Applying Deep-learning in gamma-spectroscopy for radionuclide identification

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Introduction

Neural networks, particularly deep neural networks, are used nowadays with great success in several tasks, such as image classification, image segmentation, translation, text to speech, speech to text, achieving super-human performance. In this study we explore the capabilities of deep learning on a new field: gamma-spectroscopy analysis.
Using a well-known deep neural network architecture with gamma spectroscopy data, we successfully identify the radionuclides (Am-241, Ba-133, Cd-109, Co-60, Cs-137, Eu-152, Mn-54, Na-24 and Pb-210) contained in several experiments.
This neural network is also capable to identify different mixed radionuclide in the same source, demonstrating that deep neural networks can be successfully applied on gamma-spectroscopy analysis.

Methods

Using a HPGe detector to acquire several gamma spectra, from different sealed sources, we created a dataset that was used for the training and validation of the neural network.
We created our deep neural network using python as programing language, alongside with *Keras*, a deep learning framework. Applying the VGG19 network architecture, except by the last layer which using *softmax* as activation function, we used sigmoid in order to allow classification of not mutually exclusive classes in the same instance.

Results

After 250 epochs of training the classification error on the training and test datasets reached a minimum, the same occurred with accuracy.
As a final test we used a spectrum from a triple sealed source, containing Am-241, Cs-137 and Co-60. As this kind of data was never seen by the network before we expect that the network generalizes well and correctly classify the spectra as containing the three isotopes.
When applying the new data, the model correctly classified the spectra as containing the tree radionuclide.

Conclusions

The model successfully classifies different spectra with different radionuclides and his performance is good on never seen before data (the triple source sealed) demonstrating that deep learning can be used on a new domain.