APS Scientific Computation Seminar Series

Speaker:
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Title:
Algorithm-Driven Advances for Autonomous Scientific Imaging Instruments

Date:
August 12, 2024

Time:
1:00 p.m. (Central Time)

Location:
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Abstract:
Scientific imaging and diffraction instruments are widely used for non-destructive characterization to reveal important material properties such as local lattice parameters, chemical composition, and residual strains. For certain applications such as neutron computed tomography (CT), neutron-diffraction based strain imaging, and high-resolution X-ray CT, the measurement times can be long - spanning the order of hours or even days. Conventional instrument operation involves mounting the sample on a stage, acquiring multiple measurements by orienting the sample in a sequential manner according to a predetermined plan, and processing the data at the end of the experiment using conventional reconstruction algorithms at the end of the scan in order to obtain the information of interest. However, this open-loop approach is not robust to imperfections in the acquisition system and requires a large number of measurements to obtain high-quality 3D information when using conventional algorithms thereby limiting instrument throughput. Furthermore, the instrument users have limited feedback of the overall structures in the sample during the experiment which can potentially lead sub-optimal use of instrument time if the experiment did not reveal the relevant information. In this talk, Venkat will present research on designing algorithms for building autonomous scientific imaging and diffraction instruments - that make the fewest possible yet most informative measurements and adapt to the specifics of the sample to be measured. The approach involves using controllable sample stages, designing new acquisition protocols, moving measurements to powerful compute nodes, developing advanced image reconstruction algorithms and processing the results from partial measurements using machine-learning methods to drive the next set of measurements. Using examples from hyper-spectral neutron CT, X-ray CT, and neutron diffraction Venkat will demonstrate how the methods we have developed can reduce overall measurement times dramatically while providing useful real-time feedback to end users.