Realizing Real-Time Augmented Microscopy and Analysis on the Latest Advanced Scanning Transmission Electron Microscopes

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Extending from the micron to the atomic scale transmission electron microscopy is a powerful research tool for structural and chemical analysis for materials research. The breadth of data collected simultaneously in the latest generation of scanning transmission electron microscopes presents challenges and opportunities for advancements in microscopy, multi-modal data analytics, image-based forensics, and materials research. Recent advancements in deep learning have made it possible to analyze these massive data sets and perform complex imaging tasks. However, deep learning and augmented analysis have not yet disrupted the microscopy and microanalysis community like they have the computer vision community. Breakthroughs in automating and augmenting microscopy data collection and analysis could more than halve research cycle times in fields that rely on microscopy including materials and biological research.

The goal of this technological development is to create a suite of tools to expand the real-time analytic capabilities of microscopy as well as post-hoc analysis. By applying cutting edge deep learning, computer vision, and signal processing techniques to microscopy, this project aims to make real-time event tracking and automation of imaging, diffraction, and spectroscopy acquisition a reality. This suite of computational tools and analytical packages is being developed in collaboration with commercial partners, national laboratories, and universities/academia. The software has been designed to draw from standard materials libraries including the Materials Project database and the Open Crystallography database, but has also been enhanced by research and experimental data from contributors.

Augmented analysis, human-guided computer exploration of data, creates a powerful symbiosis between researchers and their analytical tools. Prompting a user in real-time with type of image recognized and potential regions of interest to explore is the first step of developing an analytics engine. Once we can combine human input with computer-aided analysis the machine learning engine can begin to elucidate materials-centric data from quantitative information and vast multidimensional datasets.

In this presentation, we will discuss the development of an emerging real-time augmented feedback framework for microscopy. This includes pending developments that utilize hybridized first principal and deep learning models for augmented analysis of material properties, spectroscopy, and diffraction patterns. In addition, we will discuss the growing potential of automating data collection from live analysis of microscope feeds for real-time event tracking for in-situ microscopy. The talk will conclude with examples taken from our current collaborations to augment and eliminate the burden of collecting, processing, and analyzing multidimensional and temporally-resolved datasets.