Opportunities and Challenges for AI-Enhanced Decision Making in Nuclear Proliferation Detection

Angela Sheffield
Eisenhower School, National Defense University
National Nuclear Security Administration

Defense Nuclear Nonproliferation R&D

Nuclear nonproliferation, counterproliferation, and counterterrorism prevent state and non-state actors from acquiring nuclear weapons or expanding weapons-usable capabilities

- Technologies and science-based capabilities to detect and monitor activities to develop nuclear weapons are key capability

New opportunities to transform nuclear proliferation detection

- Leverage advances in computing and new algorithms to *enhance* and *expand* monitoring and verification

- Exploit new data sources with AI to reveal *early* indicators of proliferation that push detection "*left of boom*" – and afford U.S. more options for intervention

To verify nuclear treaties, scientists analyze **gas samples** for specific types of radioactivity.

PNNL's Emily Mace uses AI to improve algorithms that help detect nuclear explosions around the globe

Detecting Nuclear Weapons Proliferation

Analyses and decisions enabled by nuclear proliferation detection

- Determine or verify the location and nature of an activity or facility

- Inform operations and strategies for intervention

- Enable broad and state-level assessments

- Inform National security and resourcing strategies

- Guide signature discovery and research and development to enhance and expand capabilities

Types of analyses and decisions

- Detection and prediction

- Characterization and inverse modeling

- Data fusion

- Generating and evaluating alternatives

- Resource allocation and orchestration

Defense Nuclear Nonproliferation R&D

Challenges and Requirements

Nature of the Decision Space

- Complex systems and noisy data

- Highly-technical missions demand specialized capabilities

- Limited pathways constrain decision space; some processes and responses are well-understood

- Observable indicators, signatures and patterns, latent behavior

- Data sparse; distributed across information sources, time, and space

Operational Conditions

- Cooperative and uncooperative operations, *unknown unknowns,* initiated adversary

- Constrained resources

- Uncertainty is a certainty

Opportunities and Methods

Decision-Centered AI

- "Law" of the *Conservation of Information*

- Human-centered and decision-obsessed AI

- Context, constraints, and operational conditions; usefulness and generalizability

- Decision-centered uncertainty, assurance, and validation

- Emerging techniques: Optimal control; HPC and alternative hypotheses

- Outstanding needs: Theories, practices, and methods that match the scale of complexity of the decision space

Defense Nuclear Nonproliferation R&D

Building robust and useful systems

- Analysts, operators, and decision makers will not wait for your tech

- Design for the decision; understand the context

- Any new technique or capability will join an ecosystem of context and capabilities

- *Specific* makes a difference for trust, adoption, and usefulness

- Your work **<u>will</u>** make a difference

Graphic by Y. Belyavina, BNL

Angela M. Sheffield
Eisenhower School, National Defense University
National Nuclear Security Administration, Department of Energy
angela.m.sheffield.stu@ndu.edu