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#11-111 Neutron-Gamma Discrimination of Stilbene Crystal, 6Li-doped Plastic and BC501A Liquid Scintillators-based Machine Learning and Signal Processing Techniques

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This paper presents a comparative study of neutron-gamma discrimination performance with stilbene crystal, 6Li-doped plastic and BC501A liquid scintillators coupled to photomultiplier tubes. Neutron-gamma discrimination itself relies upon supervised and unsupervised machine learning algorithms. The method, which is based on blind non-negative matrix factorization (NMF) as an unsupervised model-based source separation and support vector Machines (SVM) as a supervised learning model, aims to achieve separation of neutron and gamma-ray pulses generated from scintillation detectors with high specificity, and high sensitivity as well. The NMF is used for blind source separation when there is no prior information about the mixing process and source signals. It is applied to reconstruct a set of statistically independent original sources from a mixture of output signals induced from radioactive decay of Cf-252 source. A factor of merit, namely the signal-to-interference ratio, is used to validate the separation and reconstruction quality of original sources. The reconstructed independent sources are then characterized by applying a continuous wavelet transform that converts the one-dimensional into two-dimensional time-scale representation (or scalogram). The latter is a complete analysis of the time and scale of the one-dimensional time series signal and allows to identify the characteristics of the reconstructed original sources more accurately. We then use these scalograms to construct and train a binary classification SVM model devoted to the quantitative recognition of neutrons and gamma-rays in a mixed radiation filed. Before using SVM, the Otsu thresholding method and a principal components analysis are implemented to increase the prediction ability of the SVM model. The performance evaluation of the proposed method using stilbene crystal, 6Li-doped plastic and BC501A liquid scintillators is performed by comparing it with a conventional pulse shape discrimination method, namely the charge comparison method (CCM) that is used to obtain the pure training data set for SVM model. Finally, the SVM model based on NMF and CCM is assessed using proper performance metrics, namely the confusion matrix and precision-recall.

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