Introductory Bayesian Approach to Gamma Spectra Analysis for Isotopic Identification

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Abstract: Prompt Gamma-Ray Activation Analysis (PGAA) is a non-destructive assay technique for sample isotopic analysis by measuring the gamma-rays emitted from activated products within the sample. This technique is effective in many situations, but when the energies of emitted gamma-rays from various isotopes in the sample are close to each other or a large background is present, statistical variance can render data useless. Even when the data does have statistical merit, analysis can still be tedious.

Machine learning can automate this process by determining the merit of the data and automating analysis. Analysis automation uses an algorithm to identify regions of interest to the user and quickly disentangle the true response from the background with lower uncertainty. This is done by reading in a gamma-ray spectrum of a sample measured by a detector.

The code currently relies on user input of an energy window where a region-of-interest (i.e., an energy region that allows for isotopic determination) is potentially located. From there, the code fits a gaussian distribution to each potential peak within that window providing the user with the total number of counts contained in the peak and the associated uncertainty for the peak. The gaussian distribution is determined using a Bayesian approach coupled with Markov Chain Monte Carlo analysis. The code also provides the isotopes that emit gamma rays within the specified window based on the PGAA database maintained by Pacific Northwest National Laboratory. (continue on next page …)

Future work will focus on further automation of the code and implementing the use training spectra of known materials to compare against unknown materials.

Broader Impacts: AI has been described as the new electricity because of its ability to transform many industries. Nuclear engineering and nuclear energy are no different. PGAA, because of the detail and background knowledge for correct analysis, is one instance in which the human ability to analyze and interpret data is challenged. The creation of a deployable machine learning algorithm to automate this knowledge in PGAA would be among the first applications in the nuclear field to leverage the ability of computers. This proof-of-concept is only the beginning as Cole Thompson and Ryan Lester have many additional modules to further refine the codes data processing and automation capabilities.