Statistical Methods for Pre-detonation Nuclear Forensics Analysis

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Motivation: Speeding up nuclear emergency response

After a nuclear weapon is detonated or nuclear material is intercepted, a priority for emergency responders is to determine both where it came from and the radioactive danger to the public.

While the latter can be determined quickly, the former often involves lab work that can take days or weeks.
Presented here is a methodology that seeks to rapidly provide investigation-guiding information using measurements taken in the field compared against statistical models. While this work focuses on spent nuclear fuel (SNF) from reactors outside of regulatory control, this methodology can apply to any nuclear material, intact or remnants of a detonation. Statistical methods may be able to determine reactor operation parameters faster than the traditionally utilized empirical relationships. To evaluate their utility in this context, a number of questions must be answered.
Figure **??** blah blah.

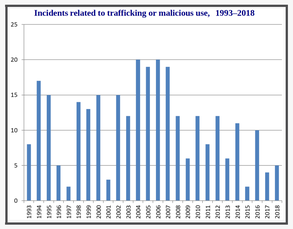

Figure: 138 participating countries report intercepted nuclear materials intended for illicit use to the IAEA.[1]

Background: Using statistical methods to evaluate nuclear forensics signatures

Nuclear forensics research initiatives include characterization of both pre- and post-detonation materials. Measuring isotopic ratios, chemical compounds, and trace elements are signatures used to identify the chain of custody of these materials. One such material is spent nuclear fuel (SNF) from power reactors. The analysis of this is usually focused on determining a set of reactor parameters that generated the material: reactor type, fuel enrichment, burnup, and cooling time. This provides information that can lead to the source of the material in question.
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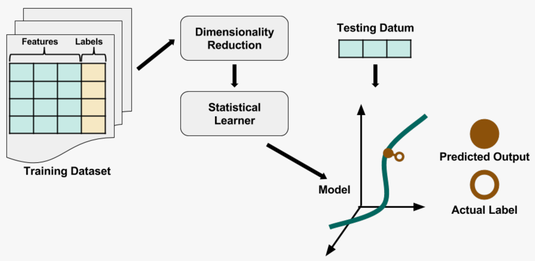

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Methodology: Maximum likelihood estimation for prediction

Toy training set for demonstration, describe features chosen + labels of interest Show generic ML workflow MLE method chosen for measure of uncertainty Include uncertainty?
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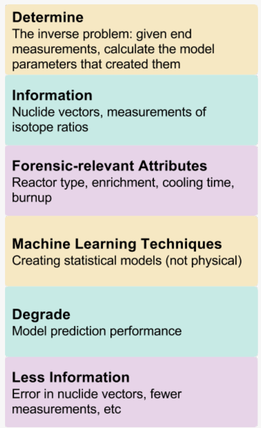

Figure: Caption me

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Title3

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References

[1]Incident and Trafficking Database (ITDB) Program, *IAEA Incident and Trafficking Database: 2019 Fact Sheet*, tech. rep. (International Atomic Energy Agency, Division of Nuclear Security, 2019).

Funding

This material is based upon work supported by the U.S. Department of Homeland Security under Grant Award Number, 2012- DN-130-NF0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the U.S. Department of Homeland Security. This material is also based upon work supported by the U.S. National Science Foundation Graduate Fellowship Program.