Developing an Automatic Nonrigid Image Registration Algorithm for Nanoscience Research

Yu, Melissa

Scanning Tunneling Spectroscopy (STS) images are powerful tools that allow scientists to quantify the local atomic properties of surfaces, supporting the characterization and development of materials. However, acquiring hyperspectral STS data is time consuming, and as a result, STS images have significant distortions from piezoelectric creep and thermal expansion. To reduce distortions, the resolution of the image is often lowered, thus shortening scan time and reducing drift, etc. Recognizing that low-resolution STS images do not yield accurate quantitative analysis results, I address these problems in this project by developing an automatic nonrigid image registration algorithm to correlate distorted low-resolution hyperspectral data from STS images with less distorted high-resolution spatial information from a related electron imaging technique, Scanning Tunneling Microscopy. My algorithm uses bivariate polynomials and builds on the SIFT and RANSAC schemes to robustly identify locally distorted keypoints, minimize the impact of false matches, and improve the accuracy of the registration. I also devised an application-specific outlier rejector, which is shown to significantly reduce the search space during model fitting and speed up the computation. Experiments prove that this algorithm outperforms many common registration methods. This algorithm has the potential to improve our understanding of materials at the atomic level, and the techniques developed are also expected to be generally applicable to images from other imaging technologies.

Awards Won: