doi:10.1017/S1431927618003069
Microsc. Microanal. 24 (Suppl 1), 2018

Pioneering the Use of Neural Network Architectures and Feature Engineering for Real-Time Augmented Microscopy and Analysis

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The breadth of data collected simultaneously in the latest generation of scanning transmission electron microscopes (STEM) presents opportunities for significant advancements in microscopy, multi-modal data analytics and materials research. Recent advancements in deep learning have made it possible to analyze 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. Major breakthroughs in automating STEM/TEM data collection and analysis could drastically reduce 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 augmented by research and experimental data from contributors.

Using the instrumentation and expert collaborations, to date we have trained neural networks to perform classification on experimental images without the use of any stored metadata. Based on image information alone we are able to distinguish between microscope operational modes and classify the experimental data. The neural networks were trained on an augmented dataset consisting of a wide variety of STEM/TEM data ranging from atomic imaging to complex polycrystalline materials that we then augmented by applying translations and rotations where applicable. This allowed for a more robust training set that was more representative of possible new experimental data. The trained networks were optimized for accuracy and speed to allow for several readings to be taken each second allowing for real time feedback to the user about streaming data. 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 that can elucidate materials-centric data from quantitative information and vast multidimensional datasets.

In this talk, we will discuss the development of an emerging real-time augmented analysis 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 [1].

References:

[1] Work supported through the INL Laboratory Directed Research& Development (LDRD) Program under DOE Idaho Operations Office Contract DE-AC07-05ID145142. Drs. Brian van Deevner and Ian Harvey are thanked for her many useful discussions and contributions to this work. Authors also acknowledge Sudhajit Misra, Dr. Jing Gu, and Robert Mariani for helpful discussions.

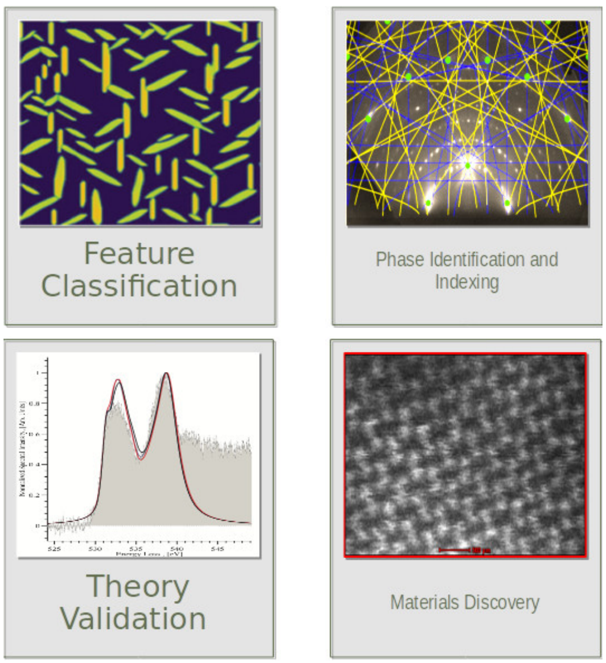

Illustration 1. Some of the capabilities the software

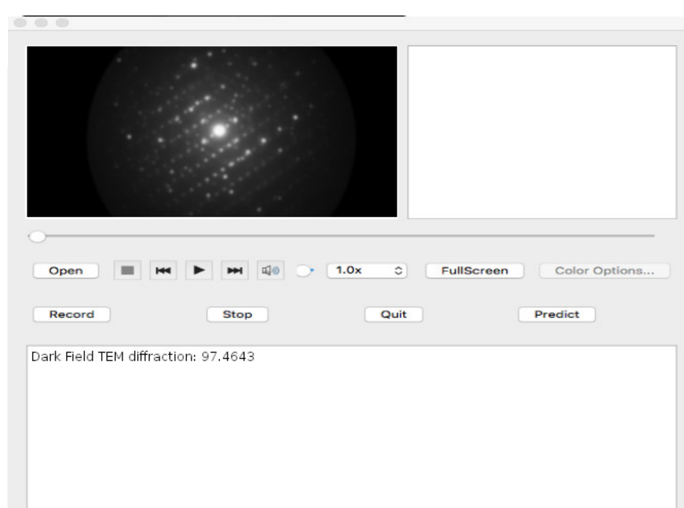

Illustration 2. Live classification of streaming microscope data to aid in feature tracking and analysis.

https://doi.org/10.1017/S1431927618003069 Published online by Cambridge University Press