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A comparison of machine learning methods for automated gamma-ray spectroscopy

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ABSTRACT

Pattern recognition algorithms such as artificial neural networks (NNs) and convolution neural networks (CNNs) are prime candidates to perform automated gamma-ray spectroscopy. The way these models train and operate mimic how trained spectroscopists identify spectra. These models have shown promise in identifying gamma-ray spectra with large calibration drift and unknown background radiation fields. In this work, two algorithms for mixtures of radioisotopes based on NN and CNN are presented and evaluated.

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1. Introduction

Traditionally, isotope identification is conducted by a trained spectroscopist. Rawool-Sullivan et al. identified a common workflow performed by a group of gamma-ray spectroscopists [1]. This workflow included discriminating background and source photopeaks, adjusting the calibration using background photopeaks and checking for shielding effects in the low-energy photopeaks. Once photopeaks are identified, the spectroscopist would use their prior knowledge of isotope emissions (or consult a database of these emissions) to match isotopes to the spectrum. The researchers also noted that while spectroscopists used this book knowledge, they often would use intuition developed from analyzing tens or hundreds of gamma-ray spectra. The researchers also noted the difficulty in incorporating this subjective analysis into an automated algorithm.

Neural networks (NNs) can mimic the intuition a trained spectroscopist uses when identifying spectra. It has been previously shown that NNs can be trained to identify and quantify isotopes in gamma-ray spectra [2]. There have also been a number of published papers which apply NNs to automated isotope identification. NNs have been applied to peak fitting [3], isotope identification [4,5], and activity estimation [4,6,7].

Previous work applying NNs to spectroscopy have focused on fully-connected architectures. Fully-connected NNs do not assume the input channels have local spatial structure, while convolutional neural networks (CNN) do. Because gamma-ray spectra have local spatial structure in the form of photopeaks and Compton continua, it may be better to use a convolutional NN over a fully connected NN. This work will focus on comparing the performance of a fully-connected NN and a CNN for automated gamma-ray spectroscopy.

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