Pacific Northwest NATIONAL LABORATORY

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A signature is a unique or distinguishing measurement, pattern or collection of data that predicts, detects or identifies a phenomenon (object, action or behavior) of interest.

Signature Discovery

A systematic process to rapidly discover new signatures in any domain

Researchers at the Pacific Northwest National Laboratory are developing a methodology that will enable decision makers ability to

- ***anticipate future events*** by detecting precursor signatures, such as combinations of line overloads that may lead to a cascading power failure, biomarkers for the onset of disease and mechanical and chemical hallmarks of material fatigue
- ***diagnose current conditions*** by matching observations against known signatures, such as the characterization of chemical processes via comparisons against known emission spectra
- ***analyze past events*** by examining signatures left behind, such as the identity of cyber hackers whose techniques conform to a known modus operandi. Such analyses can contribute to larger signature libraries which in turn serve as a resource for future anticipation and characterization.

THE CHALLENGE

Current practice is typically accomplished by asking domain experts to characterize and/or model individual phenomena to identify what might compose a useful signature. What is lacking is an approach that can be applied across a broad spectrum to efficiently and robustly **construct** candidate signatures, **validate** their reliability, measure their quality, and overcome challenges associated with the detection of those signatures; despite **dynamic** conditions, measurement obfuscation and "noisy" data environments.

OUR APPROACH

The solution is a systematic process to rapidly discover new signatures in any domain. PNNL's transformational research agenda is expected to yield new algorithms, methods, tools and techniques that will solve pressing national challenges, and produce an analytic framework where these tools can be tested and evaluated in the context of multi-domain application projects and integrated demonstrations.

U.S. DEPARTMENT OF ENERGY

SIGNATURE DISCOVERY RESEARCH FOCUS

Construction —
How do we select the best features for a signature?

Useful signatures often exist at the boundary of knowledge domains; e.g., the integration of multi-sensor data, media, social networks, and imagery to recognize trafficking, improvised explosives or proliferation. Attributes may be generated from underlying data through very complex and nonlinear relationships. The identification of relevant attributes and the generation of these relationships are essential.

Validation —
How do we know if we've found a "good" signature?

A critical step is to test and validate potential candidates in an environment filled with incomplete and noisy data or derived attributes. Given the diversity of possible signatures for a given phenomenon, quantitative comparison is essential, using methods that weigh signature performance against "costs" such as sensor expense, time required to perform the measurement and computational resources.

Dynamics —
What is the "performance life" of a signature?

Many phenomena of interest are not static events; instead, they unfold and evolve over time within a background of changing interference from natural noise or intentional obfuscation. Signatures must be flexible and adaptable to preserve their efficacy. Dynamic adaptation requires the capability to continuously monitor the efficacy of a signature and to revise or replace the signature.

Detection —
Can we find this signature in a noisy background?

Ultimately, the usefulness of a signature lies in its ability to detect the phenomenon of interest despite confounding observables and large volumes of noisy data. Optimized collection, measurement and elucidation approaches will address a wide range of these detection challenges.

Integrating diverse data types for bioforensics to identify signatures of biosamples

Combining data analytics with sensor expertise for nuclear non-proliferation to identify signatures of production facilities

Our goal is to develop and demonstrate new scientific approaches that include the implementation of algorithms, methods and tools in a reusable analytic framework. We are currently exploring their application in the areas of bioforensics, proteomics, cyber security and nuclear non-proliferation to solve important real-world problems.

The Pacific Northwest National Laboratory has over 40 years of experience in the development of nuclear signatures, and has developed signature libraries in multiple domains, including: the infrared spectral library, optical signatures of bacteria and signature discovery for nerve agent precursors, among others.

CONTACT

Nathan Baker
(509) 375-3997
Nathan.Baker@pnnl.gov

http://signatures.pnnl.gov

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