“Prompt-Gamma Neutron Activation Analysis (PGNAA)” Metal Spectral Classification using Deep Learning Method

Ka Yung Cheng[a], Helmand Shayan[b], Kai Krycki[c], Markus Lange-Hegermann[b]

[a] *Institute of Medical Informatics and Statistics, University Hospital Schleswig-Holstein and Kiel University, Kiel, Germany*

[b] *Institute Industrial IT, OWL University of Applied Sciences and Arts, Lemgo, Germany*

[c] *Department of Mathematical Methods & Software Devolopment, AiNT GmbH, Stolberg, Germany*

PGNAA spectra can be classified and analysed with Deep Learning technologies

Introduction

- PGNNA can analyse material composition via characteristic peaks (Fig. 1)
- Knowledge about scrap metal composition simplifies metal recycling.
- For real time applications, we aim to reduce measurement time.
- To simplify measurements, discard energy channels.

Methodology

- Interpret every spectrum as probability distribution.
- Use the random sampling method to produce training data (Fig. 2).
- Train deep learning model: Inception-Resnet-V2, a CNN.
- Discard less important energy range using Class Activation Map (Fig. 3)

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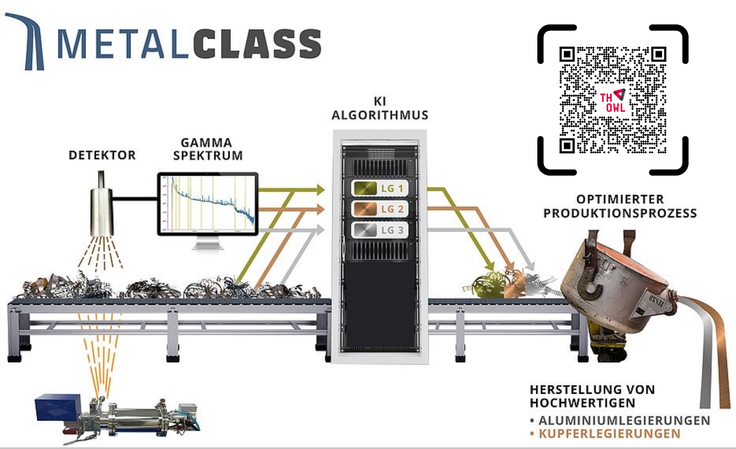

Results

- For the Dataset in Fig 1, the highest and lowest energy range are discarded.
- The trained CNN model achieves 96.88% accuracy when reducing the measurement time to 2.479 s.
- For a dataset of only copper, more misclassifications occur.
- After comparing five different sample count rates (Fig. 4), we choose 500.000 counts, corresponding to 24.44 s measurement time. The average accuracy is increased to 97.5%.

Discussion

- CNN is attractive for general classify purpose and requires less data knowledge.
- CNN yields interpretable results on the importance of measurement ranges.
- Other strategies, e.g. Density Estimation, achieve better result in speed and accuracy

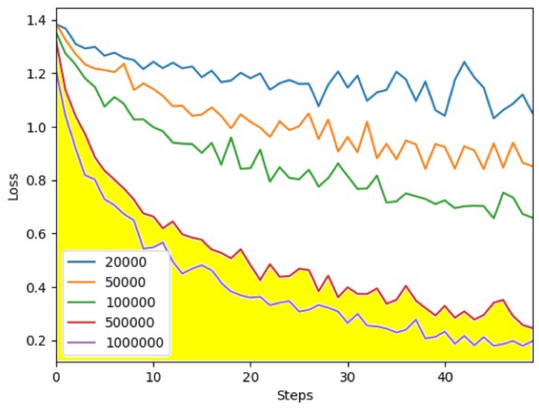

Figure 4 *Increase sample count rate (live time) to achieve better learning accuracy, i.e. lower Cross Entropy loss*

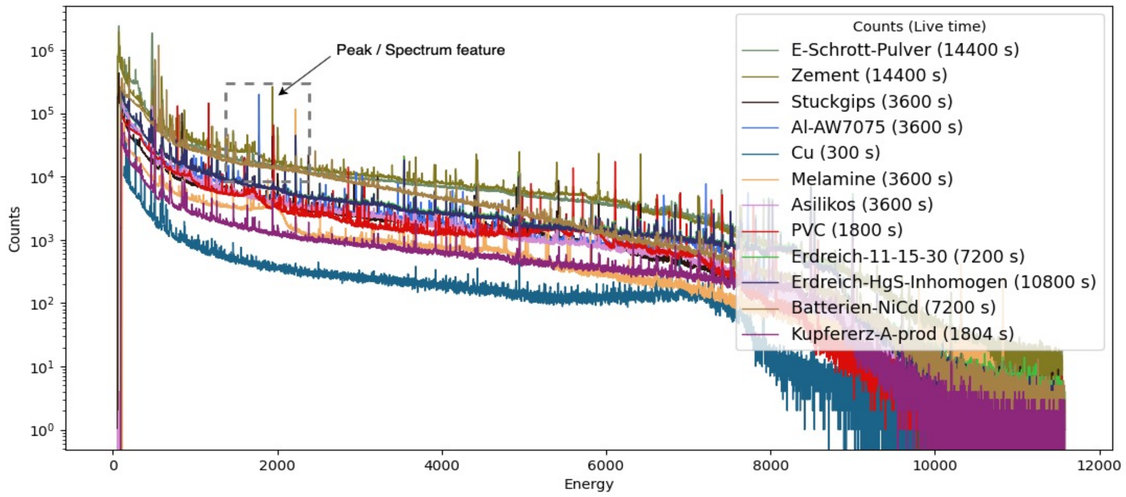

Figure 1 *Log-linear Spectrum illustration of PGNAA measurement*

```
import random

csv_energy = [1.1, 2.2, 3.3, 4.4]
csv_count = [1, 10, 2, 0]
k = 5            # output length, 1024 for CNN input

sample1 = random.choices(csv_energy, weights = csv_count, k = k)
print("Sampling Method 1 output = ", sample1)
#Sampling Method 1 output = [2.2, 1.1, 2.2, 3.3, 2.2]
```

Figure 2 *A simple example of Random Sampling Method*

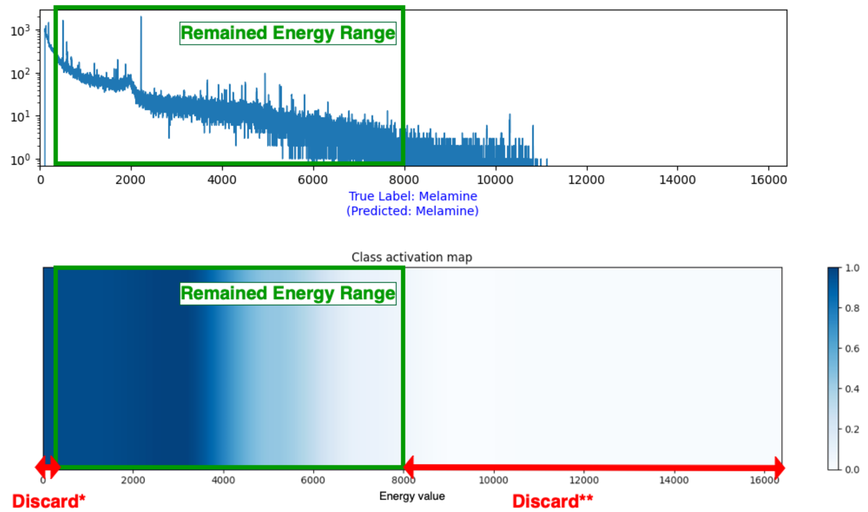

Figure 3 *Visualize CNN prediction process with CAM to discard less important energy range*

kayung.cheng@uksh.de