Radionuclide identification using subtractive clustering

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Introduction

The correct radionuclide identification can be crucial to planning protective measures, especially in emergency situations, by defining the type of radiation source and its radiological hazard. There are many methods that can be used for automatic radionuclide identification. This report describes an algorithm that can be used to perform a rapid and efficient radionuclide identification, the subtractive clustering algorithm (SC) proposed by Chiu in [1].
The Figure 1 shows a spectrum, generated by simulation, to a radioactive source with Cs-137 and Co-60. The x-axis represents the channels for a 12-bit ADC. In such representation, 4096 channels of the MCA correspond to 2.048 MeV in the energy spectrum. The first peak in channel 1324 is characteristic of Cs-137 (0.662 MeV). The second and third peaks are energies of Co-60. These energies are known as decay energies and define the decay scheme of the radionuclide. Each radionuclide, among many others, has a unique decay scheme by which it is identified.

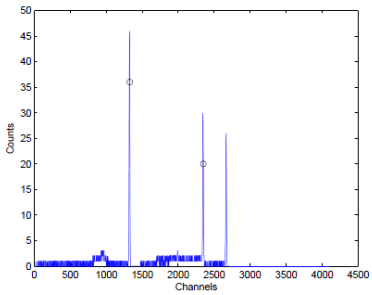

Fig. 1 – Simulated energy spectrum with Cs-137 and Co-60.

Subtractive clustering

The aim of the clustering task is to group these data into clusters in such a way that similarity between members of the same cluster is higher than that between members of different clusters. Clustering of numerical data forms the basis of many classification algorithms [3]. The subtractive clustering [4] uses the so-called potential value defined as in Equation (1).

$$P_i = \sum_{j=1}^{n} e^{-\alpha \|x_j - x_i\|^2}, \text{ where } \alpha = \frac{4}{r_a} \qquad (1)$$

The potential value associated with each data depends on its distance to all its neighborhoods. Considering Equation (1) a data point or sample that has many points or samples in its neighborhood will have a high value of potential, while a remote data point or sample will have a low value of potential. After calculating potential for each point or sample, the one, say x^* with the highest potential value, say P_i^* will be selected as the first cluster center. Then the potential of each point is reduced as defined in Equation (2), in order to avoid closely spaced clusters. Until the stopping criterion is satisfied, the algorithm continues selecting centers and revising potentials iteratively.

$$P_i = P_i - P_i^* e^{-\beta \|x_i - x_i^*\|^2}, \qquad (2)$$

The main advantage of this method is that the number of clusters or groups is not predefined. Therefore, this method becomes suitable for applications where one does not know or does not want to assign an expected number of clusters *a priori*. This is the main reason for choosing this method for the identification of radionuclides.

Results

The data shown in the Figure 1 were obtained using a simulation program. These data are in spreadsheet format of two columns, where the first column corresponds to the channel and the second is the number of counts accumulated in each channel. To apply the subtractive clustering algorithm in Matlab, data provided by the simulation program have to be converted into one-dimensional data in one column. For example, if channel 1324 accumulates 100 counts, it means that the value 1324 should appear 100 times as input. The black circular marks near the first and second peaks show the result of applying the subtractive clustering algorithm on the available data with Matlab. These circular marks are the center of the clusters found. This is enough to conclude that data provided belong to a radioactive source with Cs-137 and Co-60 and the subtractive cluster method can be used to identify radionuclides [2].

References

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