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An Enhanced Image Stitching Method for Atomic Force Microscopy

Atomic Force Microscopy (AFM) enables high-resolution imaging of material surfaces at the atomic scale, offering detailed insights into structural and functional properties. However, its limited scan area poses challenges in linking nanoscale features to macroscopic structures, particularly in applications like large-area composite analysis or dynamic change studies. To overcome this, it is necessary to acquire and stitch multiple small-range, high-resolution images into a seamless composite that retains accurate physical details. This requires a robust stitching tool capable of merging overlapping AFM images into a single, coherent, high-resolution mosaic. Conventional stitching methods, such as those based on features or Fourier transforms, often fail when dealing with images that are feature-sparse, minimally overlapping, or affected by complex transformations and noise artifacts. To address these limitations, we present an enhanced feature-based stitching approach, demonstrated using AFM images of biofilms formed by the bacterial strain Pantoea sp. YR343. Our method leverages domain expertise to select a feature-rich and correlated imaging channel (e.g., amplitude) to guide the alignment of a more challenging channel (e.g., topography). By using the correlated channel for feature detection and matching, we improve alignment accuracy and stitching performance. We compare our method with traditional direct stitching approaches and show that our technique significantly outperforms them. Further analysis reveals that computing the derivative of the topographical images along the x-axis produces features similar to those in the amplitude channel, enabling our method to generalize even in the absence of amplitude data. Although our focus is on AFM, the proposed strategy can be extended to optical microscopy by combining channels such as brightfield and fluorescence. We believe this multi-channel stitching workflow offers a powerful and generalizable solution for large-area microscopy image reconstruction and analysis.

Topical Area

AI and data science

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