Isotope Identification (RIID) using Convolutional Neural Networks (CNNs) has been actively studied for their ability to identify key gamma-ray spectrum features. Our research team enhanced RIID performance by innovatively transforming traditional 1D gamma spectra from CsI(Tl) scintillator measurements of radioisotopic mixtures into 2D image data for CNNs training [1]. To improve model generalization, this study incorporated random background noise, gain shifts, and count variations into the dataset. RIID performance was then compared between models trained with 1D and 2D inputs across varying gain shift and count levels.
Experimental setup involved acquiring spectra at 20℃ from eight target radioisotopes, including 241Am, 57Co, 137Cs, 60Co, 22Na, 133Ba, 109Cd, and 54Mn, as well as background sources 226Ra, 232Th, 40K, and depleted uranium. Spectra for 232Th and 40K were generated via Monte Carlo simulation based on gamma energies and intensities obtained from IAEA Nuclear Data. Individual spectra were normalized to a maximum intensity and assigned random weights to create composite spectra with radioisotopic mixtures. To account for temperature-induced channel shifts, gain variations from -10% (0℃) to +10% (35℃) relative to 20℃ were applied randomly to the composite spectra. The total spectrum count was set between 1,000 and 20,000, with random counts assigned to each channel according to its probability distribution.
The model trained with 2D data was evaluated against the model trained with 1D data regarding gain shift and count changes, using mean square error (MSE) between target and predicted values as a performance metric. Across all radioisotopes, the MSE for the 2D model trained with 2D averaged $(1.02\pm0.05)\times10^{-3}$, approximately 2.3 times smaller than that for the model trained with 1D, which was $(2.33\pm0.22)\times10^{-3}$. This 2D image-based CNN approach improves RIID accuracy, reliability, and generalization in varied conditions.
Reference:
[1] Kim, Yong Hyun, et al., Radiation Physics and Chemistry 210 (2023): 111054.

Contribution track

ICABU WG4. Applications of Particle Beams

Paper submission Plan

No

Best Presentation

No

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