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Advanced Analytics for International Safeguards

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Introduction

Sandia National Laboratories is investigating advanced analytic techniques that can be applied to nonproliferation-related sensor data to highlight irregularities or areas of concern that may be undetectable by a human analyst. Sandia's current research focuses on future arms control agreements, and seeks to understand subtle patterns of expected activities at facilities to support an inspector's or analyst's understanding of the complex data sets resulting from sensors at those facilities. This position paper asserts that analytic techniques to find patterns, trends, and anomalies could be applied to international safeguards to further the aims of the International Atomic Energy's (IAEA's) State Level Concept.

The IAEA is facing an increasingly complex and diverse data environment. The international growth of the nuclear fuel cycle has correspondingly resulted in additional data collected by the Agency, both in the field and at IAEA headquarters. In addition, the continuing evolution of the State Level Concept means that safeguards inspectors and analysts are driven to more thoroughly comprehend states' nuclear activities and safeguards compliance at that state-level, rather than in piecemeal analysis. The result is a complex and heterogeneous body of safeguards data.

While previous discussions of information analytics have been delayed due to the IAEA's on-going MOSAIC project, in May 2015 the Agency completed its migration of data from the historic mainframe to an integrated, secure, safeguards information environment. Thus the timing is ripe to discuss advanced analytic techniques that can combine disparate but related data, and guide safeguards analysts to potential abnormalities within the data for a more complete use of IAEA data for safeguards analysis and furthering the goals of the IAEA's State Level Concept.

Example Techniques and Applications

The IAEA collects a wide variety of information, including state reporting, information collected in the field through measurements, sampling, and remote or unattended monitoring, satellite information, and other open source information collected at IAEA headquarters. While all of these data streams are critical to evaluating state compliance with their safeguards agreements independently, additional analysis of the unique combinations and derived features of these data could also prove relevant for safeguards analysis. These potential benefits can be illustrated through two examples: a state-based declaration verification tool, and machine learning.

Knowledge Generation: Knowledge Generation is Sandia-developed software that automatically compares operator declarations to collected sensor data and modeled processes. The software is able to analyze large heterogeneous datasets and identify events in which sensor readings differ by a user-defined threshold from expected outcomes of a declared activity, which could warrant additional attention from a safeguards inspector or analyst. In 2011, Sandia demonstrated Knowledge Generation for a safeguards use case, in which the software was able to detect discrepancies between the

operations and declared activities of a simulated input accountability tank representing part of a reprocessing plant. The software could also be applied to other safeguards verification activities in which declarations and operator records are compared to on-site sensor data, for example verification of facility receipts with load cell data.

Machine Learning: Machine learning is a field in computer science that seeks to automate computer recognition of patterns not normally detectable using human cognition alone, with supervised (training data on what is "correct" or "important") or unsupervised (purely computational) algorithms. Machine learning can be used to detect subtle patterns of life, trends, and interdependencies between disparate data sets. Sandia is currently conducting research into the use of machine learning on proxy arms control data sets, specifically those related to sensors performing chain of custody roles. However, similar methods could be applied for international safeguards, to detect subtle shifts in operational norms, unusual combinations or patterns within sensor data, or other trends that could be used to support verification of a state's declaration of operations at a nuclear facility. As an example, machine learning algorithms could detect irregularities at a UF_6 cylinder portal for a nuclear fuel fabrication facility. They could identify a cylinder with unusual properties such as persistent higher weight than others, longer process time, or perhaps a slow increase in operational activity at the facility, potentially indicating changes in production.

Desired Outcomes

Sandia believes that the application of these and other advanced analytical techniques can be applied to international safeguards to allow the IAEA to more fully use the information it collects, and to potentially detect subtle yet relevant patterns, trends, or anomalies in its safeguards data. This deep analysis of integrated data sets could allow the IAEA to more fully implement the State Level Concept.

More research is needed to explore algorithms that could support safeguards analysis. Collaboration between U.S. national laboratories, academia, safeguards regulators and inspectorates, and other research agencies would strengthen these research efforts.