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Computer Vision Algorithms for 3D Reconstruction of Microscopic Data – A Review

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The ability to produce high quality images and 3D reconstructions of objects leads to better defect detection and also a better understanding of the quantum effects that occur at the nano-level. This presentation reviews recent advances in the use of raw microscope data for the creation of 3D models representing real micro and nano-structures. The presentation is divided into five sections, each section dealing with a different set of algorithms and microscopy technology. The different technologies and algorithms include morphological reconstruction from atomic force microscopy (AFM), tomographic reconstruction methods used in transmission electrom microscopy (TEM), interferometry methods and optical microscopes, stereo imaging with scanning electron microscopy (SEM), and multifocus methods using confocal and general optical microscopes.

Each microscope has unique advantages and disadvantages that have led to different reconstruction algorithms. Distortions from the finite tip of an AFM can be reduced using morphological reconstruction methods, and several different approaches are discussed in our presentation [1]. Tomography methods, analogous to techniques developed to maturity in the field of medicine, have since been applied to non-medical fields, one particular area being electron microscopy [2].

The most common method of 3D reconstruction in scanning electron microscopes (SEM's) is depth from stereo. Depth is extracted from stereo pairs using equations first introduced in [3]. In this presentation an overview is presented of work done in the enhancement of stereo matching with SEM images. In terms of optical microscopes, two main methods include interferometry and multifocus methods. Interferometry methods obtain metrological data of a specimen's surface from an interference pattern created between a reference light beam and the light reflected from the specimen [4]. Multifocus methods extract depth by acquiring multiple images at different focal planes, with the reconstruction done by evaluating in which image an area of the scene appears most in focus. By knowing at what heights the focus was set over an image series, depth can be assigned to pixels based on which image they are sharpest in [5].

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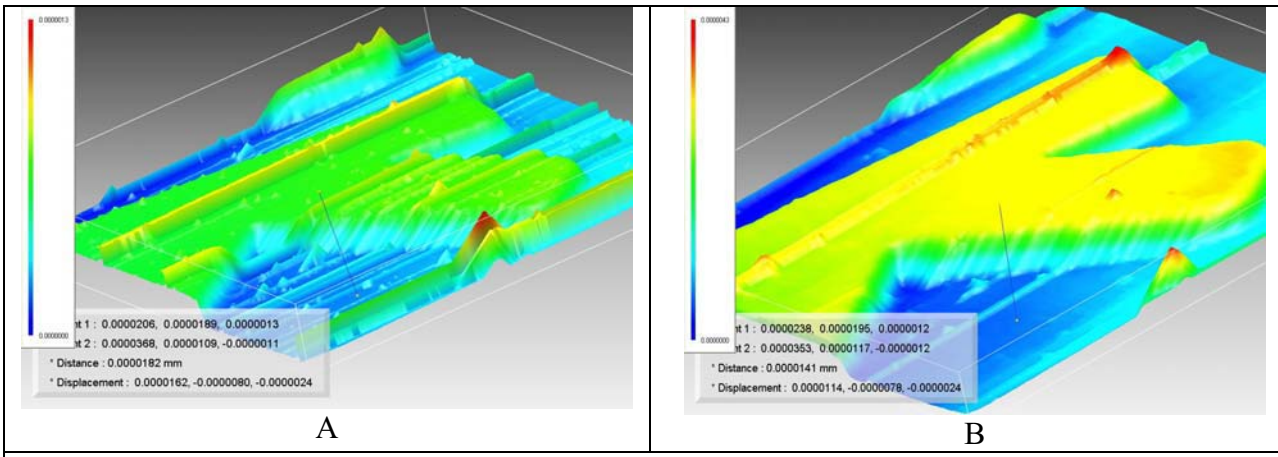

Fig. 1. Data of a MEMS sample from an AFM microscope. A. Raw data with pseudo-colored texture based on height. B. Processed 3D data.

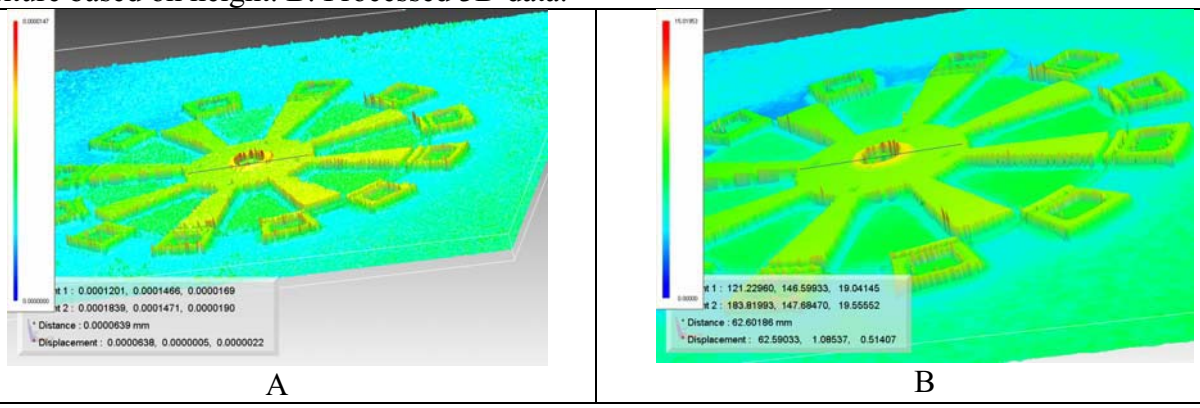

Fig. 2. Data of a MEMS sample from a confocal microscope. A. Raw data with pseudo-colored texture based on height. B. Processed 3D data.

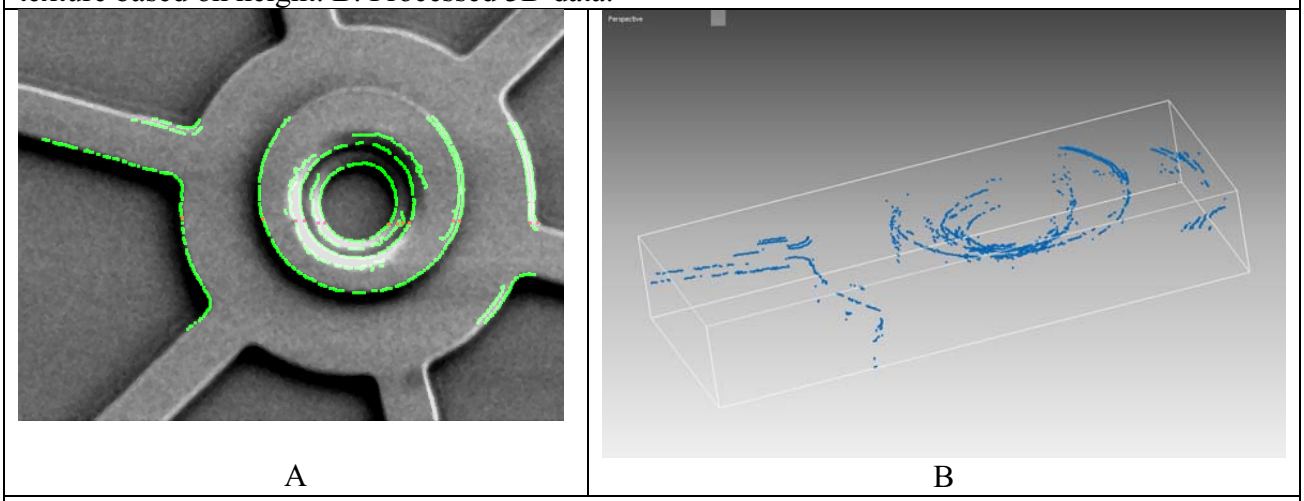

Fig. 3. Data of a MEMS sample from an SEM microscope. A. Single image from a stereo pair showing matched points. B. 3D Point Cloud.

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