National Nuclear Security Administration

Next-Gen AI for Proliferation Detection:

**DOMAIN-AWARE METHODS WORKSHOP**

**FEB 23-24**

# GLOSSARY

## Session 1: Complex and Noisy Environments

- **Imposing Harmonic Structure in Neural Networks**

  **Mark Adams** (ORNL), Joel Brogan (ORNL), Philip Bingham (ORNL)

- **Domain Adversarial Networks and Explainability Assessment**

  **Tom Grimes** (PNNL), Eric Church (PNNL), Karl Pitts (PNNL), Lynn Wood (PNNL), Eva Brayfindley (PNNL), and Luke Erickson (PNNL)

- **Dissolution Event Classification Using Isotope Decay Chains and Half-Life Estimates**

  **Nageswara Rao** (ORNL), Christopher Greulich (ORNL), Michael P. Dion (ORNL), Jared Johnson (ORNL), Will Ray (ORNL), Jason Hite (ORNL), Ken Dayman (ORNL), and Riley Hunley (ORNL)

- **Inferring the Dynamic Location of an Environmentally-Constrained Radiative Source with a Network of Detectors**

  **Dave Osthus** (LANL), Emily Casleton (LANL), Paul Mendoza (LANL), Andrew Nicholson (NA-22 HQ), Dan Archer (LANL), James Ghawaly (ORNL), Irakli Garishvili, (ORNL), Andrew J. Rowe (Cadre5), Ian R. Stewart (U. of Tennessee), and Michael Willis (ORNL)

- **An Artificial Neural Network System for Special Nuclear Material Detection in Photon Based Active Interrogation Scenarios**

  **A. J. Jinia** (U Michigan), T. E. Maurer (U Michigan), S. D. Clarke (U Michigan), H. S. Kim (U Michigan), D. D. Wentzloff (U Michigan), S. A. Pozzi (U Michigan)

- **Spectral Signatures for Shielded Sources**

  **Jason Hite** (ORNL), Kenneth Dayman (ORNL), Riley Hunley (ORNL), Nageswara Rao (ORNL), Christopher Greulich (ORNL), Michael Willis (ORNL), James Ghawaly (ORNL), Dan Archer (ORNL), and Jared Johnson (ORNL)

## Session 2: Early Proliferation Detection and Signature Discovery

- **Open-Source Data Analytics Value Quantification to Inform and Explain Radiological Source Detection, Localization, and Tracking**

  **Sannisth Soni** (PNNL), Ellyn Ayton (PNNL), Ren Cooper (LBNL), Mark Bandstra (LBNL), Brian Quiter (LBNL), and Svitlana Volkova (PNNL)

- **Applying Domain-Aware Artificial Intelligence on the CBRN Battlefield**

  **Adam Seybert** (US Army Nuclear and CWMD Agency) and Robert Prins (US Army Nuclear and CWMD Agency)

- **Extracting Dynamic Proliferation Expertise and Capability Representations from Heterogenous Multilingual Open-Source Data Streams**

  **Maria Glenski** (PNNL), **Emily Saldanha** (PNNL), Sannisth Soni (PNNL), Ellyn Ayton (PNNL), and **Svitlana Volkova** (PNNL)

- **Plutonium Attribution Methodology Development Using Machine Learning Techniques**

  **Patrick O'Neal** (Texas A&M University) and Sunil S. Chirayath (Texas A&M University)

- **Toward Early Intent Detection of Search Queries with Transformers and Experts in the Loop**

  **Adithya V Ganesan** (Stony Brook University), Michael DePhillips (BNL), H. Andrew Schwartz (SBU)

- **Proliferation Monitoring with Hidden Markov Models**

  **Andrew Hollis** (NC State University), George Tompkins (LANL), Alyson Wilson (NCSU), and Ralph Smith (NCSU)

# GLOSSARY

## Session 3: Sparse Data and Rare Events

- **Constraining Data Driven Models for Detection of Sparse, Temporally Correlated Events**

  **Garrison Flynn** (LANL), Nidhi Parikh (LANL), Dan Archer (ORNL), Tom Karnowski (ORNL), Monica Maceira (ORNL), Omar Marcillo (ORNL), Andrew Nicholson (ORNL), Will Ray (ORNL), and Randall Wetherington (ORNL), and Michael Willis (ORNL)

- **Domain-Informed Assessment of Nuclear Reactor Operations**

  **Tom Reichardt** (SNL), Sam Eaton (SNL), Tom Kulp (SNL), Stephanie DeJong (SNL), Will Ray (ORNL), Tom Karnowski (ORNL), Randall Wetherington (ORNL), Omar Marcillo (ORNL), Monica Maceira (ORNL), Chengping Chai (ORNL), Edna Cardenas (INL), Scott Watson (INL), David Chichester (INL), Chistine Gammans (LANL), John Krebs (ANL), Brian D'entremont (SRNL), Michael Willis (ORNL)

- **Persistent DyNAMICS: Remote Sensing Based on Domain-Informed Analytics**

  **Thomas Kulp** (SNL), Mark Smith (SNL), **Siddharth Manay** (LLNL), Bob Priest (LLNL), Norma Pawley (LANL), Paul Pope (LANL), Tom Vestrand (LANL), Jereme Haack (PNNL), Romie Morales (PNNL) and Chris Burt (STL)

- **Node and Region Importance for Classifying Nuclear Operations using Multisensor Arrays**

  **Jake Tibbets** (UC Berkeley)

- **One-shot Target Detection via Physics-Informed Training**

  **Natalie Klein** (LANL) and Kevin Mitchell (LANL)

## Session 4: Robust Deployment and Decision Support

- **Annotation Transfer for Prediction of Industrial Operations**

  **Erik Skau** (LANL), Lakshman Prasad (LANL), Kim Rasmussen (LANL), and Boian Alexandrov (LANL)

- **Automated Synthesis of Soft Labels using Neural Stochastic Differential Equations and Attribution Based Confidence**

  **Sumit Kumar Jha** (University of Texas at San Antonio), Laura Pullum (ORNL)

- **Robustness in the Wild using Domain-Aware Surrogate Functions**

  Rushil Anirudh (LLNL), **Jay Thiagarajan** (LLNL), and Bhavya Kailkhura (LLNL)

- **Domain-Aware Approach for Deterrence**

  **Michelle Quirk** (NNSA NA-114)

- **On-the-Fly Robustness in the Wild via Data-Driven Generative Priors**

  **Rushil Anirudh** (LLNL), Jayaraman J. Thiagarajan (LLNL), Bhavya Kailkhura (LLNL), Peer-Timo Bremer; (LLNL)

# ABSTRACTS

## Session 1: Complex and Noisy Environments

Chair: Boian Alexandrov (LANL)

### Imposing Harmonic Structure in Neural Networks

**Mark Adams** (ORNL), Joel Brogan (ORNL), Philip Bingham (ORNL)

Electrical signals contain harmonic structures, which can help with detection and characterization of equipment in a building using non-intrusive load monitoring (NILM). Traditional signal processing approaches to isolate harmonic structures in an electromechanical (EM) signals can involve peak finding, background noise suppression, and a priori knowledge of fundamental frequencies. Harmonic Convolutional Networks attempt to utilize the harmonic structure explicitly to provide the deep network with better priors during training for improved performance. Testing the harmonic layer with a ResNet network on high quality data collected from ORNL's Flexible Research Platform (FRP) results in an improvement in accuracy from 7% to 83%.

### Domain Adversarial Networks and Explainability Assessment

**Tom Grimes** (PNNL), Eric Church (PNNL), Karl Pitts (PNNL), Lynn Wood (PNNL), Eva Brayfindley (PNNL), and Luke Erickson (PNNL)

This presentation will describe a novel variant of Domain Adversarial Neural Networks (DANNs) with impactful improvements to the loss functions, training paradigm, and hyperparameter optimization. DANNs use an additional fork grafted onto the end of the network's feature extractor to remove domain indicative features. Using a gradient reversal layer, updates are sent in the opposite direction of those useful for domain classification – resulting in features that are not domain indicative (and thus insensitive to changes in background). It is possible to extend the concept of 'domain' to include arbitrary user defined labels applicable to subsets of the training data, the test data, or both. In the 'Test Collection Informed' variant, domain information from the test data is incorporated during training to form features that are also insensitive to background encountered in the test data (without providing class labels and thus not upsetting the supervised training paradigm). Using this technique, a neural network was applied to construct a binary classifier used to identify the presence of EM signal emitted by a turbopump. By finding these domain adverse representations of the features, the DANN was able to reduce the rate of misclassification in the test set by ~25% relative to an unaugmented CNN architecture. Finally, the features identified by the network were assessed using a semi-global model formed by aggregating individual LIME explanations and found to correspond with SME identified features in the turbopump output.

BACK TO GLOSSARY

# ABSTRACTS

## Dissolution Event Classification Using Isotope Decay Chains and Half-Life Estimates

**Nageswara Rao** (ORNL), Christopher Greulich (ORNL), Michael P. Dion (ORNL), Jared Johnson (ORNL), Will Ray (ORNL), Jason Hite (ORNL), Ken Dayman (ORNL), and Riley Hunley (ORNL)

The ability to infer occurrences of dissolution operations associated with radioisotope production at a radiochemical processing facility at Oak Ridge National Laboratory is addressed using measurements from an independent monitoring sensor system. Each dissolution campaign consists of multiple events, including aluminum cladding removal by physical and chemical means, chemical dissolution of actinide material, and follow on activities that involve mixing, boil down, and other operations. Radioactive isotopes are released and transported to the off-gas stack during these events, which result in complex signatures. Multiple radioactive species that correspond to these source terms migrate to the off-gas stack, as reflected in the measured gamma spectrum. The measurements or count rates of isotopes are generated by processing their energy regions in the gamma spectrum and are available along with ground truth information. By using simple models for the source terms and sensor measurements of transported effluents, we formulate an on/off classification problem wherein a classifier is trained to produce Boolean output that corresponds to a dissolution event. In this work, the physics-based radioactive decay chains are used to select isotope features to be used as input to classifiers, and their half-life estimates to select feature window-size to achieve improved performance beyond the simple classifier fusion. We describe our approach using the dissolution process used for Pu-238 isotope production, and it has also been applied to the Cf-252 dissolutions, both at the Radiochemical Engineering Development Center.

## Inferring the Dynamic Location of an Environmentally-Constrained Radiative Source with a Network of Detectors

**Dave Osthus** (LANL), Emily Casleton (LANL), Paul Mendoza (LANL), Andrew Nicholson (NA-22 HQ), Dan Archer (LANL), James Ghawaly (ORNL), Irakli Garishvili, (ORNL), Andrew J. Rowe (Cadre5), Ian R. Stewart (U. of Tennessee), and Michael Willis (ORNL)

Data collected from a network of sensors and analyzed together has the opportunity to provide a more complete picture than when the data from each individual sensor are analyzed independently. However, even with a dense array of sensors, the network data will not provide a complete picture and constraints will need to be added to the model in order to maximize the usefulness of the conclusions that can be drawn. In this work, we demonstrate this concept by considering the task of tracking a moving radiative source of special nuclear material in a structured environment with data from a network of radiation detectors. Our approach uses a Bayesian model and analysis that naturally provides uncertainty in the estimate of the source's location. The main conclusion is that adding domain aware constraints to a model can improve both location inference and do so with diminished uncertainty even though the fit to data is unchanged.

# ABSTRACTS

## An Artificial Neural Network System for Special Nuclear Material Detection in Photon Based Active Interrogation Scenarios

**A. J. Jinia** (U Michigan), T. E. Maurer (U Michigan), S. D. Clarke (U Michigan), H. S. Kim (U Michigan), D. D. Wentzloff (U Michigan), S. A. Pozzi (U Michigan)

The ability of stilbene organic scintillators to simultaneously detect gamma rays and neutrons can present great challenges in environments where one radiation type is more prevalent than another, such as in photon induced active interrogation scenarios. Accurately classifying neutrons with minimum misclassification is crucial in such intense photon environment and the desired accuracy cannot be easily achieved using traditional hand-crafted classification algorithms. To address this need, an artificial neural network (ANN) system is developed. This system works in two steps: The first step is identifying photon, neutron, and piled-up pulses and the second step is to reclassify each part of the pile-up pulses. In this work, a depleted uranium (DU) target is actively interrogated using bremsstrahlung radiation from a 9 MeV endpoint electron linear accelerator (linac). The developed ANN system successfully classifies pulses in the stilbene organic scintillator that are detected during the interrogation of the DU target. The recovery of the piled-up pulses further increases confidence in particle count rates. Traditional hand-crafted algorithm such as the charge integration method eliminates all piled-up pulses resulting in loss of information.

## Spectral Signatures for Shielded Sources

**Jason Hite** (ORNL), Kenneth Dayman (ORNL), Riley Hunley (ORNL), Nageswara Rao (ORNL), Christopher Greulich (ORNL), Michael Willis (ORNL), James Ghawaly (ORNL), Dan Archer (ORNL), and Jared Johnson (ORNL)

In this presentation we will provide a potential solution to a particular in-field gamma detection problem relying on a physics-informed feature construction procedure. This novel feature construction allows for successful analysis by conventional AI/ML methods in situations where these approaches will typically fail when operating on raw data (i.e., purely data driven implicit feature construction during model training). In our example, we consider the detection of special nuclear material transported in heavy shielded containers, which mask signatures upon which canonical spectral analyses rely. We will also discuss ongoing work to use this signature with AI-driven sequence modeling for automated detection of vehicle routes from raw sensor data.

# Session 2: Early Proliferation Detection and Signature Discovery

Chair: Zoe Gastelum (SNL)

## Open-Source Data Analytics Value Quantification to Inform and Explain Radiological Source Detection, Localization, and Tracking

**Sannisth Soni** (PNNL), **Ellyn Ayton** (PNNL), Ren Cooper (LBNL), Mark Bandstra (LBNL), Brian Quiter (LBNL), and **Svitlana Volkova** (PNNL)

The national security community looks to expand threat detection capability through the deployment of urban-scale ubiquitous sensing systems. These systems must operate without continuous reliance on human subject matter expertise. The deployment of unattended sensors will rely on the reliable incorporation of contextual data from both physical and non-physical senor systems to: (a) forecast potential background signature; (b) separate signal from noise; and (c) mitigate the operation burden posed by nuisance alarms. In this talk we present our data-driven approach that relies on Natural Language Processing (NLP), Machine Learning (ML), Deep Learning (DL) and Visual Analytics (VA) – to extract radiological pattern of life and actionable insights from real-world unstructured and semi-structured data to fuse them with sensor networks to inform nuclear source detection, localization, and tracking. We present experimental results from our machine learning models to evaluate the predictive power of open-source data (police reports, construction permits, and indoor complaints etc.) for dynamic radiological sensor alerts in one location – Washington DC. Our experimental results demonstrate the potential of using these additional signals to detect and explain radiological sensor alerts. Next, we will focus on estimating the value of additional contextual data sources, like traffic information and hospital proximity data to inform static sensor detection, tracking and localization across multiple locations – Washington DC and Fairfax.

# ABSTRACTS

## Applying Domain-Aware Artificial Intelligence on the CBRN Battlefield

**Adam Seybert** (US Army Nuclear and CWMD Agency) and Robert Prins (US Army Nuclear and CWMD Agency)

In many ways, the pursuit of early proliferation detection mirrors the hunt for rapid post-detonation characterization methods. While early proliferation detection results in a reduced threat of strategic surprise, early fallout characterization reduces risk to first responders during consequence management operations and allows greater operational freedom of movement for forces on a nuclear battlefield. However, sorting out the useful information continues to challenge even the most knowledgeable person when presented with the sheer volume of available data, sources, and formats. The same domain-aware and traceable AI technologies that enable early detection of nuclear weapons development should be applied to post detonation nuclear modeling to bridge the gap in data discrimination. These methods may also provide refined analysis enabling more informed and rapid operations in a contaminated battlespace. Applying these methods will reduce decision support timelines for critical consequence management and contamination avoidance missions.

## Extracting Dynamic Proliferation Expertise and Capability Representations from Heterogenous Multilingual Open-Source Data Streams

**Maria Glenski** (PNNL), **Emily Saldanha** (PNNL), Sannisth Soni (PNNL), Ellyn Ayton (PNNL), and **Svitlana Volkova** (PNNL)

Detecting and anticipating proliferation signatures, e.g., expertise and capabilities from unstructured dynamically evolving real-world data, is a challenging but highly desired task that supports the nuclear nonproliferation mission. Existing efforts primarily focus on proliferation expertise detection in bibliometric data in English via co-citation network analysis, completely ignoring content. In this talk we present our novel AI-driven mixed-method approach that (1) fuses a variety of multilingual, heterogenous open-source data streams and converts unstructured data (both content and context) into knowledge, and (2) uses these dynamically evolving proliferation expertise and capability representations to enable predictive modeling and counterfactual reasoning. We present our experimental results on in-domain and out-of-domain evaluation (nuclear and AI domains), and outline next steps for inference and interactive analytics tasks (e.g., predict and prescribe). Our research will supplement traditional nonproliferation efforts by detecting, forecasting, and reasoning about illicit proliferation though adding strong multilingual, knowledge representation and summarization, and inference components.

# ABSTRACTS

## Plutonium Attribution Methodology Development Using Machine Learning Techniques

**Patrick O'Neal** (Texas A&M University) and Sunil S. Chirayath (Texas A&M University)

A nuclear forensics methodology capable of identifying the source of an undeclared plutonium sample would act as a deterrent to potential nuclear proliferation. Previous work at Texas A&M University, yielded a methodology able to find a plutonium sample's reactor of origin, burnup, and the time since irradiation by comparing a set of intra-element isotopic ratios against a database of isotopic ratios using a straightforward maximum likelihood calculation. In an effort to improve the robustness of the methodology, the attribution step uses models trained using machine learning techniques in lieu of the maximum likelihood calculation. The machine learning approach consists of a support vector classifier to resolve the reactor of origin and a set of gaussian process regression models to quantify the sample's burnup while the time since irradiation is quantified analytically. This change allows the methodology to better leverage our knowledge of how each isotopic ratio is related to the three parameters of interest as well as scale the methodology to handle plutonium samples with more complex characteristics.

## Toward Early Intent Detection of Search Queries with Transformers and Experts in the Loop

**Adithya V Ganesan** (Stony Brook University), Michael DePhillips (BNL), H. Andrew Schwartz (SBU)

Most technical report search engines retrieve information for a single given search query, but one might be able to infer the end goal or general intent by considering the sequence of multiple queries. In fact, such intent may often be inferred early in a sequence, before a search is complete, enabling, for example, detection of intent to perform illicit activities. We propose an early event detection algorithm and pipeline to classify sequences, using only an early subsequence as well as deriving the sequence length necessary to confidently make such classifications. We propose a self-supervised approach of classifying these sequences of queries, by attempting to classify the eventual cluster a sequence will belong before the sequence is complete. This aids an "expert-in-the-loop" process whereby topical expertise (e.g. proliferation) will be able to inform the cluster objectives of our model. In turn, our predictive models seek to be able to learn the patterns in the sequences associated with such expert information to induce the final intent at an early stage.

BACK TO GLOSSARY

# ABSTRACTS

## Proliferation Monitoring with Hidden Markov Models

**Andrew Hollis** (NC State University), George Tompkins (LANL), Alyson Wilson (NCSU), and Ralph Smith (NCSU)

A longstanding goal in non-proliferation research has been the monitoring of development, manufacturing, or testing processes that might present a proliferation risk. For a particular process, we wish to determine what activity is underway by using a combination of observed data and subject matter expertise about the process. In many cases, the data we gather from standard monitoring and surveillance systems does not yield direct knowledge of the activities underway. Thus, we need a model that allows us to infer the process activity based on what we do observe. Using hidden Markov models (HMM), we develop a probabilistic model that encodes subject matter knowledge about the process and can be used to infer and characterize our uncertainty about the most likely process activity underway at any given time given the observed data.

# Session 3: Sparse Data and Rare Events

Chair: Becky Olinger (DTRA)

## Constraining Data Driven Models for Detection of Sparse, Temporally Correlated Events

**Garrison Flynn** (LANL), Nidhi Parikh (LANL), Dan Archer (ORNL), Tom Karnowski (ORNL), Monica Maceira (ORNL), Omar Marcillo (ORNL), Andrew Nicholson (ORNL), Will Ray (ORNL), and Randall Wetherington (ORNL), and Michael Willis (ORNL)

A key problem of interest for nuclear nonproliferation is monitoring activities at nuclear facilities, where proliferation events may only take place a few times and are most likely under variable conditions. Artificial intelligence, such as machine learning, presents methods to learn data-driven models relating measurable signatures to facility operations. However, traditional methods for training and testing these models require large, reliable data sets with hundreds to thousands of labeled observations; an unrealistic scenario for nuclear nonproliferation. Through the NA-22 Multi-Informatics for Nuclear Operations Scenarios (MINOS) venture, we explore constraints to data-driven models to detect the power level of a nuclear reactor in a complex environment. This presentation highlights challenges faced and solutions found for developing accurate, robust machine learning models in sparse, temporally corelated events such as those of interest for nuclear nonproliferation. First, we discuss methods for carefully defining test and training sets, as well as new ideas for optimizing the training set to be most appropriate for new observations. Next, we present three unique state-space model forms for including knowledge of process continuity throughout an event, as well as a method for optimizing the models to fuse disparate signals using only observable data. Further domain knowledge is considered by inclusion of environmental measurements to learn the relationship between reactor power and heat exchange at the cooling towers where the majority of measured signals are generated. Finally, interpretation of model performance is presented through correlation analysis to explain the importance of individual modalities.

# ABSTRACTS

## Domain-Informed Assessment of Nuclear Reactor Operations

**Tom Reichardt** (SNL), Sam Eaton (SNL), Tom Kulp (SNL), Stephanie DeJong (SNL), Will Ray (ORNL), Tom Karnowski (ORNL), Randall Wetherington (ORNL), Omar Marcillo (ORNL), Monica Maceira (ORNL), Chengping Chai (ORNL), Edna Cardenas (INL), Scott Watson (INL), David Chichester (INL), Chistine Gammans (LANL), John Krebs (ANL), Brian D'entremont (SRNL), Michael Willis (ORNL)

We present efforts to merge domain-informed physical models with data-driven analytics, in order to create algorithms to describe the operational state of a nuclear reactor that is being observed by a set of multimodal sensors. This work is being conducted under the DNN R&D MINOS (Multi-Informatics for Nuclear Operations Scenario) Venture, using data generated by sensors deployed at the Oak Ridge National Laboratory (ORNL) High Flux Isotope Reactor (HFIR) facility. Following the use of unsupervised methods to extract physically interpretable features, domain knowledge is injected via physical models used at multiple levels of the analysis – including (1) the conversion of the raw sensor data (e.g., acoustic sensor output) to reactor-relevant parameters (e.g., fan-speed in a cooling tower), (2) the fusion of meteorological data (wet-bulb temperature) with derived fan-speed, to relate fan activity to heat disposal under different weather conditions, and (3) the adoption of a generalized thermodynamics-based framework for fusing sensor data streams at an arbitrary cooling-tower site.

## Persistent DyNAMICS: Remote Sensing Based on Domain-Informed Analytics

**Thomas Kulp** (SNL), Mark Smith (SNL), **Siddharth Manay** (LLNL), Bob Priest (LLNL), Norma Pawley (LANL), Paul Pope (LANL), Tom Vestrand (LANL), Jereme Haack (PNNL), Romie Morales (PNNL) and Chris Burt (STL)

This presentation will describe how domain-informed data analytics are being used in a nuclear-activity detection system being developed under the Persistent DyNAMICS Venture. Industrial production processes generally follow process "recipes" in which the order and timing of the steps are defined and constrained by scientific rules and engineering best practices. As production proceeds, the facility executing the process exhibits time-varying observables that are indicative of the production steps, and which can be observed by multimodal sensors. Analysis of sensor data is complicated by the facts that 1) examples of proliferation activity are sparse, making the application of "Big Data" methods problematic and 2) sensor data is sparse due to the many constraints on real-world collection. Persistent DyNAMICS is leveraging Domain Awareness, via Subject Matter Expertise, to offset this data sparseness. The Persistent DyNAMICS system is being designed to recognize processes through the viewing of these observables. In particular, it is an integrated system that can: (1) codify domain knowledge for use by data analytics and sensor coordination; (2) use SME-driven Case-Based Reasoning (CBR) to coordinate observations to be made among a diverse set of sensors; and (3) infer activities using domain-informed analytics. The presentation will describe the development of the system and its deployment at the HFIR reactor at ORNL.

BACK TO GLOSSARY

# ABSTRACTS

## Node and Region Importance for Classifying Nuclear Operations using Multisensor Arrays

**Jake Tibbets** (UC Berkeley)

Distributed multimodal sensor arrays record multiple data streams which can be used as inputs to machine learning models designed to classify proliferation-relevant operations at nuclear reactors. This work assesses the node and region importance within a given multimodal sensor network topology to provide insight into model explainability, a critical requirement of data driven applications in nuclear security. To determine the importance of the various multisensors and collections of spatially collocated multisensors to a classification problem, traditional wrapper feature importance and selection methods were extended to nodes and regions in a multimodal sensor network. These methods were tailored to address high dimensionality and feature correlation, challenges particularly relevant in the nuclear security domain. On an example dataset collected at the High Flux Isotope Reactor at Oak Ridge National Laboratory, these methods identify high value and irrelevant nodes and regions for classifying nuclear reactor operational state. Specifically, the facility's cooling tower was identified as a high value source. Combined with other forms of analysis and subject matter expertise, node and region importance can provide insight into an otherwise opaque classification model in the nuclear security domain.

## One-shot Target Detection via Physics-Informed Training

**Natalie Klein** (LANL) and Kevin Mitchell (LANL)

While deep neural networks have proven successful for many tasks, they usually require large labeled data sets, which complicates their application to proliferation applications. In addition, interpretation and explanation of model predictions is important for assessing trustworthiness, particularly when applying trained models to novel scenarios. We demonstrate one potential avenue for addressing these problems. We use physics-based synthetic hyperspectral data to train a deep neural network model for one-shot target detection, a task in which the trained network is applied to detect novel materials under realistic natural variation. We demonstrate good preliminary results and outline future steps for interpreting and explaining the model. We anticipate that similar methodology will be useful in other proliferation-relevant applications.

# Session 4: Robust Deployment and Decision Support

Chair: Stefan Hau-Riege (LLNL)

## Annotation Transfer for Prediction of Industrial Operations

**Erik Skau** (LANL), Lakshman Prasad (LANL), Kim Rasmussen (LANL), and Boian Alexandrov (LANL)

Detecting complex natural and anthropogenic activities utilizing diverse datasets represents a critical component in objectives such as counterterrorism and proliferation detection. Typically, clandestine locations and actions (target dataset) do not follow exactly the same sequence of events we use to train our machine learning models. We need to be able to transfer/recognize similar objects/signals and activities based on the annotations of the objects in the training dataset and the new target data regardless of their exact sequence. Here we present a transfer of annotations on the latent features extracted by Nonnegative Tensor Factorization from a training to a target dataset. Our data represents a large set of high-resolution seismic and electric power signals, collected by geophones and sensors at the Dry Alluvium Geology testbed. To fuse the different types of data (seismic and electric power) we use a graph interval technique.

## Automated Synthesis of Soft Labels using Neural Stochastic Differential Equations and Attribution Based Confidence

**Sumit Kumar Jha** (University of Texas at San Antonio), Laura Pullum (ORNL)

Benchmark data sets such as ImageNet include data items with hard labels that are hard to justify. This observation gives rise to two interesting questions:

(1) How can we algorithmically detect such images in large data set that clearly require soft labels?

(2) How can we automatically identify such candidate soft labels so that human experts may approve or modify them with less effort?

Our approach using stochastic ensembles of neural SDEs is capable of detecting multiple soft labels for inputs. Further, our attribution-based confidence (ABC) metric can be normalized and used as soft probability values for such data items. We present our preliminary results in this talk, including our findings on images that have been attacked using adversarial patches.

## Robustness in the Wild using Domain-Aware Surrogate Functions

Rushil Anirudh (LLNL), **Jay Thiagarajan** (LLNL), and Bhavya Kailkhura (LLNL)

Though nuclear non-proliferation has witnessed a data deluge in the recent years, our inability to collect data from novel test environments that the model might potentially encounters makes machine learned detectors brittle in practice. The I.I.D assumption is the simplest case in which unseen samples come from the same distribution as the training dataset. However, in most real-world situations, this assumption breaks down and so do models trained under the I.I.D paradigm – often in unpredictable and uncontrollable ways. Such model behavior can be detrimental in high-regret applications that usually deploy sensors "in the wild" and have a high cost of incorrect predictions such as security, autonomous vehicles, or nuclear proliferation detection. Many existing techniques for robustness focus on achieving robustness to Lp-norm bounded corruptions, i.e., when the input to the model is perturbed by a small amount without significantly changing its appearance or characteristics, like in the case of adversarial attacks. Unfortunately, most real-world corruptions cannot be well characterized by simple Lp-norm perturbations, thus limiting their usefulness in actual problems of interest. We propose an adversarial training approach which learns to generate new samples so as to maximize exposure of the classifier to the attributes-space, without having access to the data from the test domain. We demonstrate the applicability of our approach on three types of naturally occurring perturbations -- object-related shifts, geometric transformations, and common image corruptions.

# ABSTRACTS

## Domain-Aware Approach for Deterrence

**Michelle Quirk** (NNSA NA-114)

The concept of deterrence can be defined as the display of possible threats by one party to influence another party to refrain from initiating certain courses of action. The most common deterrent is that of a threat that persuades the adversary not to carry out intended actions because of costly consequences.

In a nutshell, deterrence analyses comprise these three factors:

1. The benefits of a course of action
2. The costs of a course of action
3. The consequences of restraint (i.e., costs and benefits of not taking the course of action sought to deter).

Deterrence analyses aim to create scores based on these three elements and prioritize courses of action. Often these analyses are static in nature and conducted for a special problem, without automation or significant reuse of previous results. One preferred method is to create typical colored tables (High/Red, Medium/Yellow, Low/Green) of scores and risks. These tables are compiled mostly manually. A more elegant approach was brought to deterrence by game theory. In this talk we discuss briefly behavioral game theory and its suitability to deterrence analyses. Further, we propose a computational framework that has an ICA foundation and employs domain knowledge and cognitive sciences in the design and as means to achieve a permeating validation. This framework captures the domain knowledge of deterrence experts for drawing inferences, using both statistical methods and expert judgements. The talk closes with a list of deterrence open questions and an example of their refinement, as a first step to create a true ICA, domain-aware engine.

## On-the-Fly Robustness in the Wild via Data-Driven Generative Priors

**Rushil Anirudh** (LLNL), Jayaraman J. Thiagarajan (LLNL), Bhavya Kailkhura (LLNL), Peer-Timo Bremer; (LLNL)

Recent solutions for detecting nuclear proliferation are increasingly relying on AI models that are designed under controlled train settings and deployed in the wild, i.e., we have little or no control over the kinds of changes (or distortions) that one may encounter during testing. Most existing solutions place different priors on how the images might be modified and develop training strategies to improve the model's generalization. However, in practice, such priors are rarely available – for example, in nuclear proliferation detection, the signal of interest could be mixed with other irrelevant signals or contain measurement noise. Distinguishing or separating the signal of interest from this mixture is a challenging (often ill-posed) pre-processing step before invoking the pre-trained classifier. In this paper, we propose MimicGAN, which is a data-driven generative prior for adapting models to become robust on the fly.

# BIOGRAPHIES

## Mark Adams

Mark Adams received his BS degree in mechanical engineering and MS degree in agricultural and biological engineering from the University of Illinois Urbana/Champaign and his MS degree in computer science from the University of Tennessee, Knoxville. He is a researcher at Oak Ridge National Laboratory and a PhD student in computer science at the University of Tennessee, Knoxville. His current research interests include machine learning/artificial intelligence, high-performance computing, and signal processing.

BACK TO GLOSSARY

# BIOGRAPHIES

## Boian Alexandrov

Boian Alexandrov is a scientist in the Theoretical Division at LANL: he holds an MS in theoretical physics, one PhD in nuclear engineering, and a second PhD in computational biology. He has been working at LANL for more than 17 years. From 2010–2013, Boian was a Research Fellow at BIDMC, Harvard Medical School. For his pioneering research of THz influence on bio-matter, he was awarded LANL Early Carrier Award and EU, Marie Curie Senior Research Fellowship. Boian led the development of LANL-patented unsupervised machine learning framework for non-negative matrix factorization, NMFk. He introduced Green's functions in NMF framework. Boian was the PI of the 2018 LDRD DR for Big-DATA Analytics that developed LANL non-negative tensor factorization framework, NTFk (2019-copyrights), and is the PI of the 2019–2021 LDRD DR: Tensor Networks for Big-Data Analytics. Boian leads the Tensor Team in Advanced Data Analytics for Proliferation Detection (ADAPD) project. He is a senior scientist in the NA-22 project: Scientific Leadership Identification & Characterization (SLIC) and LANL-PI of the 2020–2024 NIH RO1 grant developing machine learning tools for DNA epigenomics. Boian is on the Advisory Board of Institutional Computing at LANL, and he is the program co-lead of LANL's Applied Machine Learning Summer Research Program. Boian's interests are unsupervised learning, non-negative factorization, extraction of explainable latent features, and AI applications in science.

# BIOGRAPHIES

## Ellyn Ayton

Ellyn Ayton is a data scientist at PNNL. She received her MS in computer science from Western Washington University. Her research areas of interest include deep learning and its many applications, such as detecting digital deception. She contributes to projects that use NLP to extract predictive signals from open source data, evaluates the effectiveness of causal mechanisms in machine learning models, and develops methods of interpretability and explainability of black-box deep learning models.

# BIOGRAPHIES

## Rushil Anirudh

Rushil Anirudh is a computer scientist at the Center for Applied Scientific Computing (CASC) at Lawrence Livermore National Laboratory (LLNL), where he leads and co-leads several efforts on using machine learning for high-impact scientific and engineering applications. He also serves as the director for The Open Data Initiative from LLNL's Data Science Institute. Prior to this, he worked as a postdoctoral researcher at Livermore from 2016–2018. He obtained his PhD from Arizona State University in 2016, working modeling human activity using machine learning and Riemannian geometry. He obtained his BS from the National Institute of Technology Karnataka (NITK) in India. His current research interests are broadly on problems in generative modeling, inverse problems, and machine learning for the physical sciences. He is an active member of the program committees for all of the top machine learning and computer vision conferences and journal publications.

# BIOGRAPHIES

## Tammie Borders

Dr. Tammie Borders is the technical advisor for AI and data science in the Office of Proliferation Detection within the Defense Nuclear Nonproliferation Research & Development program at the National Nuclear Security Administration (NNSA) in the U.S. Department of Energy (DOE). Her home institution is Idaho National Laboratory, where she leads the Data and Software Sciences team, with a research portfolio utilizing artificial intelligence, advanced decision science frameworks, digital engineering, cloud architectures, and geospatial analytics. In 2019, she was selected as a national Diversity MBA Top 100 under 50 emerging leaders. Prior to joining INL, Dr. Borders worked in the defense industry on a number of research areas, including information fusion and threat characterization algorithms, computational materials informatics methodologies to accelerate nanotechnology-reinforced materials to the warfighter, and a variety of technology incubation projects, such as femtosecond laser technology for sensing and materials applications. She holds a PhD in computational physical chemistry from the University of North Texas.

# BIOGRAPHIES

## Garrison Flynn

Garrison Stevens Flynn is an R&D engineer at Los Alamos National Laboratory in the Process Modeling and Analysis group. She has been at LANL since 2016, primarily contributing to projects in nuclear nonproliferation and plutonium sustainment. Her research interests focus on statistical methods for inverse analysis of complex systems. She earned her BS, MS, and PhD in civil engineering from Clemson University.

# BIOGRAPHIES

## Bernard R. Foy

Bernard Foy is a technical advisor at NA-22 in Washington, DC. He has been working on various aspects of nuclear-proliferation detection at Los Alamos National Laboratory for over 30 years. His work has touched on portions of the nuclear fuel cycle that include uranium enrichment technologies, uranium conversion, and actinide material storage. He has published work in an array of fields including passive and active remote sensing, hyperspectral imaging, lidar, laser-based spectroscopic methods, chemical forensics, detection algorithms, statistical signal processing, chemical kinetics, molecular reaction dynamics, and the use of machine learning methods in target detection. Following undergraduate and doctoral work in physical chemistry, he developed interests in RF and power-line sensing, computational kinetic modeling, modeling of reacting flows, supercritical fluids, atmospheric characterization, time-resolved spectroscopy, chemical sensing, and tries to find time for science and technology policy in nuclear affairs.

# BIOGRAPHIES

## Adithya V Ganesan

Adithya V Ganesan is a graduate student in the Department of Computer Science at Stony Brook University. He works under Prof. H Andrew Schwartx in the intersection of natural language processing and computational social science on interesting problems that have a human focus.

# BIOGRAPHIES

## Zoe Gastelum

Zoe Gastelum is acting manager of the International Safeguards and Engagements Department at Sandia National Laboratories. Zoe has worked at Sandia since February 2015, in which time her research has focused on information sources, analytical techniques, and methods for open source and other data analysis supporting international nuclear safeguards, and the performance of human-information systems. Prior to joining Sandia, Zoe spent five years as a nonproliferation research scientist at Pacific Northwest National Laboratory conducting research projects on computational models and methods for information analysis in support of nuclear nonproliferation objectives, focusing on open source data analysis and human behavioral modeling, and advanced information and communication technologies for international nuclear safeguards. Zoe also spent two years as a safeguards information analyst in the International Atomic Energy Agency's Department of Safeguards, where she led the content development and distribution of a daily safeguards morning briefing for the Department of Safeguards and conducted open source information analysis for over 20 countries per year.

# BIOGRAPHIES

## Maria Glenski

Dr. Maria Glenski is a data scientist in the Data Science and Analytics Group of the National Security Directorate at PNNL. Her research focuses include computational social science approaches to behavior analysis, characterization, and modeling of complex social behavior in diverse online social environments and explainable artificial intelligence (XAI) evaluating the impacts of algorithmic biases in machine learning models. Dr. Glenski received her PhD in computer science from the University of Notre Dame where she was an Arthur J Schmitt Leadership in Science and Engineering Fellow. Dr. Glenski's research has been published in top tier venues including WWW, ACL, ACM TIST, and CSCW, and she regularly serves on the program committee of several international conferences and journals.

# BIOGRAPHIES

## Tom Grimes

Dr. Tom Grimes is a physicist in the Signature Sciences and Technologies Division at PNNL. Tom earned his BS, MS, and PhD ('10, '13, '15) in nuclear engineering as well as his MBA ('15) from Purdue University. During his time at Purdue, he was funded by the National Science Foundation Graduate Research Fellowship as well as the Purdue Doctoral Fellowship. Following the completion of his PhD, Tom stayed on at Purdue and researched under an IC Postdoctoral Research Fellowship. Since arriving at PNNL, Tom has contributed to a wide variety of projects, with a heavy focus on research with and on neural networks. The non-neural part of his portfolio includes designing and operating nuclear detectors (including tension metastable fluid detectors), Monte Carlo modeling for nuclear detectors, and nuclear data. The neural part of his portfolio includes algorithms for nuclear particle ID and spectroscopy, neural radiography, neural unattended monitoring, neural signals analysis, and more. His neural work includes a strong emphasis on including techniques for explainability to understand the data being used for decision making by otherwise black-box algorithms. This includes both the application of standardized explainability tools as well as the development of new ones.

## Emma Hague – Keynote Presenter

Emma Hague received her PhD in high energy astro-particle physics from the University of New Mexico in 2009 for her work with the Pierre Auger Observatory. Her postdoctoral work was on gamma-ray astronomy at the Max-Planck-Institut für Kernphysik in Heidelberg, Germany. She then served as a researcher and emergency responder on the DOE Nuclear Emergency Support Team (NEST). She is currently the chief data scientist at the DOE Office of Intelligence Foreign Nuclear Programs Division.

# BIOGRAPHIES

## Stefan Hau-Riege

Stefan Hau-Riege is a computational and experimental physicist as well as the associate division leader for applied physics at LLNL. Stefan specializes in converging physics models, data science, and artificial intelligence methods. He also uses X-ray–free–electron lasers to study the structure, dynamics, and electronic properties of materials. Stefan earned an MS in physics from the University of Hamburg, a PhD in Materials Science from MIT, and a professional development data science certificate from Stanford University. Prior to joining LLNL in 2001, he worked for AT&T Bell Laboratories and Intel Corporation.

BACK TO GLOSSARY

# BIOGRAPHIES

## Jason Hite

Jason Hite is a postdoctoral research assistant in the Collection Science and Engineering Group in the National Security Sciences Directorate at Oak Ridge National Laboratory. He received his BS in applied mathematics in 2012 and his PhD in nuclear engineering in 2019, both at North Carolina State University. His research applies techniques of statistical parameter estimation and uncertainty quantification to problems in the domain of nuclear security and forensics including urban search, radioactive source localization, and proliferation detection.

# BIOGRAPHIES

## Andrew Hollis

Andrew Hollis is a PhD student in statistics at North Carolina State University. He got his BS in statistics from the University of New Mexico in 2018. While at NCSU, he has conducted research for the Consortium for Nonproliferation Enabling Capabilities (CNEC) focused on localizing small nuclear devices in urban environments. He has worked on data-driven nonproliferation applications for the analytics division in the Associate Directorate for Global Security at Los Alamos National Laboratory since 2015.

# BIOGRAPHIES

## Sumit K. Jha

Sumit K. Jha is a professor of computer science at the University of Texas San Antonio (UTSA). Dr. Jha received his PhD in computer science from Carnegie Mellon University. Before joining Carnegie Mellon, he graduated with a B.Tech (Honors) in computer science and engineering from the Indian Institute of Technology Kharagpur. Dr. Jha has worked on R&D problems at Microsoft Research, General Motors, INRIA France, and the Air Force Research Lab Information Directorate. His research has been supported by the National Science Foundation (NSF), DARPA, the Office of Naval Research (ONR), the Air Force Office of Scientific Research (AFOSR), the Oak Ridge National Laboratory (ORNL), the Royal Bank of Canada, the Florida Center for Cybersecurity, and the Air Force Research Laboratory (AFRL). He is a full member of the Sigma Xi and is a recipient of the IEEE Orlando Engineering Educator Excellence Award. Dr. Jha was awarded the prestigious Air Force Young Investigator Award and his research has led to four Best Paper awards. Dr. Jha is a proud U.S. citizen.

# BIOGRAPHIES

## Abbas Johar Jinia (A.J.)

Abbas Johar Jinia (A.J.) earned his MS in nuclear engineering from Purdue University in 2018. He is currently pursuing his PhD in the Department of Nuclear Engineering and Radiological Sciences at the University of Michigan. His research interests include active interrogation techniques for nuclear nonproliferation applications, radiography, neutron die-away techniques, applications of linear accelerators and machine learning techniques for nuclear material detections.

# BIOGRAPHIES

## Warnick Kernan

Warnick Kernan has a PhD from the University of Rochester. His interests in radiation detection cover both instrumentation and techniques applicable to characterizing radiation for safeguards, environmental, arms control, and emergency response applications. Key to these interests are developments in data analysis both by machines and analysts.

# BIOGRAPHIES

## Natalie Klein

Natalie Klein is a staff scientist in the Statistical Sciences group at Los Alamos National Laboratory. Natalie's research centers on the development and application of statistical and machine learning approaches in a variety of application areas, including hyperspectral imaging, laser-induced breakdown spectroscopy, and high-dimensional physics simulations. Prior to joining LANL in 2019, Natalie earned a PhD in statistics and machine learning from Carnegie Mellon University, where she developed novel methodology for neurophysiological data analysis that contributed to the fields of multivariate time series analysis, graphical model estimation, and physics-informed regression modeling.

# BIOGRAPHIES

## Thomas Kulp

Thomas J. Kulp is a senior scientist at SNL. He is a physical chemist with a PhD from the University of Illinois and a BA from the University of Chicago. He has been at SNL for the past 28 years and at LLNL for 7 years prior to that. He has worked on a variety of nuclear-proliferation detection projects during that time, involving remote sensing (lidar and hyperspectral imaging), local sensing (infrared spectroscopy and aerosol detection), laser development, nuclear process and signature assessment, and the elucidation of the chemistry and physics of optical and other signatures of interest. He is currently the science integration lead of the Persistent DyNAMICS venture.

AZ
BACK TO GLOSSARY

# BIOGRAPHIES

## Siddharth Manay

Siddharth Manay is a data science research engineer at LLNL, responsible for research, development, and testing of a variety of technologies, including mathematical methods for multi-sensor integration, a unique airborne LWIR sensor, and large-scale image and video processing problems (such as broad area search, object tracking, and compression). His roles on multidisciplinary teams include algorithm research and development, software development, operations support, and principle investigator (PI) for research projects. He joined LLNL in 2004 as a data scientist and holds a BEE, MEE, and PhD in electrical engineering (with an emphasis in computer vision) from the Georgia Institute of Technology.

# BIOGRAPHIES

## Jennifer Mendez

Jennifer Mendez is a software engineer at PNNL. Since joining the Measurement, Analysis, and Control Systems Team in 2008, Jennifer has focused on control software and data analysis for noble gas collection systems. Jennifer provides critical software support including instrument communication, data acquisition, testing, and web-based user interface development. More recently, she is developing radionuclide data quality assessment methods and tools. Jennifer holds a BS in computer science from Washington State University.

BACK TO GLOSSARY

# BIOGRAPHIES

## Kary Myers – Keynote Speaker

Kary Myers is a fellow of the American Statistical Association and a scientist and deputy group leader in the Statistical Sciences Group at Los Alamos National Laboratory. With support from an AT&T Labs Fellowship, she earned her PhD from Carnegie Mellon's Statistics and Data Science Department and her MS from their Machine Learning Department. At Los Alamos, she has been involved with a range of data-intensive projects, from analyzing electromagnetic measurements, to aiding large-scale computer simulations, to developing analyses for chemical spectra from the Mars Science Laboratory Curiosity Rover. She is currently the science integration lead for NA-22's Multi-Informatics for Nuclear Operations Scenarios (MINOS) venture, and she is Los Alamos' practicum coordinator for DOE's Computational Science Graduate Fellowship. She has served as an associate editor for the Annals of Applied Statistics and the Journal of Quantitative Analysis in Sports, and she created and organizes CoDA, the Conference on Data Analysis, to showcase data-driven research from across DOE.

BACK TO GLOSSARY

# Becky Olinger

Dr. Becky Olinger is the portfolio manager for Nuclear Threats Detection under the Nuclear Detection Division at Defense Threat Reduction Agency (DTRA). Prior to joining DTRA, Becky was the science advisor for National Nuclear Security Administration's Office of Counter Terrorism and Counter Proliferation NA-84: Nuclear Incident Response Teams. Previously, she was a program manager at Los Alamos National Laboratory Global Security Office where she managed efforts in nuclear security. Becky joined Los Alamos National Laboratory as a nuclear weapons engineer and project leader on National Nuclear Safety Administration projects in 2000. From 2007-2009 she was the DE-1 deputy group leader and program manager, supervising a team of researchers studying problems related to counter-terrorism and homemade explosives. Becky received a PhD in physical chemistry from the University of New Mexico Albuquerque in 2005 where she utilized infrared spectroscopy techniques to study a variety of materials, including explosives.

# BIOGRAPHIES

## Patrick O'Neal

Patrick O'Neal is a PhD student in nuclear engineering from Texas A&M University, where he is working with Dr. Sunil Chirayath on methods to identify forensics signatures and proliferation identifiers of foreign nuclear fuel cycles that produce plutonium. Patrick received his BS and MS in nuclear engineering from Texas A&M University, where he gained experience working on research projects concerning nuclear safety, nuclear security, and thorium fuel cycle safeguards. He has previously interned at Calvert Cliffs Nuclear Power Plant and Pacific Northwest National Laboratory.

# BIOGRAPHIES

## David Osthus

Dave Osthus is a Scientist at Los Alamos National Laboratory and holds a PhD in statistics from Iowa State University. His research interests include probabilistic forecasting applied to infectious disease and space weather and the development of Bayesian methods for dependent data applied to fractured systems and subsurface modeling.

# BIOGRAPHIES

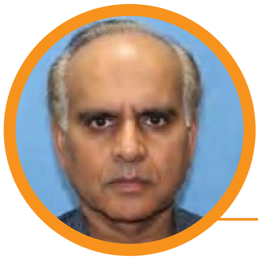
## Michelle Quirk

Dr. Michelle Quirk joined NNSA in Sept 2019. She was a scientist at LANL until 2009, a program manager and R&D scientist in the Federal Service, and an independent consultant since 2016. She worked in digital signal analysis/processing, scientific computing, information theory, and AI focused on computer vision, expert systems/cognitive assistants, natural language processing, and machine learning (ML). At NNSA/NA-114, she serves as a technical advisor for uncertainty quantification and AI/ML. She earned MS/PhD degrees in computational/applied mathematics in 1998/2003 from the University of Texas at Austin.

She is NA-11 POC for the Enterprise Modeling & Analysis Consortium (EMAC) and Defense Programs Integrated Modeling & Assessment (DPIMA), and a member of the Artificial Intelligence Working Group of NA-11.

BACK TO GLOSSARY

# BIOGRAPHIES



## Nageswara Rao

Nageswara (Nagi) S. V. Rao is a corporate fellow in the Computational Sciences and Engineering Division at Oak Ridge National Laboratory, where he joined in 1993. He published more than 450 technical conference and journal papers in the areas of nuclear facility analytics, sensor networks, information fusion and high-performance networking. He is a Fellow of IEEE and received a 2005 IEEE Technical Achievement Award and 2014 R&D 100 Award.

# Tom Reichardt

Thomas Reichardt (PhD, Mechanical Engineering, University of Illinois at Urbana-Champaign) is a staff research engineer at Sandia National Laboratories with more than 25 years' experience in the development and assessment of optical measurement and detection methods involving modeling/simulation, laboratory studies, and field deployments for energy, environmental, security, and defense applications. His prior work has contributed to advancements in picosecond-pulse fluorescence, nonlinear wave mixing, active infrared gas imaging/mapping, laser-photofragmentation-based diagnostics, and both in situ and standoff detection of bioaersols. His efforts over the past decade have centered upon developing physics-based inverse models for the hyperspectral reflectance signatures of solid chemical deposits and turbid liquid mixtures and have more recently expanded to include a broader array of signatures, specifically electromagnetic signals and their propagation, as well as the analysis of infrasound/acoustic data streams.

# BIOGRAPHIES

## Emily Saldanha

Dr. Emily Saldanha is a research scientist in the area of data science at PNNL where her work focuses on applying machine learning and deep learning techniques to identify and understand patterns in complex data. She has specific interests in the development of robust methods for application areas ranging from energy technologies to computational social science. She received her PhD in physics from Princeton University in 2016, where her work focused on the development and application of calibration algorithms for microwave sensors for cosmological observations.

BACK TO GLOSSARY

# BIOGRAPHIES

## Adam Seybert

Major Adam Seybert is a nuclear effects analyst at the U.S. Army Nuclear and Countering Weapons of Mass Destruction Agency. He currently focuses on developing methods for assessing combat power in conventional-nuclear environments. He also served as the program manager for DTRA's Tactical CBRN Situational Awareness research and development efforts, within the Nuclear Detection Division. He earned a BS in mathematics from the United States Military Academy at West Point in 2007 and an MS in nuclear engineering from the University of Tennessee in 2016. He has served in many diverse positions throughout the military, including the Logistical Operations Officer for the 3rd Infantry Regiment (The Old Guard) and as a Medical Support Company Commander in the 101st Airborne Division (Air Assault).

# BIOGRAPHIES

## Angie Sheffield

Ms. Angela Sheffield is the senior program manager for AI and data science in the Office of Proliferation Detection within the Defense Nuclear Nonproliferation Research & Development program at the National Nuclear Security Administration (NNSA) in the U.S. Department of Energy (DOE). In this position, she directs efforts leveraging artificial intelligence, advanced mathematics and statistics, and research computing technologies to develop capabilities to detect nuclear weapons development and characterize foreign nuclear programs around the world. Before joining NNSA, Ms. Sheffield led project teams at DOE's Pacific Northwest National Laboratory (PNNL) to develop modeling and simulation methodologies to model risk of WMD threats to inform national policy and decision making. Additionally, Ms. Sheffield led multidisciplinary efforts in the development of technical capabilities to detect the development of nuclear weapons with a special focus on AI and ML technologies. Ms. Sheffield joined PNNL after a distinguished career as an operations research analyst in the U.S. Air Force, where she specialized in the research and development and technical intelligence of U.S. and adversary weapon systems.

BACK TO GLOSSARY

# BIOGRAPHIES

## Ashley Shields

Ashley Shields is a PhD student in geosciences at Idaho State University with an MS in geographic information science from the same university. She also works at Idaho National Laboratory where she supports Critical Infrastructure Detection, Nuclear Reactor Anomaly Detection, and Digital Twin: Nuclear Proliferation Detection. Her research interests include machine learning and AI; image processing and feature detection; statistical analysis, data visualization, spectral analysis, and terrain modeling; geographic information science; and programming (Python, Fortran90, R).

# BIOGRAPHIES

## Erik Skau

Erik Skau received his PhD in applied mathematics from North Carolina State University in 2017. Erik's research expertise includes optimization techniques for matrix and tensor decompositions with a particular emphasis on models with physically motivated constraints and interpretability. Erik joined the Information Sciences Group at LANL as a postdoc in 2017 after completing his dissertation, and in 2020 he converted to a staff scientist.

# BIOGRAPHIES

## Sannisth Soni

Sannisth Soni is a post-masters research associate at PNNL. He received his MS in software engineering from San Jose State University. His work includes data collection, preprocessing, and modeling for projects involving causal inference and signal prediction and explanation based on open source data.

# Jay Thiagarajan

Jay Thiagarajan is a machine learning researcher in the Center for Applied Scientific Computing at Lawrence Livermore National Laboratory. His research broadly spans machine learning and artificial intelligence for applications in computer vision, health care, graph modeling, and scientific data analysis. He received his PhD from Arizona State University in 2013. He is currently the PI on multiple machine learning projects funded by the DOE and the Office of Science. He has published over 150 peer-reviewed articles and multiple book chapters on machine learning and its applications. He received his LLNL early career recognition award in 2020. He serves on the applied math visioning committee of the DOE Applied Scientific Computing Research program.

# BIOGRAPHIES

## Jake Tibbets

Jake Tibbetts is a graduate fellow of the Nuclear Science and Security Consortium at the University of California, Berkeley, where he studies computer science. His research interests lie at the intersection of technology and national security, with an emphasis on nuclear security. He is pursuing graduate research in cooperation with the DNN R&D-supported and Berkeley Lab-led SNITCHES (Sensor Networks to Identify Transferable Heuristics for Enhanced Security) project. Jake is recipient of the Bulletin of the Atomic Scientists' 2020 Leonard M. Rieser Award for his article "Keeping classified information secret in a world of quantum computing" and the winner of the Best Student Developed Game at the 2019 Serious Games Showcase & Challenge for his work on SIGNAL, an online experimental wargame to study the impact of nuclear capabilities on conflict escalation. In 2020, Jake completed undergraduate degrees in computer science and global studies at the University of California, Berkeley.

# BIOGRAPHIES

## Svitlana Volkova

Dr. Svitlana Volkova is a recognized leader in the fields of computational linguistics, machine learning, and computational social science. She leads the development of human-centered analytics to explain, predict, and prescribe human social systems and behaviors as they relate to national security challenges in the human domain. Solutions developed by Svitlana and her team advance understanding, analysis, and effective reasoning about extreme volumes of dynamic, multilingual, multimodal real-world social data. Since joining PNNL in 2015, Dr. Volkova has led more than 10 projects, including two DARPA efforts. She authored more than 50 peer-previewed conference and journal publications. Svitlana was a vice chair of the ACM Future of Computing Academy between 2017 and 2019. She received her PhD in computer science in 2015 from Johns Hopkins University where she was affiliated with the Center for Language and Speech Processing and the Human Language Technology Center of Excellence.

BACK TO GLOSSARY

# BIOGRAPHIES

## Jesse Ward

Jesse Ward earned his PhD in chemistry from the University of Michigan in 2009. He worked as a postdoc at Argonne National Laboratory from 2009–2012, performing experiments in X-ray fluorescence microscopy at the Advanced Photon Source. He joined the Radiochemical Analysis Group at Pacific Northwest National Laboratory in early 2013, and his current work applies X-ray microscopy and mass spectrometry to analyze nuclear materials. He has been using neural networks for data analysis since 2016. In 2018, he was a co-PI on a deep learning LDRD project applying neural networks to classify radiation detector data from the Shallow Underground Lab. In 2019, he served as an instructor for PNNL's Deep Learning Workshop. More recently, he was the project manager for an LDRD using fully convolutional networks to perform semantic segmentation of secondary ion mass spectrometry images.

# BIOGRAPHIES

## Marc Wonders

Marc Wonders is the current fellow in the National Nuclear Security Administration Graduate Fellowship Program for the Office of Defense Nuclear Nonproliferation Research and Development. Prior to the fellowship, he completed his PhD in nuclear engineering at Pennsylvania State University (PSU). His dissertation applied a novel multiplexing method he created to develop a compact, cost-efficient neutron imager based on silicon photomultipliers (SiPMs) and plastic scintillators. Beyond his dissertation research, he has worked on extensive SiPM characterization studies and their application especially to neutron detectors, the development of pulse-shape-discrimination-capable organic scintillators, the simulation of shielding requirements for electronic neutron generators, and machine learning applications for radiation detection, among other projects. While at PSU, he authored and co-authored over 15 journal manuscripts and full-length conference papers, including two conference student-paper-award winning papers.