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Spectrogram Pre-Processing to Improve Isotopic Identification to Discriminate Gamma and Neutrons Sources

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Abstract : Industrial application to classify gamma rays and neutron events is investigated in this study using deep machine learning. The identification using a convolutional neural network and recursive neural network showed a significant improvement in predication accuracy in a variety of applications. The ability to identify the isotope type and activity from spectral information depends on feature extraction methods, followed by classification. The features extracted from the spectrum profiles try to find patterns and relationships to present the actual spectrum energy in low dimensional space. Increasing the level of separation between classes in feature space improves the possibility to enhance classification accuracy. The nonlinear nature to extract features by neural network contains a variety of transformation and mathematical optimization, while principal component analysis depends on linear transformations to extract features and subsequently improve the classification accuracy. In this paper, the isotope spectrum information has been preprocessed by finding the frequencies components relative to time and using them as a training dataset. Fourier transform implementation to extract frequencies component has been optimized by a suitable windowing function. Training and validation samples of different isotope profiles interacted with CdTe crystal have been simulated using Geant4. The readout electronic noise has been simulated by optimizing the mean and variance of normal distribution. Ensemble learning by combing voting of many models managed to improve the classification accuracy of neural networks. The ability to discriminate gamma and neutron events in a single predication approach using deep machine learning has shown high accuracy using deep learning. The paper findings show the ability to improve the classification accuracy by applying the spectrogram preprocessing stage to the gamma and neutron spectrums of different isotopes. Tuning deep machine learning models by hyperparameter optimization of neural network models enhanced the separation in the latent space and provided the ability to extend the number of detected isotopes in the training database. Ensemble learning contributed significantly to improve the final prediction.

Keywords : machine learning, nuclear physics, Monte Carlo simulation, noise estimation, feature extraction, classification
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