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Title: Statistical Bio-Modeling for Predictive Medicine

Abstract:
A key theme in biomedical sciences today is the integration of spatial and molecular information to predict the behavior of complex systems. Integrating Electron Microscopy (EM) and Chemical imaging (CI) is an exciting new paradigm that records and integrates both spatial structure and molecular spectral information from a sample, promising to considerably extend current single modality microscopy methods. Recent advances in electron tomography and FIB-SEM (Focused Ion Beam in Scattering Electron Microscopy) together with mid-infrared (IR) CI imaging are now allowing rapid recording of full image sets within minutes, enabling a wide variety of applications ranging from visualizing anisotropic diffusion in skin, to biomaterial evaluation to cancer pathology. Here, we recast the computational needs in CI as an efficient statistical quest for information. Recently developed physics-based theory in EM and IR-CI is merged with recent developments in statistical estimation of high-dimensional and complex models to yield entirely new tools that allow joint recovery of both spectral and spatial information. This considerably extends the existing inference paradigm where statistical pattern recognition tools are applied by ignoring underlying morphologic basis of the data and spatial-spectral relationships are not well utilized. Built on physics and math foundations, our statistical framework would be able to provide strong guarantees on the reliability and accuracy of results; as well as incorporate uncertain constraint and prior information. Integration of these tools with instrumentation will provide more accurate knowledge with confidence bounds for decision-making in biological analyses or disease diagnosis, hallmarks of predictive medicine.