Few-Shot Learning for Nuclear Forensics Analysis

Powered by few-shot learning, the Sharkzor AI-driven, scalable web application makes it possible to quickly characterize and sort electron microscopy images used to analyze radioactive materials

THE CHALLENGE

When nuclear and other radioactive materials are intercepted at the border, nuclear forensics analysts examine the material to determine its origin, its history, and whether it's legal, dangerous, or a threat to national security. The forensic analysis of these materials is often conducted through the collection and identification of electron microscopy images. Each image is carefully studied by experts for classification of materials based on texture, shape, and size. Manually inspecting large image datasets takes enormous amounts of time. However, automatic characterization of large image datasets is a challenging problem because of the complexity involved, the lack of training data, and the lack of user-friendly artificial intelligence (AI) tools.

THE IMPACT

In nuclear forensics analysis, there is a significant need for automated and semi-automated methods to help analysts perform accurate image classification in large image datasets. With Sharkzor—an AI-driven web application for image classification powered by few-shot learning—analysts are able to load electron microscopy images and quickly characterize images in large datasets based on a small number of expert-created classes. This can greatly improve the ability of analysts to quickly sort and summarize datasets for nuclear forensics analysis.

SUMMARY

Despite recent advances, most AI solutions still rely on large quantities of labeled data, which limits their use. Even when data is available, it can be expensive or infeasible to collect the targeted labels necessary for many AI applications.

To address mission needs for the Department of Energy and other sponsors, Pacific Northwest National Laboratory developed Sharkzor. The web-based system leverages few-shot learning, an emerging approach to deep learning, where networks are trained to generalize to unseen classes based on only small amounts of data—as little as one example per class.
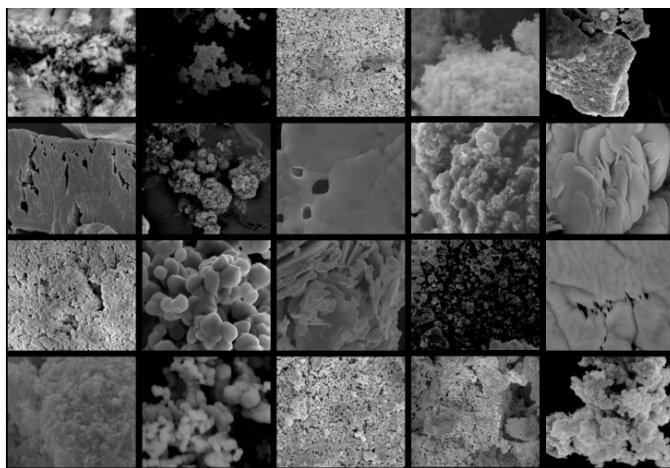
Microparticle samples as seen in the Shakzor user interface

With only a few examples, or shots, the technology generalizes to new tasks including object detection and classification, anomaly detection, and information retrieval. Few-shot is a flexible methodology that can be applied to a wide range of data types including images, audio, video, text, as well as more challenging modalities such as X-ray scans, electron microscopy, and remote sensing.

With Sharkzor, non-experts can quickly apply few-shot learning to their problems. The human-in-the-loop tool allows users to create their own categories of interest without requiring thousands of labeled images. By providing one to five examples, users are able to define their own classes and group unlabeled images into the categories they care about.

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