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Title: Plutonium Attribution Methodology Development using Experimental and Data Science Methods

Abstract:

A nuclear forensics methodology development work, capable of determining separated plutonium's reactor of origin, burnup, and the time since irradiation (TSI), is in the advanced stages at Texas A&M University. The methodology uses a set of ten intra-element isotopic ratios found in separated plutonium, which was compared to a library of isotopic ratio values produced using neutronics simulations for reactors of interest. By calculating the probability that the isotopic ratio set matched a set in the library, the methodology could predict the three parameters of interest of the sample. One shortcoming of this methodology was an inability to correctly attributing spoofed plutonium, where plutonium sourced from two different reactors or two different fuel burnup levels are mixed. An improvement to the new methodology to rectify this vulnerability using machine learning (ML) technique is under development, instead of the maximum likelihood calculation previously used. The new methodology attributes plutonium in three steps, one for each parameter, rather than resolving all of the three parameters simultaneously like the previous maximum likelihood approach. First, a support vector machine (SVM) classifier using minimum redundancy maximum relevance (MRMR) method with a set of seven isotopic ratios finds the reactor of origin and a set of regression models trained using gaussian process regression (GPR) using the neighborhood component analysis (NCA) predicts the burnup with a different set of seven isotopes. Last, TSI is calculated analytically using decay equations. Thus far, the new enhancement to the methodology is capable of attributing pure plutonium samples and has been validated using experimental data. The next step will to be augment the classifier training data set with spoofed plutonium data.